

Health, Fitness, Lifestyle and Physical Competency of School Children in Wales

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Abstract

Promoting physical activity, fitness and physical competence are effective preventative measures for a variety of health risks and non-communicable diseases. Identifying overall levels, trends and inequalities among children and young people is imperative to inform and deliver effective programmes and initiatives aimed at increasing physical activity, health-related fitness and physical competence levels. The current challenge is to identify the interrelationships between these factors and to develop new insight into their assessment and integration into physical activity frameworks and models. Therefore, the overarching aim of the thesis was to investigate the health, fitness, lifestyle and physical competency of school children.

Study 1 consolidated and translated surveillance data related to physical activity among children and young people in Wales in order to assign grades to physical activity/ inactivity behaviours and influences indicators. Studies 2 and 3 highlighted the secular changes and the socio-economic and sex differences, respectively, in selected health-related fitness measures. Taken together, Studies 1, 2 and 3 showed that physical activity behaviours and influences and overall health-related fitness levels were low, and inequalities existed across socio-economic status and sex. Given the importance of physical competence in children and young people, Study 4 summarised the development of a novel, dynamic measure of physical competence (Dragon Challenge) that incorporates fundamental, combined and complex movement skills. Study 4 revealed that the Dragon Challenge was a valid and reliable tool in 10-14 year old children, and Study 5 resulted in the first reported model that quantified the direct and indirect relationships between ecological factors on physical competence.

Overall this thesis advocates for a balance of physical activity (quantity and exposure) and fitness and physical competency (quality and outcome) in children and young people and can be used to inform the content and delivery of health education interventions and programmes.

Scientific Outputs

Publications

Tyler, R., Mackintosh, K., Palmer, A., Jones, A., & Stratton, G. (2015). Ten-Year Secular Changes in Selected Health and Fitness Parameters of 10-11 Years Old Swansea School Children - 2003-2013. *Advances in Obesity, Weight Management & Control*, 3(5), 8-13. <https://doi.org/10.15406/aowmc.2015.03.00072>

Tyler, R., Mannello, M., Mattingley, R., Roberts, C., Sage, R., Taylor, S. R., . . . Stratton, G. (2016). Results From Wales' 2016 Report Card on Physical Activity for Children and Youth: Is Wales Turning the Tide on Children's Inactivity? *Journal of Physical Activity and Health*, 13(11 Suppl 2), S330-S336. <https://doi.org/10.1123/jpah.2016-0309>

Tyler, R., Fowweather, L., Mackintosh, K. A., & Stratton, G. (2018). A Dynamic Assessment of Children's Physical Competence. *Medicine & Science in Sports & Exercise*, 50(12), 2474-2487. <https://doi.org/10.1249/MSS.0000000000001739>

Tyler, R., Mackintosh, K. A., Fowweather, L., Edwards, L. & Stratton, G. (2018). Youth Physical Competence Promotion Model: A Quantitative Investigation into Modifiable Factors. *Scandinavian Journal of Medicine & Science in Sports (under review)*.

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Presentations

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Tyler, R., Fowweather, L., Mackintosh, K.A., Stratton, G. Validity and reliability of the Dragon Challenge v1.0 assessment of physical/motor competence, United Kingdom & Ireland Motor Competence Network Meeting, Coventry, UK. January 2018. Oral Presentation

Tyler, R., Edwards, L.C. International Project on Physical Activity: Active Healthy Kids Wales Report Card, National Centre for Population Health and Wellbeing Research (NCPHWR), Public Health Wales Annual Conference, Cardiff, UK. October 2017. Oral Presentation.

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Declarations and Statements

1. I, Richard Paul Oliver Tyler, hereby declares that the work presented in this thesis has not previously been accepted in substance for any degree and is not being concurrently submitted in candidature for any degree.
2. I, Richard Paul Oliver Tyler, hereby declares that the thesis is the result of my own investigations, except where otherwise stated and that other sources are acknowledged by footnotes giving explicit references and that a bibliography is appended.
3. I, Richard Paul Oliver Tyler hereby gives consent for the thesis, if accepted, to be available for photocopying and for inter-library loan, and for the title and summary to be made available to outside organisations.

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Date: _____

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Abbreviations

20m MSRT	20m Multistage Shuttle Run Test
β	Standardised regression weight
AHK	Active Healthy Kids
ALPHA	Assessing Levels of Physical Activity - health-related test battery
ANCOVA	Analysis of covariance
ANOVA	Analysis of variance
A-STEM	Applied Sport Technology Exercise and Medicine
BMI	Body mass index; weight (kg) divided by height (m ²)
BMI z-scores	Measure of relative body mass adjusted for child age and sex with use of reference data
BOT-2	Bruininks-Oseretsky Test of Motor Proficiency, Second Edition
CAMSA	Canadian Agility Movement Skill Assessment
CHAT	Child Health and Activity Tool
CFA	Confirmatory factor analysis
CFI	Comparative fit index
CI	Confidence interval
cm	Centimetre
COSMIN	Consensus-based Standards for the Selection of Health Measurement
CRF	Cardiorespiratory fitness
CS4L: PLAYfun	Canadian Sport for Life: Physical Literacy Assessment for Youth
DC	Dragon Challenge
DEXA	Dual-energy x-ray absorptiometry
F	F-test statistic; ratio of two variances
FMS	Fundamental or simple movement skills
GFI	Goodness of fit index
HBSC	Health Behaviour in School-aged Children
ICC	Intraclass correlation coefficients
IFI	Incremental fit index
kg	Kilogram
KMO	Kaiser-Meyer-Olkin
LSOA	Lower-Layer Super Output Areas

m/ m ²	Metre/ square metre
min(s)	Minute(s)
MABC-2	Movement Assessment Battery for Children-2
MSRT	Multistage shuttle run test
MVPA	Moderate to vigorous intensity physical activity
n	Number
NGO	Non-government organisation
NICE	National Institute for Health and Care Excellence
p	Level of significance
PA	Physical activity
PCA	Principal component analysis
PE	Physical Education
PL	Physical literacy
r	Coefficient of correlation
r ²	Coefficient of determination; statistical measure that represents the proportion of the variance for a dependent variable that is explained by an independent variable
RMSEA	Root mean square error of approximation
RWG	Research working group
s	Second
SD	Standard deviation
SE	Standard error
SEM	Structural equation modelling
SSA	Stability Skills Assessment
t	t-Test statistic; measure of the size of the difference relative to the variation in the sample data
TGMD-2/3	Test of Gross Motor Development-2/3
TLI	Tucker-Lewis index
UK	United Kingdom
UNCRC	United Nations Convention on the Rights of the Child
VO _{2max}	Maximal oxygen consumption
WIMD	Welsh index of multiple deprivation
YPAP-M	Youth Physical Activity Promotion Model

1 Introduction

1.1 Rationale and background

Regular physical activity and fitness are widely accepted as effective preventative measures for a variety of health risks and non-communicable diseases across all sub-groups (e.g. age, sex, ethnicity, and socio-economic status) (Blair, Cheng, & Holder, 2001; Department of Health, 2011; Lee et al., 2012; World Health Organization, 2018a). Engaging in adequate levels of physical activity in childhood can improve childhood health status (Andersen, Riddoch, Kriemler, & Hills, 2011; Biddle & Asare, 2011; Boreham & McKay, 2011; Janssen & Leblanc, 2010), result in improved adult health status (Lee et al., 2012; Warburton, Charlesworth, Ivey, Nettlefold, & Bredin, 2010), and enable the formation of healthy behaviours that may be carried into adulthood (Boreham & Riddoch, 2001; Kelly et al., 2007; Telama, 2009; Telama et al., 2014). For children and young people aged 5-18 years to receive the associated benefits of physical activity, the UK physical activity guidelines (Department of Health, 2011), recommend engagement in moderate to vigorous intensity activity for at least 60 minutes and up to several hours each day, and vigorous intensity activities at least three days per week. In Wales, the problem remains that activity levels are low and sedentary (sitting) behaviours are high and, in fact, the population of Wales is the least active in the UK (Department of Health, 2011). Therefore, promoting physical activity and the benefits on the quality and quantity of life is needed and requires a concerted effort.

Physical activity is multi-dimensional, complex behaviour, characterised by its frequency, intensity, and duration (Department of Health, 2011; World Health Organization, 2018b). There are different types of activity that contribute to overall physical activity and these occur in a multitude of settings, for example; occupational (e.g. work-related, school-related/Physical Education), household (e.g. domestic cleaning, caregiving, chores), transport (e.g. cycling/walking to school or work), leisure-time activities (e.g. dancing, active play), and organised sport participation (Department of Health, 2011; World Health Organization, 2018a). Moreover, there are numerous potential influencing factors on physical activity behaviours, highlighted in the Youth Physical Activity Promotion Model (YPAP-M) (Welk, 1999), such as those that may enable (e.g., movement skills/physical competence, health-related fitness, environmental attributes and access), predispose (e.g., perceived competence and self-efficacy) or reinforce (e.g., parental physical activity and family, peer and coach influence) physical activity in children and young people, as well as, demographic differ-

ences (e.g. age, sex, ethnicity and socio-economic status). Physical activity is therefore notably difficult to assess (Dugdill & Stratton, 2009). Few studies have succeeded in capturing temporal data on both the quantity and quality of physical activity across the different domains of physical activity. The 2012 and 2016 *Lancet* series on Physical Activity (Bauman et al., 2012; Hallal et al., 2012; Kohl et al., 2012; Sallis et al., 2016), advocated that “optimal physical activity monitoring and surveillance should focus on physical activity levels and behaviours, their determinants and outcomes, and indicators of proven and promising solutions to address low physical activity in various segments of the population.” Specifically, it is suggested that measuring overall physical activity is not adequate for policy and intervention development (Bauman et al., 2012; Hallal et al., 2012; Kohl et al., 2012; Sallis et al., 2016). Instead, physical activity levels and behaviours, their determinants and outcomes should be the focus, and trends in physical activity across multiple domains should be monitored at the individual, social, environmental, and societal levels (Bauman et al., 2012; Hallal et al., 2012; Kohl et al., 2012; Sallis et al., 2016). With this objective, the Active Healthy Kids Global Alliance country report card series on physical activity, uses national surveillance data under key indicators to analyse physical activity behaviours, settings, and influences in children and young people (Tremblay et al., 2014).

Given the complexity of physical activity and its influencing factors (Bauman et al., 2012; Welk, 1999) and following the global recommendations from the *Lancet* series on physical activity (Bauman et al., 2012; Hallal et al., 2012; Kohl et al., 2012; Sallis et al., 2016), surveillance on overall physical activity levels as well as its subcomponents and determinants (e.g., active play/active leisure, organized sport, active transportation, sedentary time, physical fitness, physical literacy, physical competence), across subgroups (e.g. age, sex, ethnicity, and socio-economic status) is needed. Furthermore, a thorough and critical evaluation is needed for all sectors and settings that have a known impact on physical activity levels, including school, community and policy. Additionally, trends in physical activity behaviours, their determinants and outcomes across multiple domains should be examined. While the Active Healthy Kids Wales 2014 report card (Stratton et al., 2014), the inaugural report card to assess the ‘State of the Nation’ in relation to the levels of physical activity behaviours, settings, and influences in children and young people, began to address these aims, the continuation of the national report card and the monitoring of physical activity behaviours and influences on physical activity is needed.

Despite the importance of monitoring physical activity behaviours and influences in

children and young people, it is postulated that assessing products or outcomes of physical activity could also give an indication of the quantity and quality of physical activity (Guinhouya, 2012), and could potentially present a more efficient marker of physical activity levels. Physical activity and physical fitness are closely associated, with physical fitness mainly, but not completely, determined by physical activity levels (Blair et al., 2001). Physical fitness includes a range components that are associated with health outcomes, such as cardiorespiratory fitness, muscular strength and body composition (Ruiz et al., 2011). In children, many studies have reported the strong associations between low cardiorespiratory fitness (McMurray & Andersen, 2010; Ortega, Ruiz, Castillo, & Sjöström, 2008; Ruiz, Castro-Piñero, et al., 2009), low muscular strength/ fitness (Ortega et al., 2008; Ruiz, Castro-Piñero, et al., 2009; Volaklis, Halle, & Meisinger, 2015) and high body mass index (Griffiths, Parsons, & Hill, 2010; L'Allemand-Jander, 2010; Ruiz, Castro-Piñero, et al., 2009), with metabolic and cardiovascular disease risk, mental health problems, reduced quality of life and all-cause mortality (Högström, Nordström, & Nordström, 2015; Ruiz, Castro-Piñero, et al., 2009; Volaklis et al., 2015). Therefore, physical fitness is considered one of the most powerful indicators of health, both, in childhood and in adulthood (Ortega et al., 2008; Ruiz, Castro-Piñero, et al., 2009; Ruiz et al., 2011; Tomkinson, Carver, et al., 2017), independent of physical activity (Blaes, Baquet, Fabre, Van Praagh, & Berthoin, 2011; Ekelund et al., 2007). In fact, physical fitness has been shown to be a stronger predictor of health than physical activity (Andersen et al., 2011). In addition to the associations with health, cardiorespiratory fitness, muscular strength and high body mass index are also associated with the acquisition of skills essential to physical activity and sporting success (Armstrong, Tomkinson, & Ekelund, 2011; Ceschia et al., 2016). Given that measuring health-related fitness levels (i.e., components such as cardiorespiratory fitness, muscular strength and body mass index) not only provides a reflection of physical activity levels, but also supplies a predictor of current and future health, as well as, highlights the physical development of children and young people, there is an abundance of evidence highlighting the need to include health-related fitness testing as part of existing health and fitness screening and surveillance systems (Ortega et al., 2008; Ruiz, Castro-Piñero, et al., 2009; Ruiz et al., 2011; Tomkinson, Carver, et al., 2017). Nonetheless, there is currently no trend data on selected health-related fitness measures of school children in Wales, as well as, a scarcity of data on the levels of health-related fitness across sex and socio-economic status subgroups. Identifying changes and differences in health-related fitness levels among school children could indicate the need for services and interventions to improve the health and fitness inequalities in school-aged children.

Apart from the physical fitness as an outcome measure of children and young people's physical activity levels, the development of motor skills and physical competence should be viewed as an additional and independent physiological factor related to physical activity that requires specific analyses (Guinhouya, 2012). Physical competence can be defined as "the sufficiency in movement vocabulary, movement capacities and developed movement patterns plus the deployment of these in a range of movement forms" (Whitehead, 2010). Overall, there is a vast array of evidence identifying physical competence as an important component of physical literacy, and, as such, a critical precursor for increasing positive health trajectories, particularly physical activity, across the lifespan (Barnett, Lai, et al., 2016; Edwards, Bryant, Keegan, Morgan, & Jones, 2016; Hulteen, Morgan, Barnett, Stodden, & Lubans, 2018; Robinson et al., 2015; Stodden et al., 2008; Whitehead, 2010). Specifically, systematic reviews and longitudinal studies have reported strong evidence for positive associations between physical competence and physical activity levels (Barnett, van Beurden, Morgan, Brooks, & Beard, 2009; Holfelder & Schott, 2014; Lopes, Rodrigues, Maia, & Malina, 2011; Lubans, Morgan, Cliff, Barnett, & Okely, 2010), health-related fitness (Barnett, van Beurden, Morgan, Brooks, & Beard, 2008; Cattuzzo et al., 2016; Robinson et al., 2015) and perceived competence (Lubans et al., 2010; Robinson et al., 2015), as well as an inverse association with weight status (D'Hondt et al., 2014; Lubans et al., 2010; Robinson et al., 2015), in paediatric populations. Furthermore, studies have shown that enhanced physical competence during childhood tracks across the lifespan by leading to higher levels of physical activity and health-related fitness during adolescence (Barnett et al., 2009; Barnett, van Beurden, et al., 2008; Lopes et al., 2011; Robinson et al., 2015), and by supporting functional independence, general health and quality of life in later life, as well as reducing the risk of all-cause mortality (Hulteen et al., 2018; Paterson & Warburton, 2010; Sigmundsson, Lorås, & Haga, 2016). Thus, enhanced physical competence in children and young people is foundational for physical activity promotion and associated health benefits, with transferable value throughout the life course.

There is a need to develop valid tools that effectively and efficiently assess physical competence in order to evaluate whether programmes are successful (Corbin, 2016). Physical competence includes not only the acquisition of health- and skill-related components of fitness (e.g. cardiorespiratory fitness, strength, flexibility, agility, balance, coordination, power, reactions and speed), but also movement skills, and plays an important role in the growth and development of children (Barnett, Lai, et al., 2016;

Clark & Metcalfe, 2002; Gallahue, Ozmun, & Goodway, 2012; Hulteen et al., 2018; Robinson et al., 2015; Stodden et al., 2008; Whitehead, 2010). Movement skills consist of three interrelated constructs: fundamental movement skills (FMS; balance, core stability, coordination, speed variation, flexibility, control, proprioception, and power), combined movement (poise, fluency, precision, dexterity, and equilibrium), and complex movement (bilateral coordination, inter-limb coordination, hand-eye coordination, turning, twisting and rhythmic movements, and control of acceleration/deceleration) (Clark & Metcalfe, 2002; Gallahue et al., 2012; Whitehead, 2010). The development of combined and complex movement skills is speculated to be imperative to increasing levels of physical competence in children over 8 years old (Clark & Metcalfe, 2002; Gallahue et al., 2012; Tyler, Fowweather, Mackintosh, & Stratton, 2018; Whitehead, 2010), however most existing land-based movement skill assessments involve the performance of discrete skills in isolation (e.g., the Test of Gross Motor Development (TGMD-2/3) (Ulrich, 2000), the Bruininks-Oseretsky Test of Motor Proficiency, Second Edition (BOT-2) (Bruininks & Bruininks, 2005), the Movement Assessment Battery for Children-2 (MABC-2) (Henderson, Sugden, & Barnett, 2007), CS4L: Physical Literacy Assessment for Youth Fun (PLAYfun) (Cairney et al., 2018), Passport for Life: Movement Skills Assessment (Physical and Health Education Canada (PHE Canada), 2014)). Assessing discrete movement skills in isolation fails to account for the utilisation of combined and complex movement skills observed during physical activity and play and needed to demonstrate physical competence (Whitehead, 2010). In order to better measure elements of physical competence, there is a need to develop a dynamic assessment that requires the demonstration of fundamental (e.g., balance), combined (e.g., poise) and complex (e.g., rhythmic movements) movement skills through refined (complex) and specific movement patterns (e.g., hopping, turning, jumping patterns), and measured by both product/outcome- and process/technique-based evaluations. The assessment should also be feasible for national surveillance and could be used as both a formative and summative assessment in the educational context.

Ecological models provide a framework of potential influencing factors on health-related behaviours and are useful in emphasising social and psychological influences and environmental contexts (Barnett, Lai, et al., 2016; Bauman et al., 2012; Welk, 1999). As previously alluded to, research has investigated the mediating variable framework of the YPAP-M (Chen, Welk, & Joens-Matre, 2014), however the examination of the influencing factors on physical competence, guided by this model, remains to be explored. Further, few studies have investigated both psychological

influences and environmental factors on physical competence (Barnett, Lai, et al., 2016). Therefore, there is a need to quantify the direct and indirect relationships between modifiable factors on physical competence and to investigate potential sex, weight status, and school level differences. The development of an ecological model with physical competence as the endogenous variable would afford new insight and an in-depth understanding of the multiple influences on physical competence. Such a targeted approach could inform intervention development with the objective to promote physical competence in children, as well as explain effects or lack of effects in current intervention strategies.

1.2 Problem statement

Promoting physical activity, fitness and physical literacy are effective preventative measures for a variety of health risks and non-communicable diseases. Moreover, identifying levels of physical activity, health-related fitness and motor competence among school children is needed to inform effective services and interventions. The current challenge is to identify the interrelationships between these factors and to develop new insight into how these factors can be assessed and integrated into physical activity frameworks and models.

1.3 Thesis aims

The overarching aim of the present thesis was to investigate the health, fitness, lifestyle and physical competency of school children in Wales. This PhD Thesis is divided into five study chapters:

Study 1: The purpose of Study 1 was to consolidate and translate research related to physical activity among children and youth in Wales and to synthesise national surveillance data from several surveys in order to assign grades to physical activity/inactivity behaviours and influences indicators, as well as to examine trends or inequalities in the data.

Study 2: The aim of Study 2 was to highlight the secular changes in selected health and fitness measures (body mass index, prevalence of overweight and obesity, and grip strength) in 10-11-year-old school children, using data obtained in 2003 and 2013.

Study 3: The aim of Study 3 was to investigate socio-economic and sex differences in selected health-related fitness measures in 9-12-year-old children.

Study 4: The first aim of Study 4 was to develop a land-based dynamic measure of physical competence that requires a participant to demonstrate fundamental, combined and complex movement skills, movement capacities/skills and movement patterns, and assessors to score both processes and products (Dragon Challenge; DC). The second aim was to assess the psychometric properties of the DC in 10-14-year-old children.

Study 5: The aim of Study 5 was first to quantify the direct and indirect relationships between enabling, predisposing and reinforcing socio-ecological factors on physical competence, and second to investigate potential sex, weight status, and school level differences.

2 Literature Review

Physical activity enhances health benefits in children (Biddle & Asare, 2011; Boreham & McKay, 2011; Janssen & Leblanc, 2010), while preventing emerging health risk factors (Andersen et al., 2011; Janssen & Leblanc, 2010). There are strong associations between low physical fitness (McMurray & Andersen, 2010; Ortega et al., 2008; Ruiz, Castro-Piñero, et al., 2009; Volaklis et al., 2015) and high body mass index (Griffiths et al., 2010; L'Allemand-Jander, 2010; Ruiz, Castro-Piñero, et al., 2009), as well as with disease risk, mental health problems, reduced quality of life and all-cause mortality later in life (Högström et al., 2015; Ruiz, Castro-Piñero, et al., 2009; Volaklis et al., 2015). Physical competence is a critical precursor for increasing positive health trajectories, particularly physical activity and physical fitness, across the lifespan (Barnett, Lai, et al., 2016; Edwards et al., 2016; Hulteen et al., 2018; Robinson et al., 2015; Stodden et al., 2008; Whitehead, 2010). Adequate levels of physical activity, physical fitness and physical competence in childhood can improve childhood health status, result in improved adult health status (Högström et al., 2015; Lee et al., 2012; Robinson et al., 2015; Ruiz, Castro-Piñero, et al., 2009; Stodden et al., 2008; Volaklis et al., 2015; Warburton et al., 2010; Whitehead, 2010), and enable the formation of healthy behaviours that may be carried into adulthood (Boreham & Riddoch, 2001; Kelly et al., 2007; Telama, 2009; Telama et al., 2014). With this in mind, this literature review aims to delve deeper into the evidence base surrounding physical activity, physical fitness and physical competence, and the monitoring and surveillance of such variables.

2.1 Physical Activity

Physical activity is defined as “any bodily movement produced by skeletal muscles that require energy expenditure” (World Health Organization, 2018b). Physical activity includes all forms of activity, such as active travel (e.g., walking and cycling), organised and competitive sport, active recreation (e.g., dance, yoga), playing active games, as well as work-related activity (Department of Health, 2011; World Health Organization, 2018a). Physical activity a key determinant of energy expenditure, and is fundamental to energy management (Besson et al., 2009; Chaput et al., 2011; Hills, Andersen, & Byrne, 2011; Monasta et al., 2010; Warburton et al., 2010). Engaging in sufficient physical activity is widely accepted as an effective preventative measure for a variety of health risks across all subgroups (e.g. age, sex, ethnic, and socio-economic) (Department of Health, 2011; World Health Organization, 2018a). Physical activity decreases the risk of many non-communicable diseases (Besson et al.,

2009; Chaput et al., 2011; Dziura, Kasl, & Di Pietro, 2004; Hills et al., 2011; Lee et al., 2012; Li & Siegrist, 2012; Miller & Dunstan, 2004; Monasta et al., 2010; Paterson & Warburton, 2010; Sattelmair et al., 2011; Stuck et al., 1999; Taylor et al., 2004; Warburton et al., 2010; Wolin, Yan, & Colditz, 2011). In particular, regular and sufficient levels of physical activity in adults reduces the risk of hypertension (Warburton et al., 2010), coronary heart disease (Lee et al., 2012; Sattelmair et al., 2011; Warburton et al., 2010), cardiovascular disease (Li & Siegrist, 2012; Warburton et al., 2010), stroke (Warburton et al., 2010), diabetes (Dziura et al., 2004; Lee et al., 2012; Miller & Dunstan, 2004), and breast, colon and endometrial cancer (Warburton et al., 2010; Wolin et al., 2011). Physical activity also reduces depression and promotes well-being (Das & Horton, 2012; Mammen & Faulkner, 2013; Schuch et al., 2016), reduces the risk of falls, and improves bone and functional health (Paterson & Warburton, 2010; Stuck et al., 1999; Taylor et al., 2004). These reductions in risk range from 20% to 83% (Besson et al., 2009; Chaput et al., 2011; Dziura et al., 2004; Hills et al., 2011; Lee et al., 2012; Li & Siegrist, 2012; Miller & Dunstan, 2004; Monasta et al., 2010; Paterson & Warburton, 2010; Sattelmair et al., 2011; Stuck et al., 1999; Taylor et al., 2004; Warburton et al., 2010; Wolin et al., 2011). Moreover, sufficient levels of physical activity can lower the risk of early death by 30%, and therefore extends life expectancy (Lee et al., 2012). Physical inactivity (lack of sufficient physical activity) has been identified as the fourth leading risk factor for global mortality, and is estimated to cause 16.9% of all deaths in the UK (Lee et al., 2012). Furthermore, the cost of physical inactivity has been estimated as 1.5-3.0% of total direct health care costs in the UK, equivalent to £0.9 billion (Oldridge, 2008). Reducing physical inactivity by just one percent a year over a five-year period would save the UK economy just under £1.2 billion (UKActive, 2014). Despite these health and economic benefits, in Wales, the problem remains that activity levels are low and sedentary (sitting) behaviours are high and, in fact, the population of Wales is the least active in the UK (Department of Health, 2011). Therefore, promoting the benefits of physical activity on the quality and quantity of life of people represents an excellent, cost effective investment (UKActive, 2014) and requires a concerted effort.

2.2 UK Physical Activity Guidelines

The UK physical activity guidelines ‘Start Active Stay Active’ (Department of Health, 2011), were published on behalf of the Chief Medical Officers of the four home countries in July 2011. These guidelines recommend levels of physical activity for health in children under 5 years (early years), children and young people aged 5 to 18 years and adults and seniors (older adults).

2.3 Physical Activity and Sedentary Behaviours in Children and Young People

Adequate levels of physical activity in childhood can improve childhood health status, result in improved adult health status, and enable the formation of healthy behaviours that may be carried into adulthood (Boreham & Riddoch, 2001; Kelly et al., 2007; Telama, 2009; Telama et al., 2014). There is a strong body of evidence, consisting of both observational and experimental research, that indicates that regular physical activity provides short and long-term health benefits (Department of Health, 2011). Specifically, physical activity is associated with numerous physiological, psychosocial and cognitive benefits (Biddle & Asare, 2011; Boreham & McKay, 2011; Janssen & Leblanc, 2010), and prevents emerging health risk factors in both healthy and high risk children and young people (Andersen et al., 2011; Janssen & Leblanc, 2010). Moreover, physical activity has wider social benefits and promotes well-being and quality of life across the life course. The literature base continues to grow, with large-scale studies providing evidence of the strong associations that clarify the dose-response relationships between physical activity and health outcomes in children and young people (Andersen et al., 2006; Artero, Ruiz, et al., 2011; Department of Health, 2011; Dumith, Gigante, Domingues, & Kohl, 2011; Ekelund et al., 2007, 2006; Janssen & Leblanc, 2010). Alternatively, sedentary behaviours (any behaviours that occur whilst sitting or lying down while awake and typically require very low energy expenditure (Pate, O'Neill, & Lobelo, 2008) are related to poor health outcomes, such as cardio-metabolic diseases, poorer mental health, and all-cause mortality, regardless of an individual's physical activity levels (Biddle & Asare, 2011; Chinapaw, Proper, Brug, van Mechelen, & Singh, 2011; Marshall, Biddle, Gorely, Cameron, & Murdey, 2004; Tremblay, Colley, Saunders, Healy, & Owen, 2010; Tremblay et al., 2011). Therefore, it is important to identify childhood physical activity levels and sedentary behaviours to indicate current, and future, health.

For children and young people aged 5-18 years to receive the associated benefits of physical activity, the UK physical activity guidelines (Department of Health, 2011), recommend engagement in moderate to vigorous intensity activity for at least 60 minutes and up to several hours each day, and vigorous intensity activities at least three days per week. Further, all children and young people should minimise the amount of time in sedentary (sitting) behaviours for long periods of time. The British Heart Foundation summarised international recommendations from North America, Australia and the United Kingdom (British Heart Foundation National Centre (BHFNC) for Physical Activity and Health Loughborough University, 2012), and provided the

recommendation that children and young people should spend less than 2 hours per day in sedentary behaviours (British Heart Foundation National Centre (BHFNC) for Physical Activity and Health Loughborough University, 2012). More recently, a special supplement of *Applied Physiology, Nutrition, and Metabolism* (“CSEP Special Supplement - Canadian 24-Hour Movement Guidelines for Children and Youth: An Integration of Physical Activity, Sedentary Behaviour, and Sleep,” 2016), included a collection of the background research, consultations, processes, and outcomes that led to the development of the Canadian 24-Hour Movement Guidelines for Children and Youth (aged 5-17 years), the first 24 hour guidelines that integrated physical activity, sedentary behaviour, and sleep (Tremblay, Carson, & Chaput, 2016; Tremblay, Carson, Chaput, et al., 2016). The supplement also contained four systematic reviews, which assessed findings from nearly 600 published articles, and provided evidence for the development of the guidelines (Tremblay, Carson, & Chaput, 2016; Tremblay, Carson, Chaput, et al., 2016). These reviews examined the associations of physical activity (total physical activity, MVPA, and light physical activity) (Poitras et al., 2016), sedentary behaviours (Carson et al., 2016), sleep duration (Chaput et al., 2016), and combinations of objectively measured physical activity and subjectively measured sedentary behaviour and sleep (Saunders et al., 2016), with health outcomes in school-aged children and youth. Taken together these reviews suggest that for children and youth (aged 5-17 years) to obtain optimal health benefits, they should achieve high levels of physical activity, low levels of sedentary behaviour, and sufficient sleep (Carson et al., 2016; Chaput et al., 2016; Poitras et al., 2016; Saunders et al., 2016; Tremblay, Carson, Chaput, et al., 2016). Specifically, to achieve a healthy 24 hours, children and youth should; i) achieve 9 to 11 hours of uninterrupted sleep per night for 5-13 year olds and 8 to 10 hours for 14-17 year olds, ii) accumulate at least 60 minutes of moderate to vigorous physical activity per day, involving a variety of aerobic activities, and vigorous physical activity and muscle and bone strengthening activities on at least 3 days per week, iii) achieve several hours of a variety of structures and unstructured light physical activity, iv) spend no more than 2 hours per day in recreational screen time, and limit sitting for extended periods (Carson et al., 2016; Chaput et al., 2016; Poitras et al., 2016; Saunders et al., 2016; Tremblay, Carson, Chaput, et al., 2016)

2.4 Ecological Models

To develop successful targeted interventions, an appropriate conceptual promotion model should be utilised to prioritise the key characteristics of the target group and to produce a comprehensive and structured assessment of needs and barriers to a healthy

behaviour or outcome through a range of social, behavioural, physical and environmental factors (Gielen, McDonald, Gary, & Bone, 2008; Green, Kreuter, Deeds, & Partridge, 1980; Welk, 1999). The PRECEDE-PROCEED model (Green et al., 1980) is a health promotion planning model, that provides a structured organisational framework or road map for determining health education programmes for a variation of behaviours or outcomes (Gielen et al., 2008; Green et al., 1980; Welk, 1999). The PRECEDE-PROCEED model outlines a sequence of stages that should be conducted. The first stage is a behaviour and environmental assessment to identify the primary determinants of a given behaviour or outcome (Gielen et al., 2008; Green et al., 1980; Welk, 1999). The second stage is an educational and organisational assessment for categorising the determinants into factors that enable, predispose, or reinforce the given behaviour or outcome, and then weighting these on their potential influence (Gielen et al., 2008; Green et al., 1980; Welk, 1999). The final stage is administrative and policy assessment (Gielen et al., 2008; Green et al., 1980; Welk, 1999), including the assessment of resources, budgets, organisations, etc., that should be conducted to refine interventions or promotional strategies that are likely to be effective based on the ecological model produced in the other stages. Focused interventions should then be followed by process, impact and outcome evaluations to measure the effectiveness of the intervention (Gielen et al., 2008; Green et al., 1980; Welk, 1999).

The Youth Physical Activity Promotion Model (YPAP-M; Figure 1) (Welk, 1999), utilises aspects of the PRECEDE-PROCEED model, to offer an ecological conceptual model framing factors that may predispose, reinforce or enable physical activity in children, as well as, personal demographic factors (Welk, 1999).

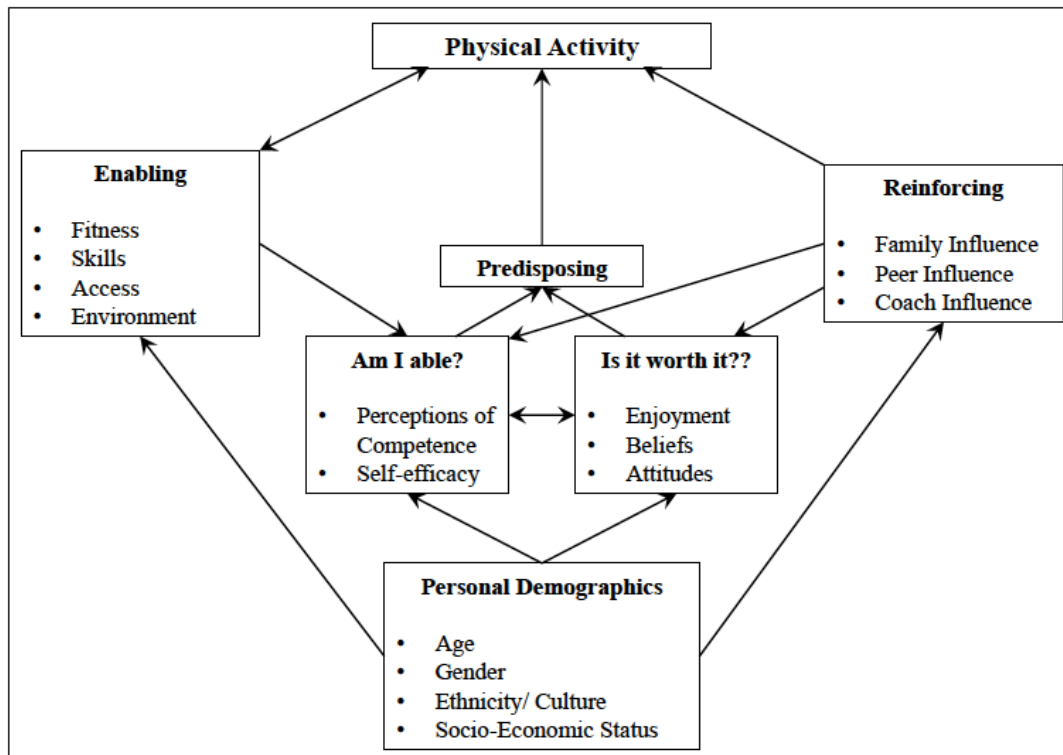


Figure 1. Conceptual schematic of the Youth Physical Activity Model (YPAP-M) (Welk, 1999)

Predisposing factors include variables that collectively increase the likelihood that a child will be physically active on a regular basis (Welk, 1999). These factors are based on self-efficacy (Bandura, 1986), perceived competence (Deci & Ryan, 1985; Harter, 1978) perceived behavioural control (Ajzen, 1985) and facilitating conditions (Triandis, 1977), and are reduced to two fundamental questions: Is it worth it? And Am I able to? (Welk, 1999). The first question refers to benefits and costs of physical activity and includes cognitive and affective components, whilst the second refers to perceived competence (Welk, 1999). Reinforcing factors include variables that reinforce children’s physical activity behaviours, and include parents/guardians facilitating and encouraging their child to be physically active (Welk, 1999). Enabling factors include variables that allow children to be physically active, and consist of biological/physiological factors such as movement skills/physical competence, health-related fitness, as well as, environmental attributes and access factors (Welk, 1999). Demographic factors are the individual differences that have been shown to have an influence on physical activity (e.g. age, sex, ethnicity and socio-economic status) (Welk, 1999). Overall, the YPAP-M provides an integrated framework for understanding the factors that influence physical activity.

Research has shown that there are numerous applications of ecological models (Glanz, Rimer, & Viswanath, 2008). These models provide a valid theoretical or causal framework of potential influencing factors on health-related behaviours or outcomes and are useful in emphasising social and psychological influences and environmental contexts (Glanz et al., 2008). As such, the PRECEDE-PROCEED and the YPAP-M approaches can be used as a guide to characterise various influences on any behaviour or outcome related to children and young peoples' health, growth and development. The construction of an ecological model/framework using these approaches can then lead to future interventions and programmes targeted to the specific behaviour or outcome.

Aspects of the PRECEDE-PROCESS model and YPAP-M are utilised in Study 1 to produce a comprehensive and structured assessment of needs and barriers to a healthy behaviour (physical activity behaviours vs. sedentary behaviours) or outcomes (physical fitness, physical competence) through a range of social, behavioural, physical and environmental factors. The YPAP-M was also considered and altered in Study 5 to produce a framework to improve the physical competency levels in children, and to quantify the relationships between socio-ecological factors and physical competence to inform future intervention strategies.

2.5 Monitoring Physical Activity

Physical activity is multi-dimensional, complex behaviour, characterised by its frequency, intensity, and duration (Department of Health, 2011; World Health Organization, 2018b). There are different types of activity that contribute to overall physical activity and these occur in a multitude of settings, for example; occupational (e.g. work-related, school-related/PE), household (e.g. domestic cleaning, caregiving, chores), transport (e.g. cycling/walking to school or work), leisure-time activities (e.g. dancing, active play), and organised sport participation (Department of Health, 2011; World Health Organization, 2018a). Physical activity (and its alternate sedentary behaviour) is therefore notably difficult to assess (Dugdill & Stratton, 2009). Most research has attempted to quantify physical activity, although there is no single method that captures the complete range of physical activity characteristics. Few studies have succeeded in capturing temporal data on both the quantity and quality of physical activity.

The gold standard measures of physical activity are those that acquire objective data (Hallal et al., 2012; Sherar et al., 2011). Objective data can be obtained by use of accelerometers, pedometers, heart-rate telemeters or electronic motion sensors (dou-

bly labelled water, actiheart) (Hallal et al., 2012; Lubans, Smith, Harries, Barnett, & Faigenbaum, 2014; Sherar et al., 2011). Although objective measures are the desired measures of physical activity, achieving a population sample with any of these measures can be extremely costly and very time consuming for both participants and staff. Also, most objective measures do not distinguish between different domains of physical activity (e.g., active transport, sport participation). Therefore, the 2012 and 2016 *Lancet* series on Physical Activity (Hallal et al., 2012; Kohl et al., 2012; Sallis et al., 2016), advocated that “optimal physical activity monitoring and surveillance should focus on physical activity levels and behaviours, their determinants and outcomes, and indicators of proven and promising solutions to address low physical activity in various segments of the population”. Specifically, it is suggested that measuring overall physical activity is not adequate for policy and intervention development (Hallal et al., 2012; Kohl et al., 2012; Sallis et al., 2016). Instead, trends in physical activity across multiple domains should be monitored at the individual, social, environmental, and societal levels (Hallal et al., 2012; Kohl et al., 2012; Sallis et al., 2016). The monitoring of levels and surveillance of trends in physical activity behaviours and influences on physical activity were incorporated in Study 1, which sought to consolidate and translate research related to physical activity among children and young people in Wales.

2.6 Product/Outcome Measure of Physical Activity - Physical Fitness

Physical fitness is “the capacity to perform physical activity or physical exercise, and refers to a full range of physiological and psychological qualities” (Janssen & Leblanc, 2010; Ortega et al., 2008; Ruiz, Castro-Piñero, et al., 2009; Ruiz et al., 2011). Physical activity and physical fitness are closely associated, with physical fitness mainly, but not completely, determined by physical activity levels (Blair et al., 2001). Genetic contributions to physical fitness are important, but account for less of the variation observed in physical fitness than is due to environmental factors, predominantly physical activity (Blair et al., 2001; Bouchard & Pérusse, 1994). Therefore, physical activity is one of the main antecedents of physical fitness, and recent reviews have shown that regular moderate and vigorous levels of physical activity increased levels of physical fitness (Janssen & Leblanc, 2010; Poitras et al., 2016).

Physical fitness is multidimensional and refers to two goals: performance, which consists of six skill-related fitness components, and health that includes five health-related

fitness components, each of which contributes to total quality of life (Bouchard & Shephard, 1994; Corbin, Welk, Corbin, & Welk, 2006). It is understood that physical fitness is an integrated measure of all body functions and structures, including, skeletomuscular, cardiorespiratory, haematocirculatory, psychoneurological and endocrine-metabolic, that are involved in the performance of daily physical activity and/or physical exercise (Ortega et al., 2008; Ruiz, Castro-Piñero, et al., 2009; Ruiz et al., 2011). Therefore, when physical fitness is assessed, the functional status of all these systems are also being tested (Ortega et al., 2008). For this reason, physical fitness is now considered one of the most powerful markers of health, both, in childhood and in adulthood (Ortega et al., 2008; Ruiz, Castro-Piñero, et al., 2009; Ruiz et al., 2011; Tomkinson, Carver, et al., 2017), independent of physical activity (Blaes et al., 2011; Ekelund et al., 2007). In fact, physical fitness has been shown to be a stronger marker/predictor of health than physical activity (Andersen et al., 2011). Physical fitness tracks moderately well from childhood through to adulthood (Andersen, Hasselstrøm, Grønfeldt, Hansen, & Karsten, 2004; Cleland, Ball, Magnussen, Dwyer, & Venn, 2009; Kristensen et al., 2006; Ortega et al., 2008; Twisk, Kemper, & Van Mechelen, 2009). Low levels of physical fitness in children and young people are significantly associated with increased risk of cardio-metabolic diseases (Dwyer et al., 2009; Ortega et al., 2008; Ortega, Silventoinen, Tynelius, & Rasmussen, 2012) and obesity (Ortega et al., 2011), reduced quality of life (Morales et al., 2013) and poorer skeletal (Moliner-Urdiales et al., 2010) and mental health (Ruiz, Castro-Piñero, et al., 2009), later in life. In addition to health associations, these fitness measures are also associated with the acquisition of skills essential to physical activity and sporting success (Armstrong et al., 2011; Ceschia et al., 2016). Therefore, identifying differences in fitness levels among school children is important in the surveillance of health, as well as, for monitoring the growth and development of children.

Health-related fitness are components of physical fitness that are specifically associated with health outcomes, e.g. cardiorespiratory fitness, muscular fitness/strength, and body composition (Bouchard & Shephard, 1994; Ruiz et al., 2011). These health-related components of fitness can be objectively and accurately measured using laboratory methods, although the application of these laboratory measures in a school-based setting is limited due to the need for sophisticated equipment, highly trained technicians and time constraints (Artero, Espaa-Romero, et al., 2011; Castro-Piñero et al., 2010; Ruiz, Castro-Piñero, et al., 2009). Field-based measures provide a reasonable alternative, as they are time- and cost-efficient, require minimal equipment and can be easily administered to many participants simultaneously, in a school based

setting, and for population-based studies (Artero, Espaa-Romero, et al., 2011; Castro-Piñero et al., 2010; Ruiz, Castro-Piñero, et al., 2009). Over the past two decades, there are numerous field-based test batteries that have been developed to assess health-related fitness in children and young people populations (Castro-Piñero et al., 2010). Three of the most well-known tests used in children and young people are: i) the FITNESSGRAM Test Battery in the USA (Plowman & Meredith, 2013), ii) the EUROFIT Test Battery (Council of Europe, 1993), and iii) the Assessing Levels of Physical Activity (ALPHA) Health-related Fitness Test Battery in Europe (Ruiz et al., 2011), all of which provide a set of valid, reliable, feasible and safe field-based tests for the assessment of health-related fitness in children and young people (Castro-Piñero et al., 2010).

2.6.1 Cardiorespiratory Fitness

The most frequently evaluated health-related fitness component is cardiorespiratory fitness (CRF) (Tomkinson, Lang, Tremblay, et al., 2017). Cardiorespiratory fitness, also called cardiovascular fitness, cardiorespiratory endurance or maximal aerobic power, is the overall capacity of the cardiovascular and respiratory systems to transport oxygen to the skeletal muscles and to utilise it to generate energy to support muscle activity during prolonged strenuous dynamic exercise (Armstrong et al., 2011; Artero, Ruiz, et al., 2011; Castro-Piñero et al., 2010; Ruiz, Castro-Piñero, et al., 2009; Tomkinson, Lang, Tremblay, et al., 2017). In children and young people, CRF is a predictor of cardiovascular disease risk factors such as, abnormal blood lipids, high blood pressure and overall and central adiposity, as well as, metabolic syndrome and arterial stiffness, cancer and mental health, later in life (Ortega et al., 2008; Ruiz, Castro-Piñero, et al., 2009). Furthermore, there is evidence of an interaction between CRF and adiposity, suggesting that high levels of CRF may reduce the effects of being overweight or obese in children and young people (Eisenmann et al., 2005; Jakicic & Davis, 2011; McAuley & Blair, 2011). Cardiorespiratory fitness is a product of vigorous physical activity (Ortega et al., 2008), therefore measuring CRF provides insight into the levels of children's physical activity, as well as the capabilities of several bodily systems that are involved in the performance of physical activity and exercise (Ortega et al., 2008; Tomkinson, Lang, Tremblay, et al., 2017). In addition, CRF tracks from childhood through to adulthood moderately well (Malina, 2001; Ortega et al., 2013), showing that the measurement of CRF in children provides information into current and future health.

Maximal oxygen consumption (VO_{2max}) obtained through a graded maximal exercise

to voluntary exhaustion test, is considered as the single best indicator of CRF (Shepherd et al., 1968). The most common worldwide field-based assessment and estimate of CRF in children and young people is the 20m multistage shuttle run test (20m MSRT) (Olds, Tomkinson, Léger, & Cazorla, 2006; Tomkinson, Lang, Tremblay, et al., 2017; Tomkinson, Léger, Olds, & Cazorla, 2003; Tomkinson & Olds, 2007, 2008). This test has been shown to be an excellent population-based surveillance and monitoring tool as it is time-, cost- and labour-efficient through its ability to test multiple individuals simultaneously with minimal equipment and across different testing locations (indoors, outdoors, smaller spaces) (Melo et al., 2011; Ruiz, Silva, et al., 2009; Tomkinson & Olds, 2008). Further, the 20m MSRT has been shown to display good validity and reliability (Tomkinson & Olds, 2008), and VO_{2max} can be estimated from the score obtained in the 20m MSRT with use of certain equations (Léger, Mercier, Gadoury, & Lambert, 1988).

Levels of cardiorespiratory fitness in children and young people, have declined globally as well as in the UK (England) in recent years (Boddy, Fairclough, Atkinson, & Stratton, 2012; Sandercock, Voss, McConnell, & Rayner, 2010; Stratton et al., 2007; Tomkinson, Lang, & Tremblay, 2017; Tomkinson et al., 2003; Tomkinson & Olds, 2007). Boddy et al. (2012), investigated changes in CRF from 1998 to 2010 using *SportsLinx* data on 9-11 year old children from England. Findings from the study identified a significant decline in CRF over time from 1998 to 2010, with all boys in cohorts 2000-2010 and girls in cohorts 2003-2010 having significantly lower CRF than baseline (1998), regardless of weight status (Boddy et al., 2012). The study also reported that the observed mean declines in CRF of 1.34% for boys and 2.29% in girls were greater than those reported globally (Boddy et al., 2012; Tomkinson et al., 2003). Tomkinson et al. (2017), examined global trends in CRF in children and young people aged 9-17 years from 19 high-income and upper middle-income countries between 1981 and 2014. The analysis indicated that since 1981 there was a considerable international decline of -7.3% in CRF, but only negligible changes were apparent since 2000 (Tomkinson, Lang, & Tremblay, 2017). This study also identified that although most countries displayed a decline in CRF (-3.6% pre-2000, -0.9% post-2000), the rate and pattern of change varied across countries, however the declines in CRF were consistently larger for boys than girls (boys: -4.2% pre-2000, -1.4% post-2000; girls: -3.0% pre-2000; -0.6%, post-2000) (Tomkinson, Lang, & Tremblay, 2017). As low CRF is significantly associated with key determinants of health (Ortega et al., 2008; Ruiz, Castro-Piñero, et al., 2009), these reported declines are suggestive of declines in population health. Therefore, continued monitoring and insight is needed to inform

interventions, programmes and policies is encouraged.

2.6.2 Muscular Strength

Muscular strength refers to the ability of a specific muscle or muscle group to generate maximum force against a resistance in a single contraction (Bouchard & Shephard, 1994; Corbin et al., 2006; Ortega et al., 2008; Ruiz et al., 2006). Muscular strength is an important aspect of fitness and health status, as well as, provides a marker of vigorous intensity physical activities, including those that strengthen muscle and bone. A decrease of muscular strength may cause significant functional limitations (Wind, Takken, Helder, & Engelbert, 2010). In children and young people, increased muscular strength has been associated with reductions in total and central adiposity and cardiovascular risk factors, and increases in bone health, self-esteem and perceived competence (Smith et al., 2014). In adults, emerging evidence suggests that handgrip strength is a strong predictor of all-cause mortality, morbidity, and the expectancy of being able to live independently (García-Hermoso et al., 2018; Metter, Talbot, Schrager, & Conwit, 2002). Consequently, more attention is now being given to assessing muscular strength in children, as a predictor of health outcomes and all-cause mortality (Cohen et al., 2011; De Miguel-Etayo et al., 2014; Moliner-Urdiales et al., 2010; Ruiz, Castro-Piñero, et al., 2009; Silverman, 2011; Tremblay, Shields, et al., 2010).

As the generation of maximum force is determined by several factors (e.g. the number and size of muscles, the proportion of muscle fibres, the coordination of the muscle groups), there is no single test for measuring overall muscle strength (Ortega et al., 2008). However, the handgrip strength test is one of the most used tests for assessing muscular strength in experimental and epidemiological studies (Cohen et al., 2011; De Miguel-Etayo et al., 2014; Moliner-Urdiales et al., 2010; Ruiz, Castro-Piñero, et al., 2009; Silverman, 2011; Tremblay, Shields, et al., 2010). Handgrip strength refers to the maximal isometric force that can be mainly generated by the hand and forearm muscles involved (Ruiz et al., 2006). The handgrip strength test is a simple and economical test that gives practical information on muscle, nerve, bone or joint disorders (Ortega et al., 2008; Ruiz et al., 2011, 2006). Moreover, the handgrip strength test is correlated with many other measures of strength and is therefore a good indicator of total muscular strength (Wind et al., 2010). Studies on grip strength as a measure of muscular strength have revealed its direct associations with chronic diseases, multi-morbidity and premature mortality (Cheung, Nguyen, Au, Tan, & Kung, 2013; Metter et al., 2002; Ortega et al., 2008; Ruiz, Castro-Piñero, et al., 2009; Volaklis et

al., 2015).

Akin to levels of CRF, levels of muscular strength in children and young people, have declined globally as well as in the UK (England) in recent years (Cohen et al., 2011; Moliner-Urdiales et al., 2010; Silverman, 2011; Tremblay, Shields, et al., 2010). A study on Canadian children (Tremblay, Shields, et al., 2010) comparing data on 8-10 year olds between 1981 and 2007-2009, and a study on Spanish adolescents (Moliner-Urdiales et al., 2010) between 2001/02 and 2006/07, both showed declines in grip strength. Further, a study in England, on 10-year old English children, also found a decline in grip strength over a 10-year secular trend from 1998 to 2008 (Cohen et al., 2011). These results may reflect that activities that produce high physical stresses on the bones to improve bone health and muscle strength are not being incorporated on at least three days per week, as per the vigorous intensity physical activities guidelines for children (Department of Health, 2011). As low muscular strength is significantly associated with key determinants of health (Cheung et al., 2013; Metter et al., 2002; Ortega et al., 2008; Ruiz, Castro-Piñero, et al., 2009; Volaklis et al., 2015), these reported declines are indicative of declines in children's health.

2.6.3 Body Mass Index

Reviews of existing field-based tests reported that most physical fitness test batteries for children and young people incorporated body composition, specifically body mass index (BMI), as a component of health-related fitness (Artero, Espaa-Romero, et al., 2011; Castro-Piñero et al., 2010). Body mass index, based on height and weight, is used in many studies that assess paediatric overweight and obesity, as a proxy measure of body size and body fatness, and represents a practical method of assessment in large-scale studies (Artero, Espaa-Romero, et al., 2011; Boddy, Hackett, & Stratton, 2009, 2010; Castro-Piñero et al., 2010; Olds et al., 2011; Stratton et al., 2007; van Jaarsveld & Gulliford, 2015). BMI assessment in children is more complex than in adults as a child's BMI changes with age, and growth patterns differ between sexes (Dinsdale, Ridler, & Ells, 2011). As such, BMI thresholds are often defined using z-scores which indicate how many units of the standard deviation the BMI is above or below the average BMI for that age group and sex (Dinsdale et al., 2011). Children with high BMI z-score and classified as overweight or obese (Cole, Bellizzi, Flegal, & Dietz, 2000), are at risk of developing a number of obesity-related conditions (Reilly et al., 2003), including type 2 diabetes (Haines, Wan, Lynn, Barret, & Shield, 2007), metabolic and cardiovascular complications (Cote, Harris, Panagiotopoulos, Sandor, & Devlin, 2013; L'Allemand-Jander, 2010) and mental health disorders (Griffiths et

al., 2010). It is well documented that childhood obesity continues into adolescence and adulthood (Park, Falconer, Viner, & Kinra, 2012), and having a high BMI in childhood and adolescence may increase the risk of death later in life (Ruiz, Castro-Piñero, et al., 2009). An increased BMI is also associated with lower performance abilities limiting development, which directly affects the capacity of children to acquire skills associated with physical activities (Ceschia et al., 2016). High BMI, and overweight and obesity, ascends from a mismatch between energy intake and energy expenditure, resulting in an accumulation of energy stores, mainly as fat, in the body (Ceschia et al., 2016). Overweight and obesity is associated with a reduction in physical activity levels (Tremblay et al., 2011), and changes in food habits towards high-energy food consumption (Flatt, 2001), as well as, an increase in overall energy intake (Livingstone, 2000). There is compelling evidence that increased physical activity in children is associated with a reduced risk of being overweight or obese (Janz et al., 2009; Moore et al., 2003; Ortega et al., 2011).

Globally the prevalence of overweight and obesity has more than doubled between 1980 and 2014 (World Health Organization, 2018b). However, the prevalence of overweight and obesity varies depending on age, ethnicity, and geographic region. The number of children in Wales classified as overweight and obese represent serious public health problems, with Wales being reported to have the highest rates of childhood obesity in the UK (National Obesity Observatory, 2015). A review presenting a vast amount of data from nine countries (Australia, China, England, France, Netherlands, New Zealand, Sweden, Switzerland and USA) suggested that the rise in the prevalence of overweight and obesity in children aged 2-19 years old has slowed appreciably, or even plateaued, and in some countries slightly decreased (Olds et al., 2011). Specifically, in England, results displayed a plateau in prevalence of overweight or obesity since 2005 (Olds et al., 2011). Further to this, studies in England on 9-11 year old school children (Boddy et al., 2009; Boddy, Hackett, et al., 2010; Stratton et al., 2007), using the *SportsLinx* project's data archives, have described an initial increase in BMI and prevalence of overweight and obesity from 1998 to 2003/4 (Stratton et al., 2007), then a slowing in the year-on-year increase between 2004 to 2006 (Boddy et al., 2009), and confirmed the levelling off in BMI and prevalence between 2005-2008 (Boddy, Hackett, et al., 2010). In fact, the latest data showed a slight decrease in overweight and obesity prevalence in girls. Regardless of these findings (Boddy et al., 2009; Boddy, Hackett, et al., 2010; Olds et al., 2011; Stratton et al., 2007; van Jaarsveld & Gulliford, 2015), the presented levels of overweight and obesity are still high. Therefore, continued investment to promote and monitor health-

related fitness, including body mass index, in children and young people is needed.

Given that investigation into the levels and analysis of trends and inequalities in health-related fitness was warranted, Study 2 aimed to highlight the secular changes in selected health and fitness measures in school children in Wales. In addition, while Study 2 displayed new findings in terms of secular changes in health-related fitness, analyses of inequalities in health-related fitness to predict inequalities in health outcomes were also needed. The aim of Study 3, therefore, was to investigate socioeconomic and sex differences in selected health-related fitness measures in school children in Wales.

2.6.4 Biological Maturation

Biological maturation refers to the progression towards the mature (adult) state and varies in timing and tempo (Malina, Bouchard, & Bar-Or, 2004). It is a process that occurs in all bodily tissues, organs and systems. Significant inter-individual differences exist for the timing, status/level, and tempo of biological maturation (Beunen, Rogol, & Malina, 2006; Malina et al., 2004; Malina, Rogol, Cumming, Silva, & Figueiredo, 2015). The timing of biological maturation is defined as the onset of change, or the time when a given maturational event occurs (e.g., growth spurt period, age at menarche); the status/level refers to the magnitude of change or level of maturation at a given chronological age; and tempo denotes the rate of change (Beunen et al., 2006; Malina et al., 2004). These variables are measured and/or observed to provide an indication of a child's progress towards maturity (mature/adult state). Children can be classified as biologically ahead of their chronological age (early-maturing), biologically in line with their chronological age (on-time), or biologically behind their chronological age (late-maturing) (Beunen et al., 2006; Lloyd, Oliver, Faigenbaum, & Myer, 2014; Malina et al., 2004). This inter-individual variation in biological maturation has an influence on growth, motor performance, and physical fitness (Beunen et al., 2006; Malina et al., 2004), and is an important covariate of the relationships between physical activity, physical fitness, unhealthy/healthy behaviours, body composition, and cardiometabolic risk (Andersen et al., 2006; Katzmarzyk et al., 2012; Malina et al., 2004; Malina & Koziel, 2014; Sherar, Cumming, Eisenmann, & Malina, 2010). Therefore, it is necessary for research studies in children to attempt to control/adjust for biological maturation when feasible.

In children, the status/level and timing of biological maturation are assessed using common methods such as pubertal staging (e.g. Tanner), skeletal age, age at menar-

che, percentage of adult height, and age at peak height velocity (Beunen et al., 2006; Malina et al., 2004; Malina, Silva, Figueiredo, Carling, & Beunen, 2012). Due to concerns regarding the invasiveness and the logistical/feasibility challenges of methods (Beunen et al., 2006; Malina et al., 2004), simple non-invasive methods to measure biological maturation have been recommended (Mirwald, Baxter-Jones, Bailey, & Beunen, 2002). Further, longitudinal data obtained across a period from childhood through to adolescence is required to estimate actual age at peak height velocity. However, this serial longitudinal data is often unavailable. Therefore, the prediction of age at peak height velocity using sex-specific regression equations provides a non-invasive method of assessing biological maturation with the use of one-time anthropometric measures (Mirwald et al., 2002). These equations provide a prediction of years from age at peak height velocity (maturity offset) and are calculated on the known differential timings of growth in height, sitting height and leg length (Mirwald et al., 2002). The maturity offset equations have been widely utilised to define maturity groups and used as a covariate or predictor of physical activity, physical fitness, motor performance, body composition (Andersen et al., 2006; Katzmarzyk et al., 2012; Malina et al., 2004, 2012, 2015; Malina & Koziel, 2014; Sherar et al., 2010). Thus, the application of these prediction equations are included wherever possible in the analyses of this thesis.

2.7 Product/Outcome Measure of Physical Activity - Physical Literacy/ Physical Competence

The International Physical Literacy Association defines physical literacy (PL) as the motivation, confidence, physical competence, knowledge and understanding to value and take responsibility for engagement in physical activities for life (International Physical Literacy Association, 2016). Such a definition describes the multidimensional and complex nature of PL, highlighting the purported importance of PL as a precursor to physical activity, as well as, being developed through physical activity itself (Edwards et al., 2016). Therefore, given that physical activity has been shown to result in numerous health benefits (Jurbala, 2015), it could be postulated that the promotion of PL is fundamental for physical activity associated health benefits. One of the key elements of PL is physical competence. Much research has looked at physical competence as being the key aspect of physical literacy that is the driving force behind the other aspects of physical literacy and for increasing physical activity participation (Barnett, Lai, et al., 2016; Edwards et al., 2016; Hulteen et al., 2018; Robinson et al., 2015; Stodden et al., 2008; Whitehead, 2010). Therefore, apart from the physical fit-

ness of children and young people, the development of their motor skills and physical competence should be viewed as an additional and independent physiological factor related to physical activity that requires specific analyses (Guinhouya, 2012).

Physical competence, as a global term relating to the development and performance of human movement, represents an individual's ability to perform skilfully on a wide range of motor tasks, as well as, the movement quality, coordination, and control, underlying a motor outcome (Haywood & Getchell, 2014; Robinson et al., 2015; Stodden et al., 2008). Physical competence includes not only the acquisition of health- and skill-related components of fitness (e.g. cardiorespiratory fitness, strength, flexibility, agility, balance, coordination, power, reactions and speed), but also movement skills, and plays an important role in the growth and development of children (Barnett, Lai, et al., 2016; Clark & Metcalfe, 2002; Gallahue et al., 2012; Hulteen et al., 2018; Robinson et al., 2015; Stodden et al., 2008; Whitehead, 2010). In addition, Whitehead (2010), describes physical competence as "the sufficiency in movement vocabulary, movement capacities and developed movement patterns plus the deployment of these in a range of movement forms." Therefore, even within itself, physical competence is a multidimensional concept. Specifically, movement vocabulary refers to the repertoire of movements that can be performed, and can be expanded through experience and progressive challenge in the deployment of a wide range of movement capacities/skills and movement patterns (Whitehead, 2010). Movement capacities are the integral abilities that make it possible to improve and develop physical competence (Whitehead, 2010). These capacities or skills consist of three interrelated constructs: fundamental or simple movement skills (FMS) (balance, core stability, coordination, speed variation, flexibility, control, proprioception, and power), combined movement (poise, fluency, precision, dexterity, and equilibrium), and complex movement (bilateral coordination, inter-limb coordination, hand-eye coordination, turning, twisting and rhythmic movements, and control of acceleration/deceleration) (Clark & Metcalfe, 2002; Gallahue et al., 2012; Giblin, Collins, & Button, 2014; Whitehead, 2010).

The first of these three constructs, fundamental movement skills (FMS), comprise locomotor skills (moving the body in any direction from one point to another), stability skills (balancing the body in one place or while in motion), and object control/manipulative skills (handling or controlling objects with the hand, foot, or an implement) (Gallahue et al., 2012; Giblin et al., 2014; Whitehead, 2010). Although many studies show a weak association between FMS competence and physical activity in young children, this relationship has been shown to strengthen with age (Lubans

et al., 2010; Robinson et al., 2015; Stodden et al., 2008). Moreover, younger children are more likely to continue to be physically active despite their FMS competence levels, however, older children lacking FMS competence are less likely to demonstrate an active lifestyle (Lloyd, Saunders, Bremer, & Tremblay, 2014; Lubans et al., 2010; Stodden et al., 2008). Higher levels of FMS competence have also been shown to have a positive relationship with cardiorespiratory fitness (Vlahov, Baghurst, & Mwavita, 2014), improved academic performance (Jaakkola, Hillman, Kalaja, & Liukkonen, 2015), and perceived competence and confidence levels (Stodden et al., 2008), whilst having a negative relationship with unhealthy weight status (Rodrigues, Stodden, & Lopes, 2015). Therefore, many studies indicate that the development and mastery of these foundation skills during childhood, forms a platform for physical competence, and causes a positive trajectory toward physical and psychological health, and sustained physical activity/sporting behaviours, in both the short and long term (Cattuzzo et al., 2016; Lloyd et al., 2014; Lubans et al., 2010; Robinson et al., 2015; Stodden et al., 2008; Van der Fels et al., 2015). The general consensus is that children have the potential to master FMS by 7-8 years of age, with a window of opportunity and FMS developing rapidly between 3 and 8 years of age (Clark & Metcalfe, 2002; Gallahue et al., 2012). However, development of FMS competence is only the foundation for the acquisition of combined and complex movement competence. While the importance of the acquisition of FMS in relation to an active lifestyle is well-documented, the development of combined and complex movement skills is needed to take part in more advanced physical and sporting activities (Corbin, 2016; Giblin et al., 2014).

The procurement of movement skills and the ability to utilise them to produce movement patterns is essential for the development of physical competence within physical literacy capability (Whitehead, 2010). Movement patterns, described as general (e.g., sending, striking, receiving, running, jumping, rotating), refined (e.g., throwing, dribbling, catching, sprinting, hopping, turning) and specific (i.e. sport-specific movement patterns), are amalgamations of movement that stem from the selection and application of movement skills (Clark & Metcalfe, 2002; Gallahue et al., 2012; Whitehead, 2010). More refined and specific movement patterns are achieved when FMS, combined and complex movement skills are utilised simultaneously (Clark & Metcalfe, 2002; Corbin, 2016; Gallahue et al., 2012; Giblin et al., 2014; Whitehead, 2010). There is therefore much need to develop combined and complex movement skills, to take part in more advanced physical activities in a variety of settings (i.e., land, water, air, ice) (Jurbala, 2015; Whitehead, 2010) and movement forms (i.e., adventure, aesthetic, athletic, competitive, fitness and health, interactional/relational) (Whitehead,

2010), and thus this development is speculated to be imperative to increasing levels of physical competence and physical literacy in maturing children (Clark & Metcalfe, 2002; Corbin, 2016; Gallahue et al., 2012; Giblin et al., 2014; Tyler et al., 2018; Whitehead, 2010).

Overall, there is a vast array of evidence identifying physical competence as an important component of physical literacy, and, as such, a critical precursor for increasing positive health trajectories, particularly physical activity, across the lifespan (Barnett, Lai, et al., 2016; Edwards et al., 2016; Hulteen et al., 2018; Robinson et al., 2015; Stodden et al., 2008; Whitehead, 2010). Specifically, systematic reviews and longitudinal studies have reported strong evidence for positive associations between physical competence and physical activity levels (Barnett et al., 2009; Holfelder & Schott, 2014; Lopes et al., 2011; Lubans et al., 2010), health-related fitness (Barnett, van Beurden, et al., 2008; Cattuzzo et al., 2016; Robinson et al., 2015) and perceived competence (Lubans et al., 2010; Robinson et al., 2015), as well as an inverse association with weight status (D'Hondt et al., 2014; Lubans et al., 2010; Robinson et al., 2015), in paediatric populations. Furthermore, studies have shown that enhanced physical competence during childhood tracks across the lifespan by leading to higher levels of physical activity and health-related fitness during adolescence (Barnett et al., 2009; Barnett, van Beurden, et al., 2008; Lopes et al., 2011; Robinson et al., 2015), and by supporting functional independence, general health and quality of life in later life, as well as reducing the risk of all-cause mortality (Hulteen et al., 2018; Paterson & Warburton, 2010; Sigmundsson et al., 2016). Thus, enhanced physical competence in children and young people is foundational for physical activity promotion and associated health benefits, with transferable value throughout the life course.

As physical literacy has been highlighted as an important precursor of physical activity, with physical competence being a critical factor in enhancing physical literacy, continued investment into developing physical competence in children is required. As such, Study 5 aimed to quantify the relationships between socio-ecological factors and physical competence to inform future intervention strategies that aim to promote physical competence in children and young people.

2.7.1 Measurement of Physical Competence

The distinct discipline of motor development (physical competence) gained widespread attention in the 1970s, with an emphasis being placed on the development of various assessments in the decades to follow (Cattuzzo et al., 2016). Nonetheless, developing

an accurate assessment is still one of the primary themes related to physical competence found in the literature, evidencing the complexity of this task and showing that significant gaps exist in established assessments (Lundvall, 2015). There is a need to develop valid tools that effectively and efficiently assess physical competence in order to evaluate whether programmes are successful (Corbin, 2016). Physical competence can be evaluated by process- or product-based assessments (Bruininks & Bruininks, 2005; Cairney et al., 2018; Henderson et al., 2007; Physical and Health Education Canada (PHE Canada), 2014; Ulrich, 2000). Primarily process-based assessments (e.g., the Test of Gross Motor Development (TGMD-2), CS4L: Physical Literacy Assessment for Youth Fun (PLAYfun), Passport for Life: Movement Skills Assessment) measure how children move and provide qualitative information on the technique of the movement patterns (Hardy, King, Farrell, Macniven, & Howlett, 2010). This type of assessment can be sensitive to assessor experience and subjectivity (Schoemaker, Niemeijer, Flapper, & Smits-Engelsman, 2012). On the other hand, assessments that are primarily product-based (e.g., the Movement Assessment Battery for Children-2 (MABC-2), the Bruininks-Oseretsky Test of Motor Proficiency, Second Edition (BOT-2)) are usually quantitative and focus on the outcome of the movement (Logan, Barnett, Goodway, & Stodden, 2017), but potentially lack the sensitivity needed to identify individual differences in movement abilities (Giblin et al., 2014). The equivocal relationship between process- and product-based assessments of physical competence has resulted in the use of combined assessments for measuring physical competence (Logan et al., 2017; Robinson et al., 2015; Rudd et al., 2016). The assessment of physical competence can be formative or summative. Specifically, formative assessments measure current levels of performance to identify a baseline and the individual needs of children, enabling the development of an educational programme catered to those children, whereas summative assessments are used to measure progress of a child at the end of a period of education (Gallahue & Donnelly, 2007).

Most existing land-based movement skill assessments involve the performance of discrete skills in isolation (e.g., TGMD-2/3 (Ulrich, 2000), BOT-2 (Bruininks & Bruininks, 2005), MABC-2 (Henderson et al., 2007), CS4L: PLAYfun (Cairney et al., 2018), Passport for Life: Movement Skills Assessment (Physical and Health Education Canada (PHE Canada), 2014)). Balancing, running, hopping, jumping, throwing, dribbling, catching and sprinting are common skills that are assessed within these existing movement skill assessment tools (Bruininks & Bruininks, 2005; Gallahue et al., 2012; Henderson et al., 2007; NSW Department of Education and Training, 2000;

Ulrich, 2000). This static testing environment limits transferability and applicability to multi-skill and sport environments and does not assess combined and complex movement skills (Giblin et al., 2014). It has been suggested that considering skills in isolation ignores a constraints-based approach (Newell, 1986), in which environmental constraints are taken into account, and by doing so this approach is not ‘authentic’. An authentic environment is one that is developmentally-appropriate and considers the interaction of the individual and the environment, as well as the specified movement skill (Barnett, Stodden, et al., 2016; Newell, 1986). Performance of movement skills in isolation does not incorporate the measurement of an individuals’ ability to alter and combine movement skills according to the task at hand and the environment, both of which are important traits to advance physical competence and progress one’s physical literacy (Whitehead, 2010). Finally, assessments that measure skills in isolation have also been criticised for being time- and resource-intensive (Giblin et al., 2014; Wiart & Darrah, 2001).

Recently, the Canadian Agility Movement Skill Assessment (CAMSA) was developed and validated to assess physical competence in 8-12-year-old children (Longmuir et al., 2017). This assessment requires a series of seven movement tasks (two-footed jump, side slide, catch, throw, skip, hop, and kick) to be completed in a continuous dynamic obstacle course to create a more authentic environment and to assess combined and complex movement skills. Performances are assessed using the time taken to complete an obstacle course consisting of 14 process/technique- and product/outcome-based criteria (Longmuir et al., 2017). This assessment has shaped the way towards assessing movement skills in a dynamic fashion. However, there are noteworthy design limitations of the CAMSA, and as such, an assessment targeting older aged children and adolescents (10-14 years), with a more balanced design, is warranted. Therefore, Study 4 aimed to develop and assess the validity and reliability of a more balanced dynamic assessment tool to measure physical competence in children and young people.

3 General methodology

The methods described in this chapter are the field-based methods of data collection common to the studies within this thesis. Detailed methods, sample sizes and statistical analyses specific to each study are presented in the relevant chapters and appendices.

3.1 Ethical Approval

Ethical approval for Studies 2-5 was granted with the guidelines and policies of the Swansea University College of Engineering Research Ethics and Governance Committee (REC numbers: PG14/2014/007; PG/2014/020; PG/2014/37; PG/2014/39). Information sheets were developed for children, parents/ guardians and school staff/ head teachers, and prior to study involvement, written informed parent/ guardian and school/ head teacher consent and child written assent was obtained (see Appendix XIII).

3.2 Instruments and Procedures

3.2.1 Swan-Linx Fitness Fun Day: Field-Based Fitness Measures

Fitness tests were taken from the EUROFIT fitness test battery (Council of Europe, 1993), and completed at a Fitness Fun Day using standard techniques (Taylor, Hackett, Stratton, & Lamb, 2004). The fitness tests reported in this chapter are those used in the thesis, but do not cover the full Fitness Fun Day measures. Further information on the full Fitness Fun Day measures, and the Standard Operating Procedures for administering the fitness measures are provided in Appendix II.

Appropriately trained and experienced Swansea City Council Active Young People Officers and Sports Science postgraduates led the Fitness Fun Day testing, with the help of undergraduate Sport and Exercise Science students and Sport Wales Young Ambassadors. Guides on each of the testing procedures were positioned at each testing station for reference. Prior to completing the tests, participants completed a warm up of 8-10 minutes and then assigned into groups. Groups then rotated around the testing stations. Due to the size of the testing facilities and variations in the number of children from each school (20-100 children), it was not possible to have all children complete the fitness tests in the same order.

Body Mass: Each participant's body mass was measured to the nearest 0.1kg using portable weighing scales [Seca 876, Hamburg, Germany]. Participants wore light, athletic clothing and removed their shoes, pull-overs (if wearing one) and anything in their pockets.

Stature: Participants removed footwear, looked straight ahead and kept their head level, while standing upright against a stadiometer [Seca 213 portable stadiometer, Hamburg, Germany]. The vertical distance between the floor and top of the skull was measured to the nearest 0.1cm.

Sitting Stature: Participants removed their footwear and sat on a sitting stature stadiometer [Harpenden Sitting Height Table, Holtain Ltd, Pembrokeshire, UK]. Participants' feet were positioned on a rung that supported their legs and allowed a right angle at the knee joint. Participants placed their hands on their legs, kept their head level and sat as straight and tall as possible. The vertical distance between the top of the skull and the base of the sitting surface was measured while the participants took a deep breath in.

Body Mass Index and Classification of Weight Status: Body Mass Index (BMI) was calculated ($BMI = \text{body mass (kg)} / \text{stature}^2 (\text{m}^2)$) and BMI z-scores were derived using the UK 1990 growth reference curves (Cole, Freeman, & Preece, 1995). Classification and prevalence of participants' being underweight, healthy weight, overweight or obese, were calculated using age and sex specific BMI cut-off points (Cole et al., 2000). Sex-specific maturation offset regression equations using interactions between body mass, stature, sitting stature, lower limb length and decimal age, were used to predict participants' age from peak height velocity (Mirwald et al., 2002). This calculation was used as a proxy measure of biological maturation.

20m Multistage Shuttle Run Test: The 20m Multistage Shuttle Run Test (20m MSRT) involved continuous running between two lines 20m apart, in time to recorded beeps from a CD. In line with a standardised lap scoring protocol of the 20m MSRT (Riddoch, 1990), the test score achieved by the participant was the number of shuttles completed before the subject either withdrew voluntarily from the test, or failed to reach the end line on two consecutive beeps. To ensure a consistent pace and to encourage participants to run to exhaustion, a researcher completed the test with the participants.

Handgrip Strength: Using hand dynamometers [Takei Corp Ltd., Tokyo, Japan], participants' handgrip strength was measured in kilograms. Participants held the dynamometer with their arm fully extended above their head and squeezed the dynamometer with maximum isometric effort for 5s, whilst bringing it down slowly towards their side.

3.2.2 Child Health and Activity Tool: Online Questionnaire

The Child Health and Activity Tool (CHAT) questionnaire, akin to the *SportsLinx Lifestyle Survey* (Taylor et al., 2004), was developed at Swansea University. The CHAT is an interactive, online questionnaire and is available in English and Welsh. The first section of the CHAT consists of questions that require children to recall what they did the previous day. The second section of the CHAT consists of asking how many times a week a child engaged in certain behaviours (e.g., how many times a week they were sedentary for >2hours). The third section includes general lifestyle questions. Participants completed the CHAT in a classroom or computer suite at school, supervised by teachers and 3-4 postgraduates or Active Young People Officers. A full paper copy of the questionnaire is shown in Appendix III and the Standard Operating Procedure for administering it is shown in Appendix IV.

3.2.3 The Dragon Challenge: Physical Competence Measure

The Dragon Challenge (DC) consists of nine tasks (Balance Bench, Core Agility, Wobble Spot, Overarm Throw, Basketball Dribble, Catch, Jumping Patterns, T-Agility, and Sprint), which require the application of a different combination of fundamental, combined and complex movement skills, to form refined and specific movement patterns. The order of the tasks is standardised, but the challenge is performed under the illusion that the order is random, except for the final task, which is always the sprint.

Participants observed a demonstration of each DC task and then the full DC. Participants were given two practice attempts at each challenge task, but they did not practise the challenge in full. One trained administrator then led the participants in the DC, while at least one trained assessor scored the participants in accordance with the instructions specified within the DC manual (see Appendix V). In particular, one point was given for each of the technical/process criterion and two points for each outcome/product criterion successfully demonstrated by participants. Time taken to complete the DC was also converted to a score (higher scores for faster time). Each of these constructs (technique, outcome, and time) was scored out of 18 in order to be equally weighted, and then summed to give a total score. For further information

on the DC assessment including equipment list, layout schematic, descriptions of the assessment and video resources, see Appendices V and VI.

3.3 Conclusion

This general methodology has outlined the methods shared by many of the studies in this thesis. Specific methods for each individual study will be discussed within the relevant chapter.

Thesis Map

	Study	Outcomes
1	Results from the Active Healthy Kids Wales 2016 Report Card on Physical Activity for Children and Youth	<p><i>Aim</i></p> <p>To consolidate and translate research related to physical activity among children and youth in Wales and to synthesise national surveillance data from several surveys in order to assign grades to physical activity/inactivity behaviours and influences indicators, as well as to examine trends or inequalities in the data.</p> <p><i>Key Findings</i></p>
2	Ten-year Secular Changes in Selected Health and Fitness Parameters of 10-11 Years Old Swansea School Children – 2003-2013	<p><i>Aim</i></p> <p><i>Key Findings</i></p>
3	A Cross-Sectional Study on the Socio-economic and Sex Differences in Health-Related Fitness Measures in School Children	<p><i>Aim</i></p> <p><i>Key Findings</i></p>
4	A Dynamic Assessment of Children's Physical Competence: The Dragon Challenge	<p><i>Aim</i></p> <p><i>Key Findings</i></p>
5	Youth Physical Competence Promotion Model: A Quantitative Investigation into Modifiable Factors	<p><i>Aim</i></p> <p><i>Key Findings</i></p>

4 Study 1

4.1 Results from the Active Healthy Kids Wales 2016 Report Card on Physical Activity for Children and Youth: “Is Wales Turning the Tide on Children’s Inactivity?”

* This chapter is a published manuscript:

Tyler, R., Mannello, M., Mattingley, R., Roberts, C., Sage, R., Taylor, S. R., . . . Stratton, G. (2016). Results From Wales’ 2016 Report Card on Physical Activity for Children and Youth: Is Wales Turning the Tide on Children’s Inactivity? *Journal of Physical Activity and Health*, 13(11 Suppl 2), S330-S336. <https://doi.org/10.1123/jpah.2016-0309>

4.2 Background

Wales has a population of approximately 3 million people of which ~702,600 are children and young people (0-19 years of age) (Statistics Wales, n.d.). The majority of children in Wales are insufficiently active leaving Wales in the bottom quartile globally for physical activity levels in school-aged children (Inchley et al., 2016). Inequalities in physical activity also exist: twice as many boys are sufficiently active as girls, physical activity levels decline with age, differences exist between ethnic groups and there is a social gradient where activity follows socio-economic status (Inchley et al., 2016). In addition, cardiorespiratory fitness levels of children in Wales are amongst the lowest in Europe (Tomkinson & Olds, 2007). Further, recent data found that less than half of 3000 9-11 year old children assessed achieved a healthy level of overall health-related fitness (Tyler, Mackintosh, Brophy, et al., 2015). In addition, obesity levels of children in Wales are the highest in the UK (Bailey, 2015) and amongst the highest globally (Inchley et al., 2016).

Conversely, Wales has a good record of supporting physical activity through policies and strategies. For example, Sport Wales have a mission to get “every child hooked on sport for life” (Sport Wales, n.d.-d), and support this with an emphasis on physical literacy through physical education and sport programming (Sport Wales, n.d.-a). In 2001 Wales was the first country to make statute article 31 of the United Nations Convention on the Rights of the Child (UNCRC) recognising the rights of children to play (“United Nations Convention on the Rights of Children - Rights - Children in Wales,” n.d.), and also the first country to have an Active Travel Act (“Active Travel (Wales) Act 2013,” 2013).

This is the second Active Healthy Kids (AHK) Wales Report Card following the inaugural 2014 version <http://www.swansea.ac.uk/activehealthykidswales/>. Swansea University coordinated the work, supported by a national network of academics and professionals from sport, play, transport, public health, sport and exercise science, and education sectors. These constituents formed the research working group (RWG).

The purpose of this manuscript is to summarise the findings of the AHK Wales 2016 Report Card. Data from a number of surveys collected from 2013 to 2015 were synthesised to assign grades to each quality indicator. Where available, data as far back as 2002 were used for the analysis of trends.

4.3 Methods

The RWG consisted of 11 members. The lead academic directed the development of the Report Card contents and RWG membership. The RWG comprised of the lead academic (Gareth Stratton), post-graduate researchers, academics, and professionals with expertise in physical activity and access to national data sources. The academic lead secured funding and outlined the programme of work. The lead post-graduate researcher (Richard Tyler) was responsible for data sourcing, synthesis and subsequent presentation to the RWG for interpretation, discussion and grading. The lead researcher was also responsible with the academic lead to produce the Report Card and web site materials. All members of the RWG collectively allocated grades to indicators. The methodology used was in accordance with the AHK Global Matrix (Tremblay et al., 2014) and was used in RWG meetings to evaluate the synthesised summary statistics, make informed decisions and assign grades.

Ten indicators were assessed, an additional two (school and physical literacy) to the eight included in the AHK Wales 2014 Report Card. School was added to be consistent with other countries and physical literacy, '*the motivation, confidence, physical competence, knowledge and understanding to value and take responsibility for engagement in physical activities for life*' (Weinberg, Talbot, & Whitehead, 2013), because of the emphasis placed on it by Sport Wales and the Education department of Welsh Government. The indicators assessed were: 1. overall physical activity levels; 2. organised sport participation; 3. active and outdoor play; 4. active transportation; 5. sedentary behaviours; 6. physical literacy; 7. family and peer influence; 8. school; 9. community and the built environment; 10. national government policy, strategies and investments. A number of surveys were selected for sources of data in the current

Report Card; these are presented in Table 1. The data sources used were the most recent (2013-2015) at the time of the grading process. In the first instance, surveys that were representative of children in Wales were selected. Where nationally representative data were not available the best available data were used. For the national government policy, strategy and investment indicator, a number of policy documents, strategy documents and other guidance that were publicly available were considered to inform the RWG during the grading process (“Physical Activity and Nutrition Network — Fitness and Health Info Resources,” n.d.).

Table 1. Data sources used to inform each grade allocated to the 10 indicators of the Active Healthy Kids Wales Report Card

Data Source	Sample Size	Age Range	Indicator*
Sport Wales: SSS (2015) (Sport Wales, 2015c)	115,398 children	7-16	2, 3, 4, 7, 8
Sport Wales: FESS (2015) (Sport Wales, 2015b)	4,568 young people	16-20+	2
HBSC Wales (2013/14) (Welsh Government, 2015a)	9,055 children	11-16	1, 4, 5
WHS (2014) (Welsh Government, 2015c)	2,800 children; 14,170 adults	4-15; 16+	1, 7
NSW (2014/15) (Welsh Government, 2015b)	14,285 parents of children	1-15	4, 9
Sport Wales: AAS (2014) (Sport Wales, 2015a)	13,145 adults	15+	7
Sustrans Wales: HUS (2014/15) ("Sustrans Wales, Sustrans Cymru," n.d.)	4356 children	7-16	4
LVS0 (2015) ("Little Voices Shouting Out Report," 2015)	724 children	7-11	3
Beth Nesa? What Next? (2015) (<i>Beth Nesa? What Next? 2015</i> , 2015)	5961 children & young people	3-18+	9
Sport Wales: DC Report (2015) Unpublished	1600 children	11-12	6

Note. The grade for indicator 10 was allocated using documents and guidance not in this table.

Abbreviations: SSS, School Sport Survey; FESS, Further Education Sport Survey; HBSC, Health Behaviour in School-aged Children; WHS, Welsh Healthy Survey; NSW, National Survey for Wales; AAS, Active Adult Survey; HUS, Hands Up Survey; LVS0, Little Voices Shouting Out; DC, Dragon Challenge.

* Number relates with the order in which the indicators were listed in the Methods.

The RWG met once a month to discuss, evaluate and critique data for each of the 10 indicators. During the meetings, data were reviewed in terms of; representativeness of the survey, methodology of data collection, age range of participants, sample size, and the reporting of subgroups such as sex, age, disability and socio-economic status. Commensurate with the AHK Global Matrix (Tremblay et al., 2014), specific benchmarks for each indicator and the grading framework of: A, we are succeeding with a large majority of children and youth (81 -100%); B, we are succeeding with well over half of children and youth (61 - 80%); C, we are succeeding with about half of children and youth (41 - 60%); D, we are succeeding with less than half, but some, children and youth (21 - 40%); F, we are succeeding with very few children and youth (0 - 20%), were used in assigning grades to each indicator. Grades were assigned a ‘+’ or ‘-’ to indicate a trend or inequality in the data. A consensus approach was used to reach a decision and assign a grade to each indicator.

4.4 Results

Grades assigned to each indicator by the RWG are presented in Table 2, and the front cover is illustrated in Figure 2. Results are discussed herein on an indicator basis.

Table 2. Grades according to physical activity indicator in the Active Healthy Kids Wales 2016 Report Card on physical activity for children and youth

Indicator	Grades
Overall Physical Activity Levels	D-
Organised Sport Participation	C
Active and Outdoor Play	C
Active Transportation	C
Sedentary Behaviours	D-
Physical Literacy (Physical Competence)	INC
Family and Peer Influence	D+
School	B
Community and the Built Environment	C
National Government Policy, Strategies and Investments	B-

Note. The grade for each indicator is based on the percentage of children and youth meeting a defined benchmark: A is 81% to 100%; B is 61% to 80%; C is 41% to 60%, D is 21% to 40%; F is 0% to 20%; INC is Inconclusive data.

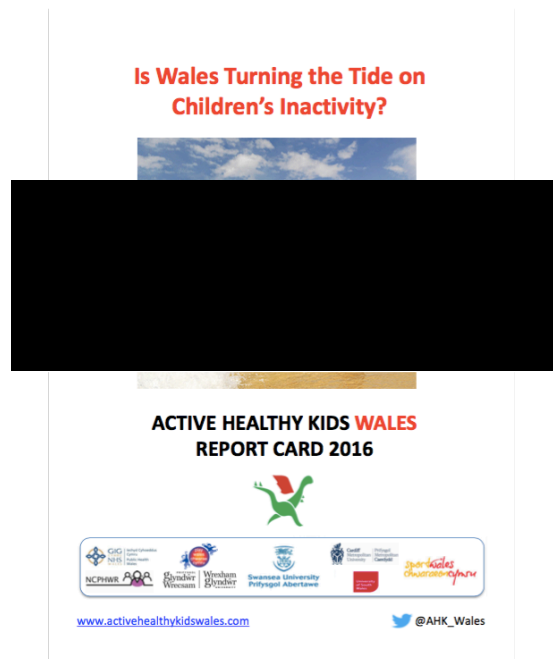


Figure 2. Front cover of the Active Healthy Kids Wales 2016 Physical Activity Report Card

The cover story for the report card is: “Is Wales Turning the Tide on Children’s Inactivity?” With over 100 beaches and over 750 miles of coastline in Wales, only 42% of children used the beach or sea at least once in the past year for exercise (Sport Wales, 2015c). Furthermore 90% of the population live within 30 minutes of the coast. Subsequently “turning the tide” captures meaning in the Welsh context and the aim of this Report Card is to “turn the tide on children’s inactivity” and advocate national efforts to increase children’s physical activity and reduce their sedentary time. Turning the tide on children’s inactivity in Wales should be used to influence and inform policies and strategies, support structures, investments and opportunities that help promote sound health, growth and development in the nation’s children and young people.

4.4.1 Overall Physical Activity Levels

Grade: D-. Two nationally representative data sources were used to assign an overall physical activity grade. Self-report data showed that 15% of children and young people aged 11-15 years old met the recommendation of at least 60 minutes of moderate to vigorous intensity physical activity (MVPA) every day of the week (Welsh Government, 2015a). Further analysis revealed that boys (20%) were more active than girls (11%) across all age groups and socio-economic status. Overall, there was little difference in MVPA by socio-economic status (15% low, 13% medium, 17% high) or geographic regions (17% North, 16% West, 17% East, 15% Southeast, 15% Central south). In terms of changes over time there was a small downward trend in

MVPA between 2006 and 2014 (21% in 2006, 19% in 2010, 15% in 2014). Proxy report (parent) data further showed that 35% of children aged 4-15 years participated in MVPA for at least 1 hour every day and, although sex differences persisted (40% of boys, 29% of girls), there was no significant change between 2007 and 2014 (Welsh Government, 2015c). D- was assigned to physical activity as the proportion of children sufficiently active was between 20 and 39% and inequalities existed between sub groups. There was no change in grade from the AHK Wales 2014 Report Card.

4.4.2 Organised Sport Participation

Grade: C. In line with Sport Wales' Vision, the proportion of children 'hooked on sport' (children who take part in sport on three or more occasions a week in an extracurricular (school-based) or a community club setting) captured in the School Sport Survey (Sport Wales, 2015c) was used as the benchmark for grading. Of children aged 7-16 years old, 48% took part in sport on three or more occasions a week (Sport Wales, 2015c). These data showed an upward trend from 27, 40, and 48 percent in 2011, 2013 and 2015, respectively. Moreover, similar proportions of primary (49%) and secondary (48%) age school children took part in sport on three or more occasions a week although more boys (52%) met the criteria than girls (44%). Even though there were differences by age (52% of 10-12 year olds, 45% 14-16 year olds), ethnicity (White 49%, Mixed Race 52%, Black 52%, Asian 36%, Other 39%), disability (40% with a disability, 49% without) and socio-economic status (43% low, 54% high), there was an overall increase in the proportion of children who took part in sport on three or more occasions a week between 2013 and 2015 for boys and girls (Sport Wales, 2015c). The Further Education Sport Survey of students aged 16 and over also showed that 49% took part in sport three or more times per week, in any setting (Sport Wales, 2015b). Of these further education students 52% of 16-19 and 37% of 20+ year olds met the criteria for taking part in sport. The RWG concluded that the increase in the proportion of children who took part in sport three or more times per week, and the finding that at least 40% of children in the vast majority of subgroups (sex, ethnicity, socio-economic status and disability) met this criterion, was sufficient to warrant an increase in the grade from a C- in 2014 to a C in the 2016 Report Card.

4.4.3 Outdoor and Active play

Grade: C. The grade for this indicator has not changed since 2014 although more data were available to support the 2016 grade. In the previous Report Card, 'use of the park' was used solely to establish the grade for this indicator. In the 2016 Report Card, the RWG agreed that the proportion of children using a variety of places

for play should be considered. Data on the proportion of children and youth using ‘streets near home or school’ (43%), ‘park’ (61%), ‘playground not at school’ (38%), ‘playing fields at school’ (48%), ‘playing fields not at school’ (50%) and ‘beach/sea’ (42%) for places of physical activity/play in the previous year were synthesised to give an overall proportion of 47% of children and youth using at least one of these places (Sport Wales, 2015c). The Little Voices Shouting Out survey of children aged 7-11 years from across Wales reported that 18% spent 3 hours, 15% 4 hours and 27% more than 4 hours playing outside on a normal day (“Little Voices Shouting Out Report,” 2015). The RWG concluded that 60% of children reporting spending ≥ 3 hours outside playing was commensurate with a C grade.

4.4.4 Active Transportation

Grade: C. The largest available survey of active transportation in 7-16 year old children showed that 40% reported they either walked, cycled, scooted or skated to school (Sport Wales, 2015c). In a survey of parents of primary and secondary school children (Welsh Government, 2015b), 49% of primary school children and 35% of secondary school pupils walked to school regardless of distance. Data on children and young people aged 11-16 years showed that 32% (34% boys, 31% girls) completed the main part of their journey to school by walking or cycling (Welsh Government, 2015a). This data indicates that little has changed in the proportion of children and young people who actively travelled to school between the years 2006 to 2014 (Welsh Government, 2015a). Data provided by Sustrans Wales (“Sustrans Wales, Sustrans Cymru,” n.d.), showed that 53.7% of children aged 7-16 years travel to school either by walking, cycling, or scooting/skating, and levels of children travelling to school by walking, cycling, or scooting/skating were consistent for the last 4 years of data collection. There was reassuring consistency across data sources for active transportation and this indicator was assigned a C grade.

4.4.5 Sedentary Behaviours

Grade: D-. On a weekday, 53% of children and young people spent 2+ hours a day playing games on an electronic device, 64% spent 2+ hours a day using an electronic device for purposes other than gaming, and 68% spent 2+ hours a day watching entertainment on a screen (Welsh Government, 2015a). On the weekend, the proportion of children and young people who spent 2+ hours a day playing games on an electronic device, using an electronic device for purposes other than gaming, and watching entertainment on a screen increased to 65%, 71%, and 80%, respectively (Welsh Government, 2015a). During weekdays, a higher proportion of boys spent 2 or more hours

a day playing games on an electronic device and watching entertainment on a screen compared to girls. On the other hand, a higher proportion of girls spent more than 2 hours a day using an electronic device for purposes other than gaming. During the weekend, the sex differences in the proportion playing games on an electronic device and using an electronic device for purposes other than gaming remained the same as on weekdays, but there were similar proportions of both boys and girls spending more than 2 hours a day watching entertainment on a screen. Findings for both weekdays and weekends were consistent across all socio-economic status, and findings for playing games on an electronic device were similar across age groups. Use of electronic devices for purposes other than gaming and watching entertainment increased with age for boys and girls. The RWG concluded that the increase in sedentary behaviour on the weekend compared to weekdays and differences according to sex and age, justified the decrease from a grade D in 2014 to a D-.

4.4.6 Physical Literacy

Grade: Inconclusive. Wales has recently designed a national measure, the Dragon Challenge, for the physical competency domain of physical literacy for children aged 8-14 years. The Dragon Challenge has produced pilot data on children across Wales and initial results suggest that continued investment in developing skilled movements in children is required (“Dragon Challenge Circuit Video,” 2015). The RWG decided to grade physical literacy as inconclusive based on the very recent development of the measurement tool for physical competency and the lack of available data on the other domains of physical literacy.

4.4.7 Family and Peer Influence

Grade: D+. Results from the Sport Wales Active Adult Survey (2014) found that 41% (46.3% M, 35.1% F) of the adult population took part in sport on 3 or more occasions per week, with the equivalent figure being 39% in 2012 (Sport Wales, 2015a). Findings from the Welsh Health Survey (2014), revealed that 3 out of 10 adults (38% M, 23% F) reported being physically active for >30 minutes on 5 or more days a week and there has been no increase in physical activity levels in adults since 2003 (Welsh Government, 2015c). Analysis of the School Sport Survey data (Sport Wales, 2015c) found there is an increased probability of children taking part in sport on three or more occasions a week if their parents or friends are also involved in sport, with a 32% increased chance if their dad, 27% increased chance if their mum and 23% increased chance if their friends were also involved in sport (Sport Wales, n.d.-c). The same survey found that 27% of mothers, 36% of fathers, 39% of brothers, 31% of sisters,

35% of other family members and 64% of children's friends (peers) took part in sport (Sport Wales, 2015c). Further, 18% and 26% of these children took part in sport with their mother and father, respectively. In addition, 25% of children took part with their brother, 19% with their sister, 20% with other family members, and 68% with their peers (Sport Wales, 2015c). Although there was little change in the participation in sport and physical activity levels of adults, the additional evidence demonstrating a parental/peer influence on children's participation in sport, which was absent in the 2014 Report Card, prompted the RWG to assign a grade of D+ compared to D in the 2014 Report Card.

4.4.8 School

Grade: B. To grade this indicator, school Physical Education Coordinators and children's responses in the School Sport Survey (2015) were synthesised (Sport Wales, 2015c). The survey provided data on: percentage of schools that offer physical activity opportunities (excluding PE) to the majority of their pupils, percentage of schools with sufficient facilities/equipment to support pupils' physical activity and sport, percentage of schools where teachers were confident in delivering quality PE lessons, and percentage of children that believe PE lessons and school sport help them to have a healthy lifestyle (Sport Wales, 2015c). In total, 60% of primary schools and 80% of secondary schools provide a wide variety of extracurricular sport and dance opportunities to all pupils. This provision includes health, fitness and wellbeing activities, competitive activities, creative activities, and adventure activities. On average, primary schools provide 11 different extracurricular activities for pupils and secondary schools provide 16. Physical education staff reported that 70% of primary and 62% of secondary schools agreed that the school had sufficient access to facilities to provide sport, and that 54% of primary and 50% of secondary schools owned sports facilities that were of high quality. Further, 73% of primary and 71% of secondary schools agreed that they had access to sufficient equipment to provide quality physical education and sport, and 77% of primary and 85% of secondary schools reported teachers were confident in delivering quality physical education lessons. From the children's perspective, 62% of children reported that physical education lessons and school sport had really helped them to have a healthy lifestyle. In summary, schools were well resourced and the RWG assigned B to this indicator.

4.4.9 Community and the Built Environment

Grade: C. Data from the National Survey for Wales found 54% and 38% of parents with a child aged 1-10 and 11-15 years, respectively, were satisfied with the play

facilities in their local area (Welsh Government, 2015b). Of parents with a child aged 1-10 years who were dissatisfied, 83% reported a lack of suitable outdoor public places for their child to play, whereas 64% reported a lack of suitable indoor spaces. Additionally, of the parents with a child aged 11-15 years who were dissatisfied, 77% cited a lack of suitable outdoor public places, 79% believed there was a lack of indoor public places, and 64% believed there were too few clubs or organised activities. Consultations with children, young people (aged 3-18+ years) and their parents showed that 'more places to play' was the highest priority (49%) for children aged 3-7 (*Beth Nesa? What Next? 2015*, 2015). Other common priorities for this age group were tackling poverty (29%), improving child safety (28%) and tackling bullying (28%). For children aged 7-11 years, stopping bullying was the highest priority (55%) (*Beth Nesa? What Next? 2015*, 2015). The next two highest priorities for this age group were helping children and families in poverty (47%) and making local areas safer for children (41%). The most common priority (53%) for young people aged 11-18 was tackling bullying (*Beth Nesa? What Next? 2015*, 2015). More than 40% of young people reported protecting children from violence and abuse at home, more facilities in the local area, and help for children and families in poverty as their highest priorities. Across all data reported, priorities did not vary substantially by age, sex or region for all age groups. The grade for community and the built environment has decreased from a B in the 2014 Report Card, to a C in 2016. This is due to the proportion of parents being dissatisfied with the play facilities in their local area.

4.4.10 National Government Policy, Strategies and Investments

Grade: B-. After extensive discussions, the RWG concluded that the grade would remain the same as in 2014. The grade was based on the findings that: a) at Governmental and quasi non-governmental levels there is still evidence of leadership and commitment to provide physical activity opportunities for all children and youth; b) there are allocated funds and resources for the implementation of strategies to promote physical activity for all children and youth; c) the Government has demonstrated progress through the key stages of public policy making; d) Wales still has a number of key national and organisational policies that include physical activity ("Physical Activity and Nutrition Network — Fitness and Health Info Resources," n.d.) and are making cross-government efforts to integrate them. With the exception of the proportion of children and young people who took part in sport on three or more occasions a week, the RWG also recognised that policies and strategies had not yet increased physical activity and that inequalities in physical activity remain.

4.5 Discussion

The results of the AHK Wales 2016 Report Card demonstrate that significant efforts need to be made to change children's inactive lifestyles and related choices. Further, using recommendations from the National Institute for Health and Care Excellence ("NICE — The National Institute for Health and Care Excellence," n.d.), the best available evidence was synthesised and showed that the majority of children in Wales were insufficiently active (did not meet recommendation of at least 60 minutes of MVPA every day of the week), and spent excess time (>2 hours) in sedentary behaviour (Sport Wales, 2015c; Tyler, Mackintosh, Brophy, et al., 2015; Welsh Government, 2015a, 2015c). The most recent HBSC international report (2016) included summary statistics on physical activity and TV watching from 42 countries worldwide (Inchley et al., 2016). These statistics demonstrate that Wales has one of the largest differences in number of boys who achieved 60 minutes of MVPA between high and low affluence groups. The differences for girls were not as marked and were more representative of other countries. A similar picture emerged for TV watching but there were negligible sex differences. Furthermore, Wales was placed in the bottom quartile of the 42 countries and had the lowest levels of physical activity in 11-15 year olds in the UK (Inchley et al., 2016). International comparisons for TV watching ranked Wales in the top 5 for the proportion of children who watched 2 or more hours of TV on weekdays (Inchley et al., 2016).

Over the past 10 years, a significant effort has been made in Wales to influence children's physical activity and sport participation through programmes such as "Dragon Sport" for primary and "5x60" programmes for secondary age children. These programmes have been developed, implemented and evaluated and found evidence that children's extracurricular participation had increased and the range of activities that schools offered had broadened (Sport Wales, n.d.-b, 2011). Moreover, Sport Wales in collaboration with Public Health Wales and the education sector have urged Government to give physical literacy the same emphasis in the school curriculum as literacy and numeracy. To a degree, these have had an effect where the number of children hooked on sport has increased steadily since 2011 although inequalities still exist.

For outdoor and active play, Wales has an influential national government organisation that advocates for play ("Play Wales — Chwarae Cymru," n.d.). Wales was one of the first countries to integrate article 31 of the UNCRC of the child's right to play into policy ("United Nations Convention on the Rights of Children - Rights - Children in Wales," n.d.), through its Children and Families (Wales) Measure 2010

(Welsh Government, 2012). Moreover Play Wales has been referred to as “a highly focused, policy-oriented NGO” (Wales UNCRC Monitoring Group, 2015). Further, the grading for outdoor and active play was encouraging compared to other countries (Tremblay et al., 2014).

Walking and cycling have also received a policy boost in Wales. In 2013 the Welsh Government successfully introduced the ‘Active Travel Act’ onto its statute (“Active Travel (Wales) Act 2013,” 2013). The increasing problem of children’s sedentary time is worrying and we have recognised this in the shift of D to D-. Community and the built environment also decreased from a B in the 2014 Report Card to a C, although this was influenced by higher quality data that provided better insight into this indicator. Similar reasons explain the increase in grade given to family and peer influence that achieved a D+ compared to D in 2014. Wales has a vibrant physical education programme that is well resourced and links to community sport that are also well established, and also has a successful Healthy Schools Network that includes physical activity in its delivery portfolio (Public Health Wales, n.d.). Similar to a number of developed countries (Tremblay et al., 2014), school achieved the highest grade of all the indicators (B).

4.5.1 Research Gaps

The AHK Wales Report Card is produced every 2 years. There were significant gaps unveiled during the production of the AHK Wales 2014 Report Card and whilst many of these still remain, the AHK Wales 2016 process was built on a more complete data platform and a more robust approach by a more experienced RWG. The School Sport Survey (Sport Wales, 2015c) captured data on over 115,000 children in 61% of primary and 87% of secondary schools in Wales, building on data from 110,000 children 2 years earlier. The HBSC international report was published in 2016 (Inchley et al., 2016) and allowed detailed analysis of the 2013/14 data (Welsh Government, 2015a) permitting trends to be analysed and also data from Wales to be compared with other countries that used the same methodology (Inchley et al., 2016). On the other hand, there are currently no large-scale studies where physical activity or sedentary time have been measured objectively and inconsistency also exists across tools used to generate data on the 10 quality indicators. These issues are being partly addressed through the development of national indicators for sedentary time, physical activity and physical literacy by a Wales physical activity measurement and indicators group. The RWG also assigned a grade of ‘inconclusive’ to the physical literacy indicator. Sport Wales and Swansea University have developed an objective measure of phys-

ical competency (Dragon Challenge) that will provide nationally representative data for use in future Report Cards.

One of the main challenges for the RWG was that most of the data available on children's physical activity and related behaviours were not aligned to quality indicators included in the Report Card. Further, the more interpretive indicators such as School, Family and Peer Influence, and National Government Policy, Strategies and Investments, and Community and the Built Environment required more synthesis of different levels and quality of data and expert opinion.

More recently, the University of South Australia used a Delphi process with two independent panels of international physical activity experts to produce 29 research priorities for the next decade (Gillis et al., 2013). The 3 top research priorities were (i) effective and sustainable interventions to affect long-term increases in children's physical activity behaviour; (ii) the influence of policy and environmental changes on physical activity and sedentary behaviour; and (iii) prospective, longitudinal studies of the independent effects of physical activity and sedentary behaviour on health (Gillis et al., 2013). Wales should seek to address these research priorities. Future Report Cards will note whether these issues have been addressed. In the meantime this Report Card will serve as an advocacy tool to promote physical activity research in Wales and to generate a national evidence base to underpin future AHK Wales Report Cards.

4.5.2 Recommendations to improve the grades

Policy makers, practitioners and educators should use the results of the AHK Wales 2016 Report Card to inform their decision processes. This is the second AHK Wales Report Card and, unlike more established cards, Wales is less familiar with using the results to influence factors affecting children's activity. Physical activity promotion in Wales has received criticism for lacking leadership and joined up approaches across Government portfolios (Wales Audit Office, 2007). This has resulted in fractures in strategy and delivery from national to local levels. Moreover, data provides the evidence to support the lack of impact on physical activity in Wales over the past decade (Welsh Government, 2015a, 2015c). Wales requires a clearly articulated ambition, and this ambition requires an unbroken chain of policy-strategy-delivery-review to translate these factors into positive physical activity outcomes. Nonetheless the RWG and stakeholders fully expect to build momentum behind children's physical activity research and promotion as the Report Card becomes more established and informa-

tive. The RWG is following the lead given by Canada to provide evidence-guided recommendations to identify where investments of effort and resources can best influence the physical activity levels of children and youth (see for example, the dissemination, implementation, evaluation procedures for the Canadian 24- hour Movement Guidelines) (Tremblay, Carson, Chaput, et al., 2016). We are concerned that we have some of the lowest levels of physical activity and highest levels of sedentary behaviour globally (Inchley et al., 2016; Welsh Government, 2015a), and we will use these data to communicate and advocate approaches to improve this situation. Our overarching aim this year is to “turn the tide on physical inactivity” and make daily physical activity the social norm.

4.5.3 Future Directions

The Welsh Government has appointed a National Programme Director for Physical Activity to work across cabinet portfolios and we hope that this will have an effect on physical activity at all levels including children. The “Getting Wales Moving” strategy will be launched in the Summer of 2016 and prompt Welsh Government to develop a coordinated action plan based on the recommendations to resource an implementation and evaluation plan. The ‘Transforming Public Health Strategy,’ ‘Communities First’ and ‘Wellbeing of Future Generations’ (Wales) Acts have the potential to correct some of the fragmented approaches to promoting uptake of physical activity in the past.

The 2016 Global Summit on the Physical Activity of Children and the second meeting of the Active Healthy Kids Global Alliance provide valuable opportunities to learn from other countries that have a more established Report Card process or are in the early years of their respective Report Cards. In the future, AHK Wales will consult with researchers, knowledge users, and key stakeholders to re-examine the Report Card framework, indicators, and processes. This consultation will start with the AHK Wales 2016 Report Card launch and dissemination event on 25th July 2016 supported by an informative independent web site (www.activehealthykidswales.co.uk). Our future plans are to improve the current state of physical activity research and knowledge needs in order to enhance policies, programmes, practices, products, communications and investments to increase physical activity of children and youth in Wales.

4.6 Conclusion

The AHK Wales 2016 Report Card results demonstrate a need for focussed action and investment in promoting children’s physical activity and reducing inactivity, seden-

tary time and their related behaviours. There has been significant investment at policy structure and delivery levels since 2007 yet these have had little effect on children's physical activity levels which remain one of the lowest out of all countries surveyed in the HBSC report 2016 (Inchley et al., 2016). On the other hand Wales has placed active transport on its statute, has a strong track record in children's right to play and is changing the school curriculum to include a significant pillar on well-being. Furthermore inter-sectoral collaboration has helped promote children's physical literacy and activity and include them as indicators in future national surveys. This Report Card urges greater investment in children's physical activity so that future generations receive the health and developmental benefits of physical activity and reduce the spiralling social and economic burden of inactivity.

4.7 Summary: Study 1

This is the second AHK Wales Report Card. The 2016 version consolidates and translates research related to physical activity among children and youth in Wales and aims to raise the awareness of children's engagement in physical activity and sedentary behaviours.

Ten physical activity indicators were graded using the Active Healthy Kids - Canada Report Card methodology involving a synthesis and expert consensus of the best available evidence. Grades were assigned as follows; overall physical activity levels, D+; organized sport participation, C; active and outdoor play, C; active transportation, C; sedentary behaviours, D-; physical literacy, INC; family and peer influences, D+; school, B; community and the built environment, C; and national government policy, strategies and investments, B-.

Despite the existence of sound policies, programmes, and infrastructure, physical activity levels of children and youth in Wales are one of the lowest and sedentary behaviour highest globally. From the 2014 Report Card, family and peer influences grade has improved from D to D+, whereas community and the built environment have dropped from B to C. These results indicate that a concerted effort is required to increase physical activity and decrease sedentary time in children and young people in Wales.

Thesis Map

	Study		Outcomes
1	Results from the Active Healthy Kids Wales 2016 Report Card on Physical Activity for Children and Youth	<i>Aim</i>	To consolidate and translate research related to physical activity among children and youth in Wales and to synthesise national surveillance data from several surveys in order to assign grades to physical activity/inactivity behaviours and influences indicators, as well as to examine trends or inequalities in the data.
		<i>Key Findings</i>	Grades were assigned as follows; overall physical activity levels, D+; organized sport participation, C; active and outdoor play, C; active transportation, C; sedentary behaviours, D-; physical literacy, INC; family and peer influences, D+; school, B; community and the built environment, C; and national government policy, strategies and investments, B-.
2	Ten-year Secular Changes in Selected Health and Fitness Parameters of 10-11 Years Old Swansea School Children – 2003-2013	<i>Aim</i>	To highlight the secular changes in selected health and fitness measures (body mass index, prevalence of overweight and obesity, and grip strength) in 10-11 year old Swansea school children, using data obtained in 2003 and 2013.
		<i>Key Findings</i>	
3	A Cross-Sectional Study on the Socio-economic and Sex Differences in Health-Related Fitness Measures in School Children	<i>Aim</i>	
		<i>Key Findings</i>	
4	A Dynamic Assessment of Children's Physical Competence: The Dragon Challenge	<i>Aim</i>	
		<i>Key Findings</i>	
5	Youth Physical Competence Promotion Model: A Quantitative Investigation into Modifiable Factors	<i>Aim</i>	
		<i>Key Findings</i>	

5 Study 2

5.1 Ten-year Secular Changes in Selected Health and Fitness Parameters of 10-11 Years Old Swansea School Children - 2003 - 2013

* This chapter is a published manuscript:

Tyler, R., Mackintosh, K., Palmer, A., Jones, A., & Stratton, G. (2015). Ten-Year Secular Changes in Selected Health and Fitness Parameters of 10-11 Years Old Swansea School Children - 2003-2013. *Advances in Obesity, Weight Management & Control*, 3(5), 8-13. <https://doi.org/10.15406/aowmc.2015.03.00072>

5.2 Introduction

In school-aged children, physical activity is associated with numerous physiological and psychosocial health benefits (Department of Health, 2011). In order to achieve these associated health benefits, current government recommends that children engage in moderate to vigorous intensity physical activity for at least 60 minutes every day (Department of Health, 2011). When these levels are attained, physical activity contributes to the prevention of childhood obesity (Guinhouya, 2012) and low physical fitness levels (Janssen & Leblanc, 2010).

Children classified as overweight or obese are at risk of developing a number of obesity-related conditions (Reilly et al., 2003), including type 2 diabetes (Haines et al., 2007), metabolic and cardiovascular complications (Cote et al., 2013; L'Allemand-Jander, 2010), and mental health problems (Griffiths et al., 2010). Globally, the prevalence of overweight and obesity has more than doubled between 1980 and 2014 (World Health Organization, 2015). The number of children in Wales classified as overweight and obese represents a serious public health problem, with Wales being reported to have the highest rates of childhood obesity in the United Kingdom (National Obesity Observatory, 2015). However, recent reports on the prevalence of overweight and obesity in children in European countries, including England, indicate that the rise in the prevalence has plateaued or even, in some countries, has slightly decreased (Boddy et al., 2009; Boddy, Hackett, et al., 2010; Olds et al., 2011; Stratton et al., 2007; van Jaarsveld & Gulliford, 2015). It is well documented that childhood obesity continues into adolescence and adulthood (Park et al., 2012); therefore it is important to identify the prevalence of childhood obesity to indicate not only current but also future health.

Low levels of physical fitness in children are also linked with similar health-related outcomes as childhood obesity, including obesity itself (McMurray & Andersen, 2010; Parfitt, Pavey, & Rowlands, 2009; Ruiz, Castro-Piñero, et al., 2009). Levels of physical fitness in children have declined globally, as well as in the United Kingdom, in recent years (Boddy et al., 2012; Tomkinson & Olds, 2007; Tremblay, Shields, et al., 2010). The majority of studies relating to physical fitness report on cardiorespiratory fitness (Boddy et al., 2012; Ortega et al., 2008; Tomkinson & Olds, 2007; Tremblay, Shields, et al., 2010), however research has highlighted the need to assess the muscular strength component of physical fitness given its relationship with health outcomes and all-cause mortality (Cohen et al., 2011; De Miguel-Etayo et al., 2014; Moliner-Urdiales et al., 2010; Ruiz, Castro-Piñero, et al., 2009; Tremblay, Shields, et al., 2010). Whilst there are numerous measures of strength, grip strength has been shown to be a good indicator for total muscular strength (Wind et al., 2010). Specifically, studies on grip strength have revealed its direct associations with chronic diseases, multi-morbidity and premature mortality (Griffiths et al., 2010; Metter et al., 2002; Ruiz, Castro-Piñero, et al., 2009; Volaklis et al., 2015). It is therefore postulated that grip strength should be measured in children in order to predict changes in overall strength, future health and mortality.

Although there is large evidence base that physical activity levels among children in Wales are low (Welsh Government, 2015c), there is a paucity of research monitoring the trends relating to obesity and physical fitness of children in Wales. Identifying changes in health and fitness levels among school children could indicate the need for focused services and interventions. Therefore, the aim of this study was to highlight the secular changes in selected health and fitness measures (body mass index, prevalence of overweight and obesity, and grip strength) in 10-11 year old Swansea school children, using data obtained in 2003 and 2013.

5.3 Methods

The current study uses data measured in 2003 during a Crucial Crew Day, and in 2013 during the Swan-Linx programme, both of which took place in Swansea, Wales. All testing procedures followed those highlighted in the EuroFit Battery (Council of Europe, 1993), and *SportsLinx* project (Taylor et al., 2004). The Swan-Linx programme has ongoing University ethical approval for its procedures and measures. The programme is a continuation of the *SportsLinx* project which has acceptable test/retest reliability for its field-based testing (Boddy, Stratton, & Hackett, 2010).

5.3.1 Participants and Settings

The current study uses data on children that were invited to take part in this study in both 2003 and 2013 from schools situated in the same electoral wards (areas) of Swansea. The children were all 10-11 years old (Year 6) at the time of testing, with a similar distribution of boys and girls at both testing periods. The schools were matched in terms of demographic status.

Data collected in 2003 were measured by staff and trained researchers from the Sport and Exercise Science department at Gower College. Participants were 10-11 year old children (Year 6) from primary schools situated across Swansea. The primary schools were invited to attend a Swansea Primary School Crucial Crew day, during which, the school children participated in health and fitness measures. Similarly, the 2013 data was obtained during the Swan-Linx programme's fitness fun days. Primary school children aged 9-11 year old (Year 5 and 6) from across Swansea were invited to take part in the programme, which was delivered by University staff and trained Active Young People officers from City and County of Swansea. The present study only uses data from the participants aged 10-11 years old (Year 6).

Out of all of the schools that took part in the events, data from thirteen schools in 2003 and thirteen schools in 2013 are used in this study. Eight schools from each of the 2003 and 2013 data were selected as these schools participated in both years of testing. From these eight schools, 258 children were measured in 2003 and 214 children were measured in 2013. An additional five schools from the 2003 data and five schools from the 2013 data were matched based on their demography using the Welsh Index of Multiple Deprivation (WIMD) scores. From these schools, 254 children were measured in 2003 and 200 children were measured in 2013. In total, 512 participants (n= 230 boys, n= 282 girls) in 2003 and 414 participants (n= 198 boys, n= 216 girls) in 2013 were measured.

5.3.2 Instruments and Procedures

Stature was measured to the nearest 0.001m and body mass was measured to the nearest 0.1kg using a portable height stadiometer (Seca 213 portable stadiometer, Hamburg, Germany) and portable weighing scales (Seca 876, Hamburg, Germany), respectively. Techniques adhered to the Kinanthropometry and Exercise Physiology Manual (Eston & Reilly, 2009). Body Mass Index (BMI) was calculated using these measures ($BMI = \text{body mass (kg)} / \text{stature}^2 (\text{m}^2)$). Hand-grip strength was measured

as an indicator of overall muscular strength, using hand dynamometers (Takei Corp Ltd., Tokyo, Japan), giving a measure of the participant's strength in kilograms. Dominant hand readings were used in this study, as this reading was available in both 2003 and 2013 data.

5.3.3 Design and Analysis

Body Mass Index was used to calculate body mass index standard deviation scores (BMI z-scores), standardised for age and sex, using the 1990 British Growth BMI reference standard (Cole et al., 1995). Decimal age of participants was not available in the 2003 data, so estimated average age was calculated (average age of school children starting Year 6 + date of testing) and used to standardise BMI to a point. The prevalence of unhealthy weight in terms of overweight and obese, were calculated using age and sex specific BMI cut-off points (Cole et al., 2000). Descriptive statistical analysis, mean and standard deviation (mean \pm SD), were initially performed on all measures. A two-way Analysis of Variance (ANOVA) was conducted to examine if there was a statistically significant difference in BMI z-score by sex and year of testing. A two-way Analysis of Covariance (ANCOVA) was used to investigate if there were differences on grip strength by sex and year of testing, while controlling for BMI z-score. BMI z-score was chosen as a covariate due to the known positive correlation of BMI and grip strength in both boys and girls during childhood (Milliken, Faigenbaum, Loud, & Westcott, 2008). Statistical analysis was completed using SPSS, version 22 (IBM SPSS Statistics Inc., Chicago, IL, USA), with a significance level of 0.05. If an interaction effect was present, a Bonferroni adjustment was applied for simple main effect analysis of year on each level of sex.

5.4 Results

Mean age for participants were 11.33 years and 10.99 years \pm 0.45 in 2003 and 2013, respectively. Mean stature, body mass and BMI z-scores for boys and girls in 2003 and 2013 are presented in Table 3.

Table 3. Anthropometric measures (mean \pm SD) for boys and girls in 2003 and 2013

<i>Anthropometric Measures</i>	2003			2013		
	Boys	Girls	All	Boys	Girls	All
	<i>Mean \pmSD</i>			<i>Mean \pmSD</i>		
Stature (m)	1.42 \pm 0.07	1.44 \pm 0.07	1.43 \pm 0.07	1.43 \pm 0.07	1.45 \pm 0.08	1.44 \pm 0.07
Body Mass (kg)	40.2 \pm 9.9	41.3 \pm 9.1	40.8 \pm 9.5	38.2 \pm 9.1	40.8 \pm 10.4	39.5 \pm 9.9
BMI z-score	0.80 \pm 1.24	0.58 \pm 1.16	0.69 \pm 1.20	0.40 \pm 1.32	0.41 \pm 1.23	0.41 \pm 1.27

Table Abbreviations: BMI z-score – Body Mass Index Standard Deviation Score

5.4.1 BMI z-scores

Mean BMI z-scores for boys and girls in 2003 and 2013 are presented in Figure 3. The interaction effect between sex and year on BMI z-scores was not statistically significant ($F_{(1,890)} = 1.790$, $p = 0.18$). Thus, main effects analysis was conducted and displayed a significant main effect of year on BMI z-scores ($F_{(1,890)} = 11.490$, $p = 0.001$) and a non-significant main effect of sex on BMI z-scores ($F_{(1,890)} = 1.476$, $p = 0.225$), demonstrating that mean BMI z-scores decreased significantly for both boys and girls between 2003 and 2013.

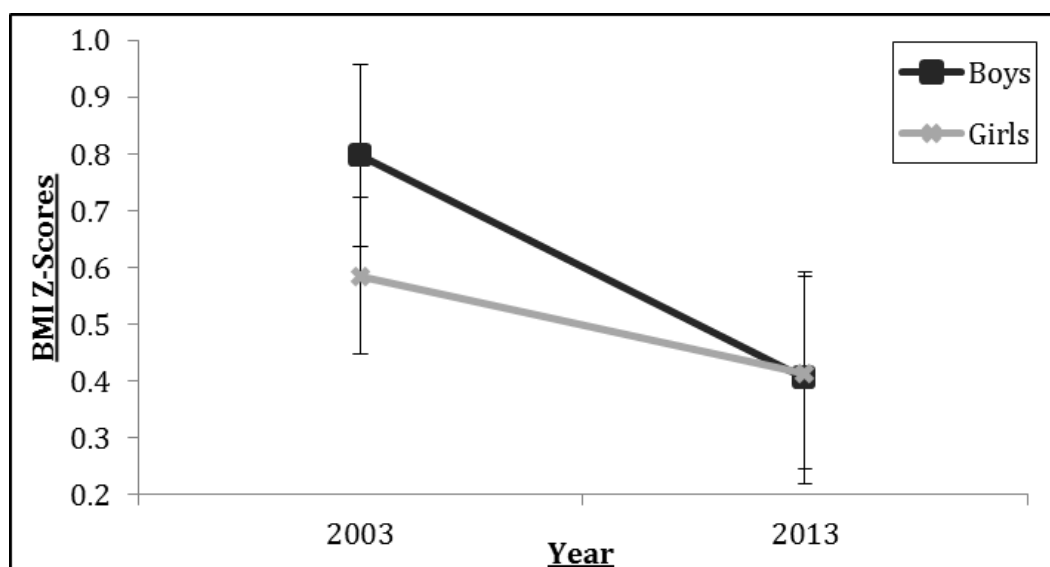


Figure 3. Mean BMI z-scores for boys and girls in 2003 and 2013, with 95% confidence intervals.

5.4.2 Prevalence of overweight and obesity

The proportion of participants classified as overweight or obese in 2003 and 2013, using age and sex specific cut-off points for BMI z-scores (Cole et al., 2000), are presented in Table 4. Prevalence of overweight and obesity in participants shows a decrease from 2003 to 2013 for both boys and girls.

Table 4. Proportion of boys and girls in 2003 and 2013 classed as unhealthy weight and percentage difference between 2003 and 2013

<i>Prevalence of unhealthy weight</i>	2003			2013			Percentage Difference		
	Boys	Girls	All	Boys	Girls	All	Boys	Girls	All
Overweight (%)	24.8	28.3	26.7	19.2	23.8	21.5	- 5.6	- 4.5	- 5.2
Obese (%)	7.0	5.6	6.2	4.7	5.9	5.3	- 2.3	0.3	- 0.9
Overweight or Obese (%)	31.7	33.8	32.9	23.8	29.7	26.8	- 7.9	- 4.1	- 6.1

5.4.3 Grip strength

Mean grip strength for boys and girls in 2003 and 2013 are presented in Figure 4. Grip Strength was log transformed for statistical analysis, and then back transformed for presentation purposes. There was homogeneity of regression slopes, as the interaction term between Grip Strength (independent variable) and BMI z-scores (covariate) was not significant ($p = 0.126$). Therefore, BMI z-scores were included as a covariate.

Controlling for BMI z-scores, there was a statistically significant two-way interaction between sex and year ($F_{(1,886)} = 8.22, p = 0.004$). Simple main effects analysis showed that boys in 2003 had significantly higher grip strength than boys in 2013 ($F_{(1,886)} = 12.74, p < 0.001$). However, there was no significant difference in grip strength between girls in 2003 and 2013 ($F_{(1,886)} = 0.16, p = 0.69$).

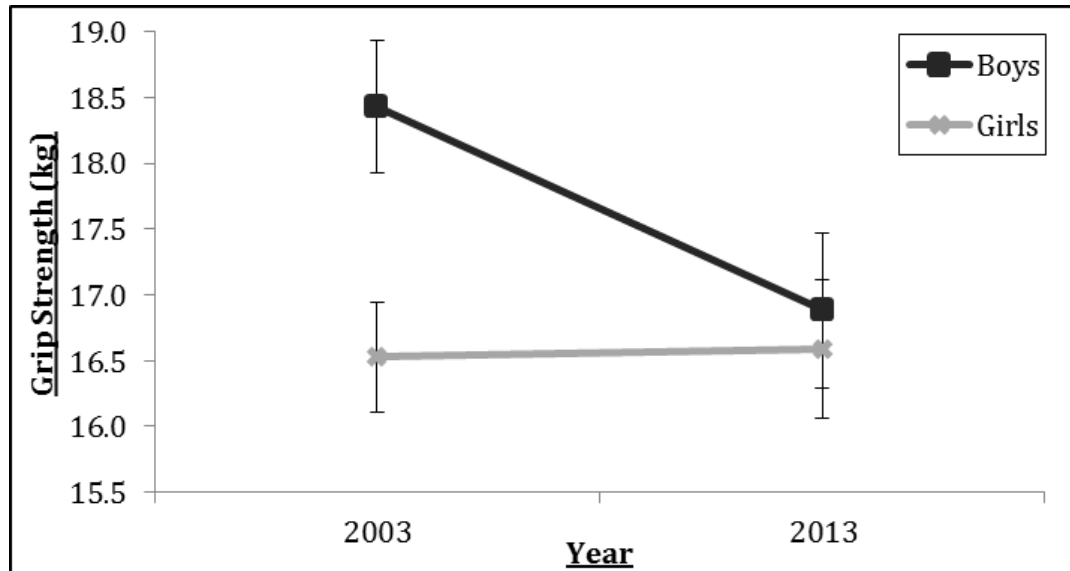


Figure 4. Mean grip strength for boys and girls in 2003 and 2013, with 95% confidence intervals.

5.5 Discussion

The purpose of this study was to report secular changes in selected health and fitness measures, in 10-11 year old children between 2003 and 2013. Our main findings show that BMI z-scores decreased significantly in all children and grip strength significantly decreased in boys. To our knowledge these are the first 10-year secular changes in health and fitness measures reported on school-aged children in Wales.

5.5.1 BMI and prevalence of overweight and obesity

Body Mass Index has been shown to represent a practical method of assessing overweight and obesity in many large-scale paediatric studies (Boddy et al., 2009; Boddy, Hackett, et al., 2010; Olds et al., 2011; Stratton et al., 2007; van Jaarsveld & Gulliford, 2015). In contrast with some reports that BMI and prevalence of overweight and obesity is still slowly rising or reaching a plateau (Boddy et al., 2009; Stratton et al., 2007; van Jaarsveld & Gulliford, 2015), the current study shows a significant mean decline in BMI z-scores from 2003 to 2013 for both boys and girls, as well as a decline

in prevalence of overweight and obesity in boys and girls, from 31.7% to 23.8% and 33.8% to 29.7%, respectively. These findings are congruent with the slight decrease in prevalence shown in girls of similar age in a study conducted in England (Boddy, Hackett, et al., 2010), and also the decreases in BMI and prevalence in both boys and girls seen in other European countries (Olds et al., 2011). These results show promise for targeting childhood obesity in Wales and may therefore show some optimism for the future. It should be noted, however, that the prevalence of overweight and obesity recorded in 2013 is still high, with an average of one in four boys and girls being overweight or obese. Therefore, a substantial number of Swansea school children are still at risk for obesity-related health outcomes, and so further decreases in the prevalence should continue to be an aim.

5.5.2 Muscular strength

In the current study, mean grip strength significantly decreased for boys between 2003 and 2013 (18.43kg to 16.88kg), but there was no significant change for girls (16.53kg to 16.59kg). These findings, which cannot be explained by differences in BMI z-score, are likely related to changes in patterns of physical activity, which has been shown to be associated with muscular strength (Paalanne et al., 2009).

We note that in many past studies, boys and girls both display the same trends in grip strength changes over time. A study on Canadian children (Tremblay, Shields, et al., 2010), comparing data on 8-10 year olds between 1981 and 2007-2009, and a study on Spanish adolescents (Moliner-Urdiales et al., 2010), between 2001/02 and 2006/07, both showed declines in grip strength for both boys and girls. Further, a study in England, on 10-year old English children, also found a decline in grip strength for boys and girls over a 10-year secular trend from 1998 to 2008 (Cohen et al., 2011). The findings of the current study support these trends in terms of boys showing a decrease in grip strength, but, in contrast with the previous studies, grip strength for girls in the current study did not significantly change. The decrease in participation in extracurricular sports by year 3-6 school children in Mid & West Wales (which includes Swansea), from 85.3% in 2002 (85.0% in 2004) to 81.5% in 2013, reported in the School Sport Survey (Sport Wales, 2015c), may provide a possible explanation behind this inconsistency in the changes in grip strength between boys and girls. Ara et al. (2007), found that grip strength was significantly greater in boys who took part in extracurricular sporting activities than in boys who did not take part in these activities; however, there was no difference in grip strength between girls who did and did not take part in extracurricular sporting activities. Thus, the decrease in extracurricular

activity participation described by the School Sports Survey may have resulted in a greater effect on grip strength performance in boys than it did in girls. Nonetheless, the decrease highlighted in grip strength in boys in the current study may mean that the boys may be at greater risk of future health-related illnesses (McMurray & Andersen, 2010; Parfitt et al., 2009; Ruiz, Castro-Piñero, et al., 2009).

5.5.3 Muscular strength and BMI

Previous studies have shown a relationship between fat-free mass (muscle mass) and grip strength in adults (Lebrun, van der Schouw, de Jong, Grobbee, & Lamberts, 2006; Yoon et al., 2009). Therefore, the decrease in grip strength in boys found in our study may be a result of a decrease in fat-free mass. We note that this may also provide a reason for the decline in BMI for boys, rather than the alternative notion of a decrease in excess adiposity (fat mass) (Field et al., 2003). Moreover, since there was no change in grip strength but there was a decrease in BMI for the girls in this study, then, using the same reasoning, this may indicate that there has been a decrease in excess adiposity in girls in this study. However, these conjectures cannot be concluded, and further investigation using more direct measures of adiposity and fat-free mass are required.

5.5.4 Limitations

There were some limitations to this study. Due to not having specific ages for the children in the 2003 data, BMI was corrected to a single age (the average age of children in Year 6 at the time of testing), which limits the adjustment for age to a single point, and may result in a slight over or under prediction of the average BMI z-score. Further, it is difficult to distinguish whether changes in BMI are a result of changes in levels of fat or fat-free mass have changed over the 10-year period. Future studies should aim to include a range of anthropometric assessments, including skinfolds and circumferences (Eston & Reilly, 2009), or dual-energy X-ray absorptiometry (DEXA) (Lohman & Going, 2006), to assess fat and fat-free mass and percentage body fat.

It should also be mentioned that deprivation, an important factor towards children's health and fitness, was not controlled for in the analysis of data, due to only having school postcodes rather than home postcodes available for the 2003 data, and using school postcodes has been shown to be a less effective way of controlling for deprivation as children may travel across postcodes to school (Dummer, Gibbon, Hackett, Stratton, & Taylor, 2005). However, this should not be considered as a limitation to the study as all children lived in the same electoral wards and little has changed in the

demographics of these wards between 2003 and 2013.

Finally, when interpreting the findings from the present study, it is important to note that only two datasets (2003 and 2013) were used to describe the changes over a ten-year period. This limits the ability to analyse year-on-year variations in the trend. There is a great need to continue to monitor trends to assess these year-on-year variations, as well as the effectiveness of any interventions working towards improving children's health and fitness. Moreover, continued monitoring could be useful in identifying whether these trends continue into older children once they have more control over their exercise and eating habits.

5.6 Conclusion

The current study is the first to report 10-year secular changes in health and fitness measures of schoolchildren in Wales. The study shows promising results in terms of BMI and prevalence of overweight and obesity. However, the study also shows that muscular strength, in boys in particular, should be a focus for future interventions regarding physical fitness, in addition to an area for further investigation. It is unclear whether the trends observed in the current study will continue or if the reductions seen in BMI and prevalence of overweight and obesity, as well as in grip strength in boys, are part of a year-on-year variation, with the children in 2013 being an abnormally low fluctuation in a year-on-year trend. Thus, there is a need for longitudinal data to show year-on-year trends in order to assess annual fluctuations.

5.7 Summary: Study 2

The aim of this chapter was to highlight the secular changes in selected health and fitness measures (body mass index, prevalence of overweight and obesity, and grip strength) in 10-11 year old Swansea school children, using data obtained in 2003 and 2013.

Accordingly, BMI z-scores decreased significantly ($p = 0.001$) between 2003 and 2013 for both boys (0.80 to 0.40) and girls (0.58 to 0.41). Prevalence of overweight and obesity decreased for both boys and girls from 31.7% to 23.8% and 33.8% to 29.7%, respectively. After BMI z-scores adjustment, grip strength decreased significantly for boys (18.43kg to 16.88kg, $p < 0.001$), but not for girls (16.53kg to 16.59kg).

While this study shows encouraging results in terms of BMI z-scores and prevalence

of overweight and obesity, further decreases in prevalence should continue to be an aim as the prevalence of overweight and obesity recorded in 2013 is still high. The study also shows that muscular strength, in boys in particular, should be a focus for future interventions regarding physical fitness.

Thesis Map

	Study		Outcomes
1	Results from the Active Healthy Kids Wales 2016 Report Card on Physical Activity for Children and Youth	<i>Aim</i> <i>Key Findings</i>	To consolidate and translate research related to physical activity among children and youth in Wales and to synthesise national surveillance data from several surveys in order to assign grades to physical activity/inactivity behaviours and influences indicators, as well as to examine trends or inequalities in the data. Grades were assigned as follows; overall physical activity levels, D+; organized sport participation, C; active and outdoor play, C; active transportation, C; sedentary behaviours, D-; physical literacy, INC; family and peer influences, D+; school, B; community and the built environment, C; and national government policy, strategies and investments, B-.
2	Ten-year Secular Changes in Selected Health and Fitness Parameters of 10-11 Years Old Swansea School Children – 2003-2013	<i>Aim</i> <i>Key Findings</i>	To highlight the secular changes in selected health and fitness measures (body mass index, prevalence of overweight and obesity, and grip strength) in 10-11 year old Swansea school children, using data obtained in 2003 and 2013. BMI z-scores, as well as prevalence of overweight and obesity, decreased significantly between 2003 and 2013 for both boys and girls. After BMI z-scores adjustment, grip strength decreased significantly for boys, but not for girls.
3	A Cross-Sectional Study on the Socio-economic and Sex Differences in Health-Related Fitness Measures in School Children	<i>Aim</i> <i>Key Findings</i>	To investigate socio-economic and sex differences in selected health-related fitness measures (body mass index, MSRT, grip strength) in 9-12-year-old children.
4	A Dynamic Assessment of Children's Physical Competence: The Dragon Challenge	<i>Aim</i> <i>Key Findings</i>	
5	Youth Physical Competence Promotion Model: A Quantitative Investigation into Modifiable Factors	<i>Aim</i> <i>Key Findings</i>	

6 Study 3

6.1 A Cross-Sectional Study on the Socio-economic and Sex Differences in Health-Related Fitness Measures in School Children

* This chapter is under review for publication:

Tyler, R., Mackintosh, K. A., Spacey, H. L. & Stratton, G. (2018). A Cross-Sectional Study on the Socio-economic and Sex Differences in Health-Related Fitness Measures in School Children. *Journal of Sports Sciences (under review)*.

6.2 Introduction

The World Health Organization defines health inequalities as “the differences in health status or in the distribution of health determinants between different population groups” (World Health Organization, n.d.). Health is not equally spread across UK society, with children from deprived areas at higher risk of poor health (Public Health Wales Observatory, 2013; Wickham, Anwar, Barr, Law, & Taylor-Robinson, 2016). Physical activity has been identified as key to enhancing numerous physiological, psychosocial and cognitive health benefits in children (Biddle & Asare, 2011; Boreham & McKay, 2011; Janssen & Leblanc, 2010), while preventing emerging health risk factors (Andersen et al., 2011; Janssen & Leblanc, 2010). For children and young people aged 5-18 years to receive the associated benefits of physical activity, the UK physical activity guidelines (Department of Health, 2011), recommend engagement in moderate to vigorous intensity activity for at least 60 minutes and up to several hours each day. In particular, vigorous intensity activities, including those that strengthen muscle and bone, should be incorporated at least three days per week (Department of Health, 2011). The physical activity levels of children and young people in Wales are low and lie in the bottom quartile of very high human development index countries (Aubert et al., 2018; Tremblay, Gonzalez, et al., 2016; Tyler et al., 2016). Moreover, in accord with health inequality research, physical activity levels have been reported to be higher in boys than girls (Tyler et al., 2016; Welsh Government, 2015a, 2017). However, whilst there is a range of physical activity levels, results display little difference in average levels between deprivation groups (Tyler et al., 2016; Welsh Government, 2015a, 2017).

Whilst physical activity levels and inequalities are well established, physical fitness has been shown to be a stronger indicator of health than physical activity (Andersen

et al., 2011). Physical fitness includes a range of components that are associated with health outcomes, such as cardiorespiratory fitness, muscular strength/fitness and body composition (Ruiz et al., 2011). In children, many studies have reported the strong associations between low cardiorespiratory fitness (McMurray & Andersen, 2010; Ortega et al., 2008; Ruiz, Castro-Piñero, et al., 2009), low muscular strength/fitness (Ortega et al., 2008; Ruiz, Castro-Piñero, et al., 2009; Volaklis et al., 2015) and high body mass index (Griffiths et al., 2010; L'Allemand-Jander, 2010; Ruiz, Castro-Piñero, et al., 2009), with metabolic and cardiovascular disease risk, mental health problems, reduced quality of life and all-cause mortality (Högström et al., 2015; Ruiz, Castro-Piñero, et al., 2009; Volaklis et al., 2015). Therefore, identifying differences in fitness levels among school children could indicate the need for focused services and interventions to improve health inequalities.

Although some recent UK studies have considered health-related fitness measures and socio-economic status in statistical analyses (Brophy, Rees, Knox, Baker, & Thomas, 2012; Charlton et al., 2014; Nevill, Duncan, Lahart, & Sandercock, 2017; Noonan, Boddy, Knowles, & Fairclough, 2016, 2017), there were inherent limitations. Specifically, the predominant focus was not comparing multiple fitness measures across socio-economic status, and the variation in health-related fitness variables included in these studies limits inter-study comparisons (Nevill et al., 2017; Noonan et al., 2016, 2017). Additionally, these studies neglected to include any measure of the muscular strength component of physical fitness (Brophy et al., 2012; Charlton et al., 2014; Nevill et al., 2017; Noonan et al., 2016, 2017). Research has purported the need to assess this fitness component given its individual relationship with health outcomes (Ortega et al., 2008; Ruiz, Castro-Piñero, et al., 2009; Volaklis et al., 2015), with grip strength, specifically, having direct associations with cardio-metabolic disease risk and early mortality (Ortega et al., 2008; Volaklis et al., 2015). Moreover, Brophy et al. (2012), and Charlton et al. (2014), used the number of children receiving free school meals and school's postcode as a proxy measure of socio-economic deprivation. However, using a solely income-based proxy for deprivation (i.e. free school meals) overlooks the multiple dimensions/domains of deprivation that affect children (Noble, Wright, Smith, & Dibben, 2006), while using school postcode has been shown to lack effectiveness as children may travel across postcodes to school (Boddy, Hackett, et al., 2010). It is therefore postulated that levels of health-related fitness, particularly grip strength, should be measured across socio-economic status groups with use of the index of multiple deprivation to predict health inequalities in children.

The aim of this study was to investigate socio-economic and sex differences in selected health-related fitness measures in 9-12-year-old children.

6.3 Methods

6.3.1 Participants and Settings

A sample of 3,407 children (49.3% boys; aged 10.5 ± 0.6 years) participated in the study. Data were collected on children as part of the Swan-Linx health, fitness and lifestyle programme (Sheldrick, Tyler, Mackintosh, & Stratton, 2018; Tyler, Mackintosh, Brophy, et al., 2015; Tyler, Mackintosh, Palmer, Jones, & Stratton, 2015), which includes selected measures from the *SportsLinx* project (Stratton et al., 2007; Taylor et al., 2004). Data were captured during Fitness Fun Days between 2013-2017, across 29 socio-demographically representative schools, in South Wales, UK. All measures were conducted in school sport halls or at Swansea University's Indoor Training Centre, by trained researchers, local community coaches and Active Young People officers. Written informed head teacher and parental consent, as well as child assent, were obtained prior to data collection. The Swan-Linx programme has institutional Research Ethics Committee approval (PG/2014/007; PG/2014/37) for its procedures and measures.

6.3.2 Measures and Procedures

Health-related Fitness:

Three components of health-related fitness were measured, namely cardiorespiratory fitness, muscular strength and body mass index, using standardised methods (Council of Europe, 1993; Sheldrick et al., 2018; Taylor et al., 2004; Tyler, Mackintosh, Palmer, et al., 2015).

20m Multistage Shuttle Run Test (20m MSRT): The 20m MRST, shown to be valid and reliable in similarly-aged children, assessed cardiorespiratory fitness (Mayorga-Vega, Aguilar-Soto, & Viciano, 2015; Riddoch, 1990). To ensure a consistent pace and to give encouragement, a researcher completed the test with the participants. The total number of completed shuttles was recorded.

Handgrip Strength Test: The Handgrip Strength test was used to measure upper body muscular strength and provide an indication of overall muscular strength (Ortega et al., 2008; Wind et al., 2010). Using hand dynamometers [Takei Corp Ltd., Tokyo,

Japan], each participant's grip strength was measured in kilograms.

Anthropometric Measures: All anthropometric measures were taken by the same trained researcher using standard techniques (Lohman, Roche, & Martorell, 1988). Each participant's stature, sitting stature, and body mass were measured to the nearest 0.1cm and 0.1kg, using a portable stadiometer [Seca 213 portable stadiometer, Seca Ltd, Birmingham, UK], a sitting stature stadiometer [Harpenden Sitting Height Table, Holtain Ltd, Pembrokeshire, UK], and electronic weighing scales [Seca 876, Seca Ltd, Birmingham, UK]. Body Mass Index (BMI) was calculated ($\text{BMI} = \text{body mass (kg)}/\text{stature}^2 (\text{m}^2)$) as a proxy measure of body composition, and BMI z-scores were derived using the UK 1990 growth reference curves (Cole et al., 1995). Sex-specific maturation offset regression equations using interactions between body mass, stature, sitting stature, lower limb length (difference between stature and sitting stature) and decimal age, were used to predict each participant's age from peak height velocity (Mirwald et al., 2002). This calculation was used as a proxy measure of biological maturation.

Deprivation:

Welsh Index of Multiple Deprivation (WIMD): The Welsh Index of Multiple Deprivation (WIMD) is used as the official measure of deprivation in Wales (Welsh Government, n.d.), in which eight domains of deprivation (employment; health; income; housing; community safety; access to services; education and the environment) are considered to provide an area-based socio-economic measurement (Noble et al., 2006). WIMD ranks have been calculated for each of Wales' 1,909 Lower-Layer Super Output Areas (LSOA), with the most deprived LSOA ranking 1, and the least deprived ranking 1,909. Participants' home postcodes were used to calculate WIMD scores, which were then split into WIMD quintile one (WIMD 23-226), two (WIMD 227-710), three (WIMD 711-982), four (WIMD 983-1604) and five (WIMD 1605-1908), with 20% of participants in each group.

6.3.3 Statistical Analyses

Descriptive statistical analysis, mean and standard deviation (mean \pm SD), were initially performed on all measures. Statistical analysis was completed using SPSS, version 25 (IBM SPSS Statistics Inc., Chicago, IL, USA), with a significance level of 0.05. Participant results were included in each respective analysis if they had sufficient data for the variable concerned. Due to the nested nature of the data (i.e. participants nested within schools), intraclass correlation coefficients (ICC) were calculated prior

to further analyses to determine the proportion of the total variability in BMI z-score, grip strength, and 20m MSRT that could be attributed to school. Subsequently, a two-way Analysis of Variance (ANOVA) was conducted to examine whether there was a statistically significant difference in BMI z-score by sex and WIMD quintiles. A two-way Analysis of Covariance (ANCOVA) was used to investigate if there were differences in grip strength by sex and WIMD quintiles, while adjusting for BMI z-score. BMI z-score was chosen as a covariate due to the known positive correlation of BMI and grip strength during childhood, irrespective of sex (Milliken et al., 2008). A second two-way ANCOVA examined the effect of sex and WIMD quintiles on shuttles achieved in the 20m MSRT, after adjusting for maturation, given its potential confounding effect. The suitability of the covariates in each ANCOVA model was investigated by ensuring the homogeneity of regression slopes assumption was met, as determined by a comparison between the two-way ANCOVA model with and without interaction terms. If an interaction effect was present in the ANCOVA model, analysis of simple main effects of both WIMD quintiles and sex was performed, with statistical significance receiving a Bonferroni adjustment ($p < 0.05 \div \text{number of simple main effects made}$), to correct for the testing of multiple simple main effects. In the case of a non-significant interaction effect, analyses of main effects were performed. If a significant simple main effect or significant main effect was present, pairwise comparisons were run with p-values Bonferroni-adjusted ($p < 0.05 \div \text{number of comparisons}$). Hedges' g was used as a measure of effect size for pairwise comparisons.

6.4 Results

The descriptive characteristics of the study participants are presented in Table 5. Intraclass correlation coefficients for BMI z-score (ICC = 0.014), grip strength (ICC = 0.083), and 20m MSRT (ICC = 0.032) demonstrated little statistical dependency in the data, suggesting that the largest proportion of variance lies among participants.

Table 5. Descriptive statistics (mean \pm SD) for Study 3 participants

Variables	Boys	Girls	All
Age (years)	10.6 \pm 0.6	10.5 \pm 0.6	10.5 \pm 0.6
Stature (cm)	142.3 \pm 7.3	142.8 \pm 7.9	142.6 \pm 7.6
Sitting Stature (cm)	74.4 \pm 4.1	74.9 \pm 4.5	74.6 \pm 4.4
Body Mass (kg)	38.4 \pm 10.1	39.7 \pm 10.3	39.0 \pm 10.2
Lower Limb Length (cm)	67.9 \pm 5.0	68.0 \pm 5.1	67.9 \pm 5.1
BMI (kg·m ⁻²)	18.7 \pm 3.7	19.3 \pm 3.8	19.0 \pm 3.8
BMI z-score	0.6 \pm 1.3	0.6 \pm 1.3	0.6 \pm 1.3
Maturity Offset (years)	-2.8 \pm 0.6	-1.2 \pm 0.7	-2.0 \pm 1.0
Deprivation Score (WIMD)	858.7 \pm 598.6	869.6 \pm 588.9	864.2 \pm 593.7
20m MSFT Score (shuttles)	35.0 \pm 18.3	24.7 \pm 12.9	29.8 \pm 16.6
Grip Strength (kg)	16.9 \pm 4.1	16.0 \pm 3.9	16.4 \pm 4.0

The interaction effect between WIMD quintiles and sex on BMI z-scores was not statistically significant ($F_{(4,3318)} = 1.240$, $p = 0.292$). Means \pm SD for BMI z-scores, for boys and girls in WIMD quintile one to five are shown in Table 6. Main effects analysis displayed a significant main effect of WIMD quintiles on BMI z-scores ($F_{(4,3318)} = 3.488$, $p = 0.008$). Pairwise comparisons revealed a statistically significant difference of 0.215 (95% CI, 0.12 to 0.419; $p = 0.029$, $g = 0.170$) between mean BMI z-score in WIMD quintile 3 and WIMD quintile 5, but there were no other significant mean differences in BMI z-score between WIMD quintile groups. There was no significant main effect of sex on BMI z-scores ($F_{(4,3318)} = 0.811$, $p = 0.368$).

Table 6. Mean \pm SD BMI z-scores by WIMD quintile (deprivation) groups

Quintiles	BMI z-scores		
	Boys	Girls	All
WIMD quintile 1 ^o (n = 699, 51.9% boys)	0.60 \pm 1.34	0.66 \pm 1.32	0.63 \pm 1.33
WIMD quintile 2 (n = 676, 49.1% boys)	0.61 \pm 1.32	0.66 \pm 1.36	0.63 \pm 1.34
WIMD quintile 3 (n = 620, 48.7% boys)	0.78 \pm 1.37	0.56 \pm 1.26	0.67 \pm 1.32
WIMD quintile 4 (n = 671, 48.0% boys)	0.53 \pm 1.27	0.47 \pm 1.30	0.50 \pm 1.29
WIMD quintile 5 [†] (n = 662, 50.8% boys)	0.48 \pm 1.21	0.44 \pm 1.18	0.46 \pm 1.19

Note: WIMD quintile 1^o = most deprived, WIMD quintile 5[†] = least deprived

Given that there was homogeneity of regression slopes ($F_{(9,3281)} = 1.066$, $p = 0.385$), BMI z-scores were included as a covariate in the ANCOVA model for grip strength. Adjusted means \pm SE (by BMI z-score) for grip strength are shown in Table 7. There was no statistically significant two-way interaction between WIMD quintiles and sex on grip strength, while adjusting for BMI z-scores ($F_{(4,3290)} = 0.696$, $p = 0.595$). The main effect of sex was statistically significant ($F_{(4,3290)} = 39.336$, $p < 0.001$, $g = 0.205$), with boys adjusted mean grip strength 0.823 (95% CI, 0.565 to 1.080) kg higher than girls. There was also a statistically significant main effect of WIMD quintile on grip strength ($F_{(4,3290)} = 3.919$, $p = 0.004$). Pairwise comparisons revealed a statistically significant difference of 0.718 (95% CI, 0.143 to 1.294; $p = 0.005$, $g = 0.174$) kg between adjusted mean grip strength in WIMD quintile 1 and WIMD quintile 5, but no other significant differences in grip strength between WIMD quintiles were found.

Table 7. Adjusted mean \pm SE grip strength (adjusted by BMI z-scores) by WIMD quintile (deprivation) groups

Quintiles	Adjusted Mean Grip Strength (kg)		
	Boys	Girls	All
WIMD quintile 1 [◊] (n = 695, 51.8% boys)	16.4 \pm 0.2	16.0 \pm 0.2	16.2 \pm 0.1
WIMD quintile 2 (n = 672, 49.0% boys)	16.7 \pm 0.2	16.0 \pm 0.2	16.4 \pm 0.2
WIMD quintile 3 (n = 616, 48.5% boys)	16.7 \pm 0.2	15.7 \pm 0.2	16.2 \pm 0.2
WIMD quintile 4 (n = 660, 47.7% boys)	17.0 \pm 0.2	16.0 \pm 0.2	16.5 \pm 0.2
WIMD quintile 5 [†] (n = 658, 51.1% boys)	17.4 \pm 0.2	16.4 \pm 0.2	16.9 \pm 0.2

Note: WIMD quintile 1[◊] = most deprived, WIMD quintile 5[†] = least deprived

Given that the interaction term between 20m MSRT and maturation was not significant ($p > 0.05$), there was homogeneity of regression slopes and so maturation was included as a covariate in the ANCOVA model for 20m MSRT. Adjusted means \pm SE (by maturation) for 20m MSRT score are shown in Table 8. There was a statistically significant interaction between WIMD quintiles and sex on 20m MSRT, while controlling for maturation ($F_{(4,3182)} = 2.659$, $p = 0.031$). Simple main effects revealed that sex was statistically significant in WIMD quintile group 1 ($F_{(1,3182)} = 11.437$, $p = 0.001$, $g = 0.319$), group 2 ($F_{(1,3182)} = 35.100$, $p < 0.001$, $g = 0.534$), group 3 ($F_{(1,3182)} = 11.560$, $p = 0.001$, $g = 0.297$), group 4 ($F_{(1,3182)} = 32.391$, $p < 0.001$, $g = 0.475$), and group 5 ($F_{(1,3182)} = 42.138$, $p < 0.001$, $g = 0.566$), with boys achieving a significantly greater 20m MSRT score than girls in each WIMD quintile group. Moreover, simple main effects showed that WIMD quintile group was statistically significant in girls ($F_{(4,3182)} = 13.793$, $p < 0.001$), and boys ($F_{(4,3182)} = 3.481$, $p = 0.008$). For girls, WIMD quintile 1 had a significantly lower adjusted mean 20m MSRT score than WIMD quintile 5 (3.694 shuttles, 95% CI, 0.230 to 7.157; $p = 0.028$, $g = 0.292$), but there were no statistically significant differences between adjusted mean 20m MSRT scores when comparing all other WIMD quintiles. For boys, WIMD quintile 1 had a significantly lower adjusted mean 20m MSRT score than WIMD quintile 2 (4.380 shuttles, 95% CI, 0.969 to 7.792; $p = 0.003$, $g = 0.251$), WIMD quintile 4 (6.544

shuttles, 95% CI, 3.121 to 9.967; $p < 0.001$, $g = 0.379$), and WIMD quintile 5 (7.921 shuttles, 95% CI, 4.529 to 11.313; $p < 0.001$, $g = 0.469$). Further, boys' adjusted mean 20m MSRT score in WIMD quintile 2 was significantly lower than WIMD quintile 5 (3.541 shuttles, 95% CI, 0.066 to 7.016; $p = 0.042$, $g = 0.200$). Finally, boys' WIMD quintile 3 had a significantly lower adjusted mean 20m MSRT score than both WIMD quintile 4 (4.307 shuttles, 95% CI, 0.747 to 7.867; $p = 0.007$, $g = 0.229$) and WIMD quintile 5 (5.684 shuttles, 95% CI, 0.969 to 7.792; $p = 0.003$, $g = 0.310$). All other pairwise comparisons between quintiles for boys' adjusted mean 20m MSRT score were non-significant.

Table 8. Adjusted mean \pm SE 20m MSRT (adjusted for maturation) by WIMD quintile (deprivation) groups

Quintiles	Adjusted Mean 20m MSRT (shuttles)		
	Boys	Girls	All
WIMD quintile 1 [◇] (n = 670, 51.6% boys)	29.0 \pm 0.9	24.4 \pm 0.9	26.7 \pm 0.6
WIMD quintile 2 (n = 635, 49.4% boys)	33.4 \pm 0.9	25.1 \pm 0.9	29.3 \pm 0.6
WIMD quintile 3 (n = 605, 48.8% boys)	31.3 \pm 1.0	26.5 \pm 0.9	28.9 \pm 0.6
WIMD quintile 4 (n = 646, 48.0% boys)	35.6 \pm 0.9	27.8 \pm 0.9	31.7 \pm 0.6
WIMD quintile 5 [†] (n = 637, 50.4% boys)	37.0 \pm 0.9	28.1 \pm 0.9	32.5 \pm 0.6

Note: WIMD quintile 1[◇] = most deprived, WIMD quintile 5[†] = least deprived

6.5 Discussion

The aim of this study was to investigate socio-economic and sex differences in selected health-related fitness measures in 9-12-year-old children. In this study, there was a large variance in WIMD scores (SD = 598.6) to classify socio-economic quintiles, with children living in one of the most deprived (WIMD = 23), to the most affluent areas (WIMD = 1908) in Wales.

The current results showed that, regardless of sex, children in the middle quintile

(WIMD quintile 3) had a significantly higher mean BMI z-score than their least deprived counterparts (WIMD quintile 5), in contrast to studies that have found no association between school deprivation (school postcode) or individual deprivation levels (free school meals) and weight status in children (Brophy et al., 2012; Dummer et al., 2005). Nonetheless, the current results are in line with a recent study on school children in England, as well as a systematic review, that show an inverse association between socio-economic status and BMI/weight status (Nevill et al., 2017; Shrewsbury & Wardle, 2008). It is important to note, however, that there were no other significant mean differences in BMI z-score between WIMD quintile groups. In fact, there was little mean difference between WIMD quintiles 1, 2 and 3, as well as between WIMD quintiles 4 and 5. This highlights that there appears to be a split in BMI z-scores, with children in the bottom 3 quintiles (middle to high deprivation), having a higher mean BMI z-score than the top 2 quintiles (least deprived). A similar split between high to middle deprivation and middle to low deprivation was also apparent in a study that showed a significant difference between socio-economic quartile 1 and 2 (least to middle affluent) and quartile 3 and 4 (middle to most affluent) (Fairclough, Boddy, Hackett, & Stratton, 2009). Since national surveillance evidence shows little difference in physical activity levels across socio-economic status in Wales (Tyler et al., 2016; Welsh Government, 2015a, 2017), it can be speculated that the socio-economic divide seen in the present study may be related to other factors. One such factor may be dietary intake, as a systematic review provided evidence that low socio-economic status was associated with poorer diets (Hanson & Chen, 2007). Further research investigating the concurrent effect of dietary consumption and possible other influencing factors on weight status and fitness by socio-economic status is warranted.

Congruent with previous studies conducted measuring muscular strength and cardiorespiratory fitness in children (Cohen et al., 2010; De Miguel-Etayo et al., 2014; Noonan et al., 2017), the current results showed that boys had a significantly higher grip strength and achieved a significantly greater 20m MSRT score than girls. Moreover, research has shown that boys have higher physical activity levels compared to girls (Tyler et al., 2016; Welsh Government, 2015a, 2017). Given that physical activity has a reciprocal relationship with physical fitness levels (Janssen & Leblanc, 2010; Ortega et al., 2008), these reported differences may be a contributing factor to the differences in fitness levels between girls and boys seen in the current study.

While muscular strength has been shown to be positively associated with socio-economic status in children (Freitas et al., 2007; Jiménez-Pavón et al., 2010), our results

were converse in that there was only a significant difference in grip strength between least deprived (WIMD quintile 5) and most deprived (WIMD quintile 1). Moreover, both girls and boys had a significantly higher 20m MSRT score in the least deprived group (WIMD quintile 5) compared to most deprived group (WIMD quintile 1), which agrees with other work (Mutunga et al., 2006). It is noteworthy that significant differences in 20m MSRT score were more apparent with increases in socio-economic status in boys. Specifically, most deprived boys (WIMD quintile 1) had a significantly lower 20m MSRT score than all other groups of boys except for boys in the middle quintile (WIMD quintile 3), while boys in the middle quintile (WIMD quintile 3) had a significantly lower 20m MSRT score than their less deprived counterparts (WIMD quintile 4 and 5). While there is little difference in physical activity levels across socio-economic status in Wales, a difference in sport participation has been reported, with around a ten percent difference in the number of children who are hooked on sport (take part in sport on 3 or more occasions a week in an extracurricular (school-based) or a community club setting) in the least deprived compared to most deprived areas in Wales (Sport Wales, 2015c; Tyler et al., 2016). Given that a recent study has shown that, regardless of socio-economic status, participation in sport is associated with better physical fitness when compared to non-participation (Golle, Granacher, Hoffmann, Wick, & Muehlbauer, 2014), the differences in fitness levels found between the least and most deprived children may be, at least in part, due to differences in sport participation.

Although not the primary aim, the present study enabled comparisons of health-related fitness data obtained to international normative values. In comparison to European sex- and age-specific normative values on over 200,000 grip strength test performances of children and young people aged 9-17 years across 30 countries (Tomkinson, Carver, et al., 2017), girls' and boys' mean grip strength score in the present study were in the 50th and 40th centile, respectively. Further, in comparison to international sex- and age-specific normative values on over 1 million 20m MSRT performances of 9-17 year olds from 50 countries (Tomkinson, Lang, Tremblay, et al., 2017), girls and boys achieved a level commensurate with the 40th and 50th centile, respectively. Therefore, cardiorespiratory fitness and muscular strength levels of girls and boys in the current study were low to moderate in comparison to international norms.

The current study showed that inequalities exist in body mass index, muscular strength, and cardiorespiratory fitness across socio-economic status and sex in children. Moreover, overall health-related fitness levels of children involved in the study were low to

moderate in comparison to international normative values (Tomkinson, Carver, et al., 2017; Tomkinson, Lang, Tremblay, et al., 2017). Given the negative implications of low physical fitness levels on health, focused services and interventions should work to improve physical fitness levels, and specifically aim to close the gap in inequalities, particularly in areas of high deprivation and in girls. These results also provide evidence for the importance spending time in vigorous intensity activities, specifically those that strengthen muscle in children, and indicate that this should be a goal in current and future health promotion policies.

6.5.1 Limitations

It is important to note that the current study is not without limitations. The cross-sectional study design of this study does not allow for causality to be determined, and therefore future investigations into the causes of (i) the potential socio-economic divide in BMI z-scores, (ii) the more pronounced differences in 20m MSRT by socio-economic status in boys compared to girls and (iii) the lack of significant difference in 20m MSRT between boys in most deprived and middle quintiles, perhaps considering any differences in physical activity, sport participation and exercise levels across specific groups. Moreover, although the measures used in this study are valid and used in many large-scale studies, future research should aim to include more objective measures of physical fitness (e.g. using treadmill based VO_2 peak assessments) and body composition (e.g. skinfolds and circumferences, or dual-energy X-ray absorptiometry (DEXA)), to assess fat and fat-free mass and percentage body fat. However, capturing this information on such large-scale data would be cost and time intensive.

6.6 Conclusion

The present study was one of the first large-scale studies to investigate differences in body mass index, muscular strength and cardiorespiratory fitness by sex and different levels of socio-economic status. In accord with previous research, boys had significantly higher muscular strength and cardiorespiratory fitness than girls. Children in the middle quintile (WIMD quintile 3) had a significantly higher mean BMI z-score than those in the least deprived quintile (WIMD quintile 5). Most deprived children (WIMD quintile 1) had significantly lower muscular strength and cardiorespiratory fitness than their least deprived counterparts (WIMD quintile 5). Overall, these results show that inequalities exist between socio-economic status and sex in selected health-related fitness measures and should be used to inform focused services and interventions to improve current health inequalities and future health implications.

6.7 Summary: Study 3

This study aimed to investigate socio-economic and sex differences in selected health-related fitness measures in 9-12-year-old children.

Data were captured on 3,407 children (49.3% boys; aged 10.5 ± 0.6 years) as part of the serial Swan-Linx programme between 2013-2017. Three components of health-related fitness were measured, namely cardiorespiratory fitness (20m multistage shuttle run test; 20m MSRT), muscular strength (handgrip strength) and body mass index (stature and body mass). Participants' home postcodes were used to calculate Welsh Index of Multiple Deprivation (WIMD) scores, and to split participants into quintile groups. A two-way Analysis of Variance examined differences in BMI z-score by sex and WIMD quintiles. Two-way Analysis of Covariances (ANCOVAs) investigated the effect of sex and WIMD quintiles on grip strength, adjusting for BMI z-score, and on shuttles achieved in the 20m MSRT, adjusting for maturation.

Regardless of sex, children in the middle quintile had a significantly higher mean BMI z-score ($p = 0.029$) than their least deprived counterparts. There was a significant increase in grip strength ($p = 0.005$) and 20m MSRT (boys $p < 0.001$; girls $p = 0.028$) between most and least deprived quintiles. Significant differences in 20m MSRT score were more apparent with increases in socio-economic status in boys. Overall, results showed that inequalities exist and should be used to inform focused services and interventions to improve current and future health inequalities.

Thesis Map

	Study	Outcomes
1	Results from the Active Healthy Kids Wales 2016 Report Card on Physical Activity for Children and Youth	<p>Aim</p> <p>To consolidate and translate research related to physical activity among children and youth in Wales and to synthesise national surveillance data from several surveys in order to assign grades to physical activity/inactivity behaviours and influences indicators, as well as to examine trends or inequalities in the data.</p> <p>Key Findings</p> <p>Grades were assigned as follows; overall physical activity levels, D+; organized sport participation, C; active and outdoor play, C; active transportation, C; sedentary behaviours, D-; physical literacy, INC; family and peer influences, D+; school, B; community and the built environment, C; and national government policy, strategies and investments, B-.</p>
2	Ten-year Secular Changes in Selected Health and Fitness Parameters of 10-11 Years Old Swansea School Children – 2003-2013	<p>Aim</p> <p>To highlight the secular changes in selected health and fitness measures (body mass index, prevalence of overweight and obesity, and grip strength) in 10-11 year old Swansea school children, using data obtained in 2003 and 2013.</p> <p>Key Findings</p> <p>BMI z-scores, as well as prevalence of overweight and obesity, decreased significantly between 2003 and 2013 for both boys and girls. After BMI z-scores adjustment, grip strength decreased significantly for boys, but not for girls.</p>
3	A Cross-Sectional Study on the Socio-economic and Sex Differences in Health-Related Fitness Measures in School Children	<p>Aim</p> <p>To investigate socio-economic and sex differences in selected health-related fitness measures (body mass index, MSRT, grip strength) in 9-12-year-old children.</p> <p>Key Findings</p> <p>Regardless of sex, children in the middle quintile had a significantly higher mean BMI z-score than their least deprived counterparts. There was a significant increase in grip strength and 20m MSRT between most and least deprived quintiles. Significant differences in 20m MSRT score were more apparent with increases in socio-economic status in boys.</p>

4	A Dynamic Assessment of Children's Physical Competence: The Dragon Challenge	<i>Aim</i>	<p>1. To develop a dynamic measure of physical competence that requires a participant to demonstrate fundamental, combined and complex movement skills, and assessors to score both processes and products (Dragon Challenge).</p> <p>2. To assess the psychometric properties of the Dragon Challenge in 10-14 year old children.</p>
<i>Key Findings</i>			
5	Youth Physical Competence Promotion Model: A Quantitative Investigation into Modifiable Factors	<i>Aim</i>	<i>Key Findings</i>

7 Study 4

In the previous years, two task and finish groups (in 2001 and 2013) recommended to Welsh Government that ‘physical literacy’ should be the highest priority in education, sport and health policy. Consequently, Sport Wales acted as the lead organisation in promoting physical literacy within Wales. The organisation received significant funding from the Welsh Government to deliver long term improvements in physical literacy and to increase physical activity among children in schools in Wales, helping younger generations to be hooked on sport for life and to adopt healthy lifestyles.

In 2013, Sport Wales convened a Physical Literacy Expert group comprising of academics and professionals from schools, community, sport, and health, who created a physical literacy framework to drive the work across Wales forward. Two main outcomes from this group were; 1) that physical literacy was a lifelong concept and needed to be considered using a ‘cradle to grave’ approach, and 2) that a stronger evidence base was required on physical literacy, particularly on school children. As such, there was a growing interest from parents, teachers, sports coaches, health professionals and researchers regarding children’s levels of physical literacy and in particular physical competence. In the Sport Wales School Sport Survey, additional questions related to physical literacy such as confidence in trying new activities (confidence) and whether PE and school sport helped them to follow a healthy lifestyle (knowledge and understanding), were included and completed by children and young people. While these questions were informative on assessing parts of the physical literacy spectrum (confidence, knowledge and understanding), there was no measure of physical competence. As a result, academics from Swansea, Liverpool John Moores and Glyndwr Universities worked with practitioners and professionals from schools and community sport to develop a robust measure of physical competency for 10-14 year old children – the Dragon Challenge. Study 4 discusses the development, validity and reliability of this tool.

7.1 A dynamic assessment of children’s physical competence: The Dragon Challenge

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7.2 Introduction

The International Physical Literacy Association defines physical literacy as the motivation, confidence, physical competence, knowledge and understanding to value and take responsibility for engagement in physical activities for life (International Physical Literacy Association, 2016). Such a definition describes the multidimensional and complex nature of physical literacy, highlighting the purported importance of physical literacy as a precursor to physical activity (Edwards et al., 2016). Therefore, given that physical activity has been shown to result in numerous health benefits (Jurbala, 2015), the promotion of physical literacy is fundamental for physical activity-associated health benefits. According to Lundvall (2015), accurate assessment of physical literacy is essential, and there is a need to develop valid tools that effectively and efficiently assess each of the affective, cognitive, and psychomotor domains in order to evaluate whether programmes are successful (Corbin, 2016).

One of the key elements of physical literacy is physical competence, which, even within itself, is a multidimensional concept. Whitehead (p204; 2010), describes physical competence as “the sufficiency in movement vocabulary, movement capacities and developed movement patterns plus the deployment of these in a range of movement forms.” Specifically, movement vocabulary refers to the repertoire of movements that one can perform, and can be expanded through experience and progressive challenge in the deployment of a wide range of movement capacities/skills and movement patterns (Whitehead, 2010).

Movement capacities are the integral abilities that make it possible to improve and develop physical competence (Whitehead, 2010). These capacities or skills consist of three interrelated constructs: fundamental or simple movement skills (FMS) (balance, core stability, coordination, speed variation, flexibility, control, proprioception, and power), combined movement (poise, fluency, precision, dexterity, and equilibrium), and complex movement (bilateral coordination, inter-limb coordination, hand-eye coordination, turning, twisting and rhythmic movements, and control of acceleration/deceleration) (Giblin et al., 2014; Whitehead, 2010). FMS comprise locomotor skills (moving the body in any direction from one point to another), stability skills (balancing the body in one place or while in motion), and object control/manipulative skills (handling or controlling objects with the hand, foot, or an implement) (Gallahue et al., 2012; Giblin et al., 2014; Whitehead, 2010). Children have the potential to master FMS by 7-8 years of age, with FMS developing rapidly between 3 and 8 years (Gallahue et al., 2012).

The procurement of movement capacities/skills and the ability to utilise them to produce movement patterns are essential for the development of physical competence within physical literacy capability (Whitehead, 2010). Movement patterns, described as general (e.g., sending, striking, receiving, running, jumping, rotating), refined (e.g., throwing, dribbling, catching, sprinting, hopping, turning) and specific (i.e. sport-specific movement patterns), are amalgamations of movement that stem from the selection and application of movement skills (Whitehead, 2010). More refined and specific movement patterns are achieved when fundamental, combined and complex movement skills are utilised (Corbin, 2016; Giblin et al., 2014; Whitehead, 2010). There is therefore much need to develop combined and complex movement skills, to take part in more advanced physical activities in a variety of settings (i.e., land, water, air, ice) (Jurbala, 2015; Whitehead, 2010) and movement forms (i.e., adventure, aesthetic, athletic, competitive, fitness and health, interactional/relational) (Whitehead, 2010), and thus this development is posited to be a foundation stone in developing physical literacy in maturing children (Corbin, 2016; Giblin et al., 2014).

Whilst many existing land-based movement skill assessments measure physical competence (Giblin et al., 2014; Robinson & Randall, 2017), the majority involve the performance of discrete skills in isolation (e.g., the Test of Gross Motor Development (TGMD-2/3) (Ulrich, 2000), the Bruininks-Oseretsky Test of Motor Proficiency, Second Edition (BOT-2) (Bruininks & Bruininks, 2005), the Movement Assessment Battery for Children-2 (MABC-2) (Henderson et al., 2007), CS4L: Physical Literacy Assessment for Youth Fun (PLAYfun) (Cairney et al., 2018), Passport for Life: Movement Skills Assessment (Physical and Health Education Canada (PHE Canada, 2014)). This static testing environment limits transferability and applicability to multi-skill and sport environments and does not assess combined and complex movement skills (Giblin et al., 2014). Moreover, it has been suggested that considering skills in isolation ignores a constraints-based approach (Newell, 1986), in which environmental constraints are taken into account, and by doing so this approach is not 'authentic'. An authentic environment is one that is developmentally-appropriate and considers the interaction of the individual and the environment, as well as the specified movement skill (Barnett, Stodden, et al., 2016; Newell, 1986). Performance of movement skills in isolation does not incorporate the measurement of an individuals' ability to alter and combine movement skills according to the task at hand and the environment, both of which are important traits to advance physical competence and progress one's physical literacy (Whitehead, 2010). Finally, assessments that measure skills in iso-

lation have also been criticised for being time- and resource-intensive (Giblin et al., 2014; Wiart & Darrah, 2001). Thus, tools that measure physical competence in children aged over 8 years should assess fundamental, combined and complex movement skills in a dynamic and more authentic environment, in an efficient manner. The assessment of refined and specific movement patterns in a variety of novel combinations and complexities will more accurately reflect physical competence.

Physical competence can be evaluated by process- or product-based assessments (Bruininks & Bruininks, 2005; Cairney et al., 2018; Henderson et al., 2007; Physical and Health Education Canada (PHE Canada), 2014; Ulrich, 2000). Primarily process-based assessments (e.g., TGMD-2, CS4L: PLAYfun, Passport for Life: Movement Skills Assessment) measure how children move and provide qualitative information on the technique of the movement patterns (Hardy et al., 2010). This type of assessment can be sensitive to assessor experience and subjectivity (Schoemaker et al., 2012). On the other hand, assessments that are primarily product-based (e.g., MABC-2, BOT-2) are usually quantitative and focus on the outcome of the movement (Logan et al., 2017), but potentially lack the sensitivity needed to identify individual differences in movement abilities (Giblin et al., 2014). The equivocal relationship between process- and product-based assessments of physical competence has resulted in the use of combined assessments for measuring physical competence (Logan et al., 2017; Robinson et al., 2015; Rudd et al., 2016). Therefore, a single assessment that aims to equally assess both the process/technique and the product/outcome aspects of physical competence is warranted.

The assessment of physical competence can be formative or summative. Specifically, formative assessments measure current levels of performance to identify a baseline and the individual needs of children, enabling the development of an educational programme catered to those children, whereas summative assessments are used to measure progress of a child at the end of a period of education (Gallahue & Donnelly, 2007). Therefore, a physical competence assessment tool developed within the context of education, should aim to be both formative and summative, so that it can be used as a self-referenced assessment, which is able to compare a child's pre- and post-educational programme performance.

Recently, the Canadian Agility Movement Skill Assessment (CAMSA) was developed and validated to assess physical competence in 8-12-year-old children for surveillance, as well as examining movement skills over time (Longmuir et al., 2017). This

assessment requires a series of seven movement tasks (two-footed jump, side slide, catch, throw, skip, hop, and kick) to be completed in a continuous dynamic obstacle course to create a more authentic environment and to assess combined and complex movement skills. Performances are assessed using the time taken to complete an obstacle course consisting of 14 process/technique- and product/outcome-based criteria (Longmuir et al., 2017). Whilst this assessment has shaped the way towards assessing movement skills in a dynamic fashion, there are noteworthy design limitations of the CAMSA. For example, the course does not include any specific stability movement skill tasks and there are a greater number of locomotor movement skill tasks than object control movement skill tasks. In addition, the scoring is unbalanced between locomotor and object control criterion, as well as between product- and process-based criterion. As such, an assessment targeting older aged children and adolescents (10-14 years), with a more balanced design, is warranted.

Therefore, the first aim of this study was to develop a dynamic assessment to measure elements of physical competence (Dragon Challenge; DC), that requires the demonstration of fundamental (e.g., balance), combined (e.g., poise) and complex (e.g., rhythmic movements) movement skills through refined (complex) and specific movement patterns (e.g., hopping, turning, jumping patterns), measured by both product/outcome- and process/technique-based evaluations. The study sought to produce an assessment that would be feasible for national surveillance and could be used as both a formative and summative assessment in the educational context. The second aim of the study was to assess the psychometric properties of the DC in measuring physical competence in children, including construct and concurrent validity and test-re-test and inter- and intra-rater reliability, as per American Educational Research Association, American Psychological Association, and National Council on Measurement in Education guidelines.

7.3 Methods

This study involved three phases. Phase one included the development of the DC, including the review process to establish face and content validity. Phase two included gathering surveillance data and establishing construct validity and phase three involved investigating concurrent validity, test-retest, inter-rater and intra-rater reliability. The COSMIN (Consensus-based Standards for the Selection of Health Measurement Instruments) framework was used to guide the design and evaluate the methodological quality (Mokkink et al., 2010). This study would achieve a quality level of good to excellent on the COSMIN rating system. The protocol, validation and relia-

bility study of the DC were approved by the institutional Research Ethics Committee (PG/2014/37 & PG/2014/39). Informed parental consent and participant assent were obtained prior to participation.

7.3.1 Phase 1. Development of the DC

Programme of Research to Develop the DC: Paediatric exercise science academics, practitioners, and professionals from schools and community sport ($n > 30$) co-designed a land-based measure of elements of physical competence in children (10-14 years of age) that was aligned to physical education and sport coaching school and community programmes that aimed to promote physical literacy. The circuit of tasks were collectively named the 'Dragon Challenge' to align with the Sport Wales' Dragon multi-skills and sport initiative (<http://sport.wales/community-sport/education/dragon-multi-skills-sport.aspx>). The DC assessment tool underwent several stages of development. The first stage involved desk research, where an initial review was conducted on existing movement skill assessment tools that inform physical competence (Bruininks & Bruininks, 2005; Gallahue et al., 2012; Henderson et al., 2007; NSW Department of Education and Training, 2000; Ulrich, 2000). From this, each of the 10 tasks/skills in the first protocol of the DC were examined for initial content validity. Subsequently, the second stage involved an iterative process of designing and testing the DC, whereby each task and its subsequent process- and product-based criteria were defined, with significant input from expert practitioners in physical education and community sport from across Wales ($n > 30$). This stage included six iterations of protocol development, with the overall aim being to refine and assess the suitability of tasks, and to establish whether each individual task, and the overall assessment tool, could be used as an appropriate measure of children's physical competence. The initial tasks selected were therefore modified to incorporate refined and specific movement patterns that would adequately challenge children's fundamental, combined and complex movement skills, developed during physical education curriculum and the Dragon Sport multi-skill and sport initiative. The protocol development process was completed over a 12-month period (July 2013 to 2014). Two hundred and eighty-eight children aged 10-12 years took part in the DC pilot testing days. The final DC protocol included nine tasks ordered to create continuity of movement and allow assessors to accurately observe children's performances (see Appendix VI). Process/technique and product/outcome indicators for the assessment criteria were continuously developed and refined by discussion and consensus until the DC was finalised.

Establishing Face and Content validity: Face and content validity refers to how well a

specific assessment measures what it intends to measure. The group of University paediatric exercise specialists, with expertise in physical education, physical competence and physical literacy research were involved in reviewing the DC. Face and content validity was qualitatively reviewed by a trained researcher (Lawrence Foweather) with over 10 years' experience of physical competence and movement skill assessment. In addition, internationally recognised experts (n=5) in childhood movement skill, fitness, and physical literacy assessment within the personal networks of this researcher, advised Lawrence Foweather and provided comments (in confidence) to inform the review process.

The review process comprised of in situ observations of children's performances, and a subjective analysis of the assessment protocol. Checks were made for the inclusion of critical movement tasks in accordance with a developmentally-appropriate assessment of physical competence through comparisons with existing assessment tools (Bruininks & Bruininks, 2005; Gallahue et al., 2012; Henderson et al., 2007; NSW Department of Education and Training, 2000; Ulrich, 2000). Further checks were made to ensure that the DC circuit of tasks were in line with physical education curriculum content for children in this age range (10-14 years old), in that it required the utilisation of fundamental, combined, and complex movement capacities/skills to perform refined and specific movement patterns. Finally, clarity in behavioural definition (descriptions of the movement characteristics associated with the performance of each task) used in the assessment criteria was ensured.

Face validity: Children complete the nine DC tasks in a set sequence; Table 9 shows the primary and secondary skill types necessary for each component. Several tasks (five out of nine) require children to perform a combination of skills and movement patterns, to demonstrate competence. Components of motor fitness such as agility, balance, coordination, strength, power, speed and reaction time are all widely utilised within the DC. The DC challenges children to demonstrate movement skills and motor fitness in combinations of different movement patterns and in continuous fashion as opposed to discrete skills in assessments such as the TGMD-2 or MABC-2. Further, children are required to demonstrate movement concepts and attributes expected of a physically competent person, (i.e., "movement with poise, economy and confidence in a wide variety of challenging situations" and "sensitive perception in 'reading' all aspects of the physical environment, anticipating movement needs or possibilities and responding appropriately to these, with intelligence and imagination") (Whitehead, 2010). Thus, the DC tasks were representative of multiple elements of physical com-

petence.

Table 9. Description of Dragon Challenge protocol and tasks and types of skills utilised during each task

DC Task	Description	Stability	Locomotor	Object Control
1. Balance Bench	Runs to bench. Walks length of narrow side of bench beam, completing a 360° turn at mark before dismounting at the end of the bench and returning to iPad. If the child falls off then task is ended and the child returns to iPad immediately.	●	○	
2. Core Agility	Runs to gym mat. Completes 4 positions (dish on back - arch on front - dish on back - arch on front), rotating both ways. Returns to iPad.	●		
3. Wobble Spot	Runs to wobble spot and picks up bean bag on floor. Completes 5 bean bag passes around body whilst balancing on wobble spot on one leg. Returns to iPad. If child falls off after starting, the task is ended and the child returns to the iPad immediately.	●		○
4. Overarm Throw	Collects tennis ball from hoop. Overarm throw at target from badminton court service box line approx. 10m from target. The child does not collect ball and returns to iPad.			●
5. Basketball Dribble	Collects basketball from hoop. Dribbles around coloured spots on floor in z formation (body <u>and</u> ball move around outside of spots) with either hand. After dribbling around last spot, finishes with a dribble down the middle, returning ball to hoop/iPad.		○	●
6. Catch	Runs forward and collects tennis ball from floor. Underarm throws ball against rebound net to catch from any distance without a bounce. Does not collect ball if dropped. Returns to iPad.		○	●
7. T-Agility	Completes t-agility run, facing forwards throughout. Returns to iPad.	○	●	
8. Jumping Patterns	Runs to coloured foot markers and hurdles. Follows jumping pattern sequence to finish (2-footed jump over hurdle → 2-footed landing → 2 left hops → 2 right hops → 2-footed jump over hurdle → 2-footed landing. Returns to iPad.	○	●	
9. Sprint	Runs through start gate and then 10m sprint acceleration to finish line.		●	

Note: ● = primary skill category involved in task; ○ = secondary skill category involved in task

Content Validity: Internationally recognised experts (n=5) in childhood movement skill, fitness, and physical literacy assessment, confirmed that the DC was a valid and practical measure of physical competence, and that each task was challenging, achievable, and age-appropriate. Further, the tool was praised for its feasibility and efficiency.

DC task design: Balancing, running, hopping, jumping, throwing, dribbling, catching and sprinting are common skills that are assessed in isolation within existing movement skill assessment tools (Bruininks & Bruininks, 2005; Gallahue et al., 2012; Henderson et al., 2007; NSW Department of Education and Training, 2000; Ulrich, 2000). Whilst the DC incorporates these skills and others, it is conducted in a continuous fashion within a timed trial, thus tasks are dynamic, sequential and include additional layers of complexity. The order of the tasks is standardised (as displayed in Table 9) but children perform the challenge under the illusion that the order is random, except for the final task, which is always the sprint (note, the full demonstration is in a different order to the standardised protocol). Each subsequent task is displayed on an iPad/tablet. Thus, the DC also explores perception-action coupling, as participants must coordinate recognising environmental information and the associated movement responses to such information, in order to complete the goal of each task.

Children observed a demonstration of each DC task and then the full DC. An introduction and demonstration video (see Appendix VI) of the DC was produced to ensure consistent administration and adequate demonstrations of the tasks were provided to the children in line with those outlined in the DC manual. In addition, the full video of the completion of the DC (see Appendix VI) could be shown. Children were given two practice attempts at each challenge task but they did not practise the challenge in full.

Children typically took between 90 and 240 seconds to complete the DC. An assessor used a stopwatch to record completion time (to nearest 0.1s). Each assessment required at least one trained assessor and one administrator. An additional assistant was required to supervise the non-participating children. The space requirement was designed to fit within the dimensions of a full-sized badminton court (13.4m x 6.1m), which most school gymnasiums and community sports centres are likely to have. Taken together, including set-up (15 minutes), the viewing of the videos and questions (26 minutes for a full group), and practice and completion of DC (approximately 10 to 12 children in 60 minutes), the total assessment time per child was approximately 10 minutes. For further information on the DC assessment including equipment list and descriptions of the assessment, see Appendix V.

DC assessment criteria: The DC indicators included both technical (process) and outcome (product) characteristics of movement performance (Table 10). Due to the

challenges of real-time observation, the number of criterion to be assessed was limited to three per task (i.e., two technical/process criteria and one outcome/product criteria). Given that there were several technical characteristics that could be examined for each task, it was important that assessment criteria represented critical features of movement. Existing assessment tools and reference to developmental sequences were used to inform these decisions (Bruininks & Bruininks, 2005; Gallahue et al., 2012; Henderson et al., 2007; NSW Department of Education and Training, 2000; Ulrich, 2000). A global review of the criteria (Table 10) suggested that the majority assess important characteristics of each task.

The DC was scored in three ways in accordance with the instructions specified within the DC manual (see Appendix V): (1) **TECHNIQUE** - 1 point was given for each of the technical/process criterion (n=18) successfully demonstrated by the child (2) **OUTCOME** - 2 points were awarded for each outcome/product criterion (n=9) successfully demonstrated by the child, and (3) **TIME** - time taken to complete the DC was recorded and converted to a score (higher scores for faster time). Each of these constructs (technique, outcome, and time) was scored out of 18 in order to be equally weighted, and then summed to give a total score (DC total score=54). Cut-points were also produced for the DC total score using the 33rd, 66th and 95th percentiles based on pilot data collected across Wales in 2015. These percentile thresholds were selected to categorise typically-developing 10-12 year old children into Bronze, Silver, Gold and Platinum bands, thus making results easier to interpret by children, coaches, teachers, and parents.

Table 10. Dragon Challenge assessment criteria

DC Task	Technique Criterion	Technique Criterion	Outcome Criterion
1. Balance Bench	1.1 Moves without hesitation up to turn	1.2 Body posture stable <i>(head & trunk stable, minimal arm flailing)</i>	1.3 Walks length of beam, completes full turn at 3/4 mark without falling off, dismounts at end zone
2. Core Agility	2.1 Hands & legs extended & held with tension, with shoulders & feet off the floor	2.2 Controlled & fluent transition through shapes	2.3 Completes 4 positions in correct order <i>(dish on back - arch on front - dish on back - arch on front)</i> , rotating both ways
3. Wobble Spot	3.1 Non-support foot does not touch support leg/foot/wobble spot/floor	3.2 Body & head are stable/still	3.3 Completes 5 bean bag passes around body whilst balancing on wobble spot on one leg # 'correct' passes 0 1 2 3 4 5
4. Overarm Throw	4.1 Throwing arm moves in a backward arc to initiate throw <i>(shoulder rotates)</i>	4.2 Steps with the foot opposite throwing hand towards target	4.3 Overarm throw directly hits target <i>(ball should not bounce prior to hitting target)</i>
5. Basketball Dribble	5.1 Pushes ball with fingertips <i>(not slapping at the ball)</i>	5.2 Controlled directional dribbling	5.3 Dribbles around all spots using either hand. <i>(body & ball must move around outside of spots)</i> . Cannot catch ball/use two hands simultaneously
6. Catch	6.1 Feet move in line with rebound	6.2 Catches ball with hands only <i>(must be caught without a bounce)</i>	6.3 Successful catch off rebound net <i>(must be caught without a bounce)</i>
7. T-Agility	7.1 Plants & drives off outside foot <i>(right to left & left to right)</i>	7.2 Side-stepping on balls of feet <i>(right to left & left to right; feet don't cross)</i>	7.3 Moves through all points of 'T' facing forwards <i>(must enter both right & left court tramlines)</i>
8. Jumping Patterns	8.1 Arms drive over first hurdle <i>(elbows bent & arms swing to produce force)</i>	8.2 Rhythmical pattern throughout	8.3 Completes jumping pattern sequence correctly. No contact with hurdles
9. Sprint	9.1 Drives off balls of feet, leaning forwards	9.2 Arms bent, driving forward & backwards <i>(arms bent at approx. right angles)</i>	9.3 Runs through start gate & then through to finish <i>(must be running not walking)</i>

7.3.2 Phase 2. Surveillance Data and Construct Validity

Participants and Procedures: During the development process, a workforce of physical educators, coaches and other professionals in related areas, were trained to implement the DC assessments across four regions of Wales: South East, Mid & West, Central, and North. At least two assessors from each region received >20 hours of training led by Lawrence Foweather, and were only permitted to do assessments once reaching an 85% level of agreement (3 errors per child) with Lawrence Foweather. This workforce acted as ‘gold standard assessors’ within their respective region, and rolled out training to their constituents, with use of a gold standard training package for other professionals to be assessed against. In total, circa 200 assessors were trained across the four regions. Trained regional teams then conducted DC assessments in schools between January 2015 and November 2016.

The DC was scored in accordance with the instructions specified within the DC manual. For comparison purposes, technique and outcome scores were also summed to give sub-category scores for tasks primarily utilising stability (sum of technique and outcome criteria in tasks 1-3), object control (sum of technique and outcome criteria in tasks 4-6), and locomotor skills (sum of technique and outcome criteria in tasks 7-9; Table 9). Overall, data were successfully collected for analysis on 4,355 participants from 66 schools, aged 10-12 years from Central South Wales (n=875), South East Wales (n=1,238), Mid and West Wales (n=1,336) and North Wales (n=906). Within this overall sample, 49.9% of participants were boys, 7.2% were black and minority ethnic, 20.7% classified as special educational needs/additional learning needs status and 13.2% received free school meals (a proxy measure used in Wales for social economic status).

Construct Validity: To ascertain whether the DC behaves according to motor development theory (Gallahue et al., 2012), total, technique/process, outcome/product, and time scores, as well as successful demonstration of each criterion, were examined by sex (boys expected to have higher scores than girls) and age/school level differences (older children expected to achieve higher scores than younger children). The factor structure of the DC was also examined. As each of the nine DC tasks required combinations of movement skills (Table 10), it was hypothesised that the outcome may not produce a 3-factor structure (namely, stability, object control and locomotor), but instead produce a structure with a greater number of factors, each representing a distinct combination of skills. It was also hypothesised that these factors would load on to a higher order factor, namely physical competence.

7.3.3 Phase 3. Concurrent Validity and Reliability

Participants and Procedures: A convenience sample of 50 participants (52% boys) aged 12.66 ± 1.51 years from two schools performed the DC twice with a one-week interval between the two DC data collection days. Participants were from school year 5 (n=8; 10.32 ± 0.31 years), year 6 (n=8; 11.28 ± 0.32 years), year 7 (n=10; 12.42 ± 0.23 years), year 8 (n=12; 13.48 ± 0.25 years), and year 9 (n=12; 14.51 ± 0.26 years) and had a mixture of abilities according to their physical education teacher. Each attempt at the DC was video recorded using two tripod-mounted video cameras [Sony Handycam, Model HDR-PJ410, Sony Corporation, Tokyo, Japan]. Scoring was completed by an expert assessor (>50 hours of DC training and in situ experience), trained assessor (20 hours of DC training and in situ experience), and/or newly trained assessor (5 hours of DC training), in accordance with the instructions specified within the DC manual. For comparison purposes, sub-category scores were also calculated for tasks primarily utilising stability skills, object control skills, and locomotor skills.

On a separate day, participants performed two trials of the Test of Gross Motor Development-2 (TGMD-2) (Ulrich, 2000) and the Stability Skills Assessment (SSA) (Rudd et al., 2015), previously validated movement skills assessments, which required the completion of six locomotor (run, gallop, hop, leap, horizontal jump, and slide) and six object control (striking a stationary ball, stationary dribble, catch, kick, overhand throw, and underhand roll) subtest skills, and three gymnastics training stability skills (rock, log- roll, and back support), respectively. Participants were video recorded using two tripod-mounted video cameras [Sony Handycam, Model HDR-PJ410, Sony Corporation, Tokyo, Japan]. A trained assessor scored the video footage based on the presence (=1) or absence (=0) of three to five component (process) criteria for each of the skills in both trials of the TGMD-2 and SSA (Rudd et al., 2015; Ulrich, 2000). ‘Overall skill scores’, the cumulative criteria scores for each skill across both trials, were calculated for each of the TGMD-2 and SSA tasks. ‘Overall skill scores’ for each of the TGMD-2 (=0-96) and SSA (=0-24) tasks were summed to give a ‘combined TGMD-2 and SSA overall skill score’ (=0-120). Lastly, subcategory skill scores were also calculated for stability, object control and locomotor skill tasks (e.g., ‘overall skill scores’ for each of the stability tasks were summed to give a stability skill score).

Concurrent validity: Concurrent validity refers to the extent to which the DC relates to a previously validated movement skills assessment. This was first investigated at an overall level by examining the extent to which the week 1 DC scores related to the

TGMD-2 and SSA scores. Further, the relationship between week 1 DC score and TGMD-2 skill score was investigated.

The TGMD-2 and SSA were used as the comparison measures for concurrent validity for the following reasons: (i) the validity and reliability for both assessments have been established (Rudd et al., 2015; Ulrich, 2000); (ii) the TGMD-2 has been extensively used as an assessment for movement skill performance; (iii) the SSA provides additional stability tasks that are missing in the TGMD-2, and tasks have been validated to add to the measurement model (Rudd et al., 2015); (iv) the TGMD-2 and SSA have been used in movement skill research in school settings; (v) the TGMD-2 has been validated for children/adolescents of similar age (Issartel et al., 2017); (vi) although the skills in both the TGMD-2 and SSA are completed in isolation by children, the skills assessed within these batteries more closely align with those included in the DC than those used in other movement skill assessments available at the time of study development (no comparative dynamic movement assessments were available); (vii) while TGMD-2 and SSA are considered primarily process-based assessments, there are a selection of product-based criteria (e.g., hop three consecutive times, dribble ball for four consecutive bounces (Ulrich, 2000), log roll for four complete rotations, and back support held for 30 seconds (Rudd et al., 2015)), thus aligning scoring more closely with the DC.

Reliability: Test-re-test reliability was examined by the stability of participants' DC results over the repeated rounds of assessment. The same expert assessor scored each participant on both time-points, and the level of agreement was evaluated.

Inter-rater reliability was explored by investigating how consistent two or more assessors' scores were when observing the same performance. Inter-rater reliability was first assessed at an overall level using the scores given by 3 separate expert assessors on video footage from 12 participants of mixed ability completing the DC. In order to investigate whether amount of training and experience received by assessors influenced reliability, additional analyses examined consistency between expert and newly trained assessor and between expert and trained assessor when scoring DC for 12 and 15 participants, respectively.

Intra-rater reliability was examined by investigating the consistency between scores, when the same trial was scored by the same rater on two separate occasions. Three expert assessors each scored video footage of 12 participants of mixed ability com-

pleting the DC on two occasions, with a one-week interval between viewings, and levels of agreement between the scores for each assessor was evaluated.

7.3.4 Statistical Analyses

Descriptive statistics are presented as mean \pm SD. All statistical tests, with the exception of the confirmatory factor analysis (CFA), were completed using SPSS, version 24 [IBM SPSS Statistics Inc., Chicago, IL, USA]. The CFA was completed using lavaan version 0.6-1 (Rosseel, 2012), in R version 3.5.0 [R Core Team, Vienna, Austria]. In all analyses, data were assessed for violation of the assumptions of normality and statistical significance was set at $p < 0.05$. Participant results were included in each respective analysis if they had sufficient data for the variable concerned.

Surveillance Data and Construct Validity: The proportion of participants successfully demonstrating each DC criterion for the surveillance data was calculated. Two-way ANOVA tests and Chi-squared tests were used to explore the effects of sex and school level on DC scores and on each individual DC task assessment criterion, respectively.

A Principal Component Analysis (PCA) was performed on all DC binary criteria scores. The suitability of each PCA was assessed prior to analysis by inspection of the correlation matrix (each variable required to have at least one correlation with another variable above $r = 0.3$), further the Kaiser-Meyer-Olkin (KMO) measure needed to be at least 0.6, for sampling adequacy (Kaiser, 1974). In addition, Bartlett's test of sphericity had to achieve statistical significance ($p < 0.05$). To establish DC components, the eigenvalue-one criterion was used (Kaiser, 1960), as well as visual inspection of the scree plot. A Varimax orthogonal rotation was used to aid interpretation, where applicable. A loading of .40 or greater was used to align items onto factors.

Based on the results of the PCA, a CFA was performed to cross-validate the factor structure of the DC. As binary criteria scores were used as indicator variables, weighted least square mean and variance adjusted estimator was used to fit the model. By default, the factor loading of the first indicator of a latent factor was fixed to 1, thereby fixing the scale of the latent factor. Error terms from the indicator variables were allowed to co-vary within the same factor. Comparative fit index (CFI), Tucker-Lewis Index (TLI), and root mean square error of approximation (RMSEA) were used to assess model fit, with CFI and TLI of >0.95 and RMSEA of <0.05 , indicating a good fit (Hu & Bentler, 1999).

Concurrent Validity: A Pearson's product-moment correlation was used to investigate the strength of relationships between DC, and TGMD-2 and SSA scores and sub-category scores. An r value of, 0-0.19, 0.2-0.39, 0.4-0.59, 0.6-0.79, >0.8 were interpreted to demonstrate no, low, moderate, moderately-high and high correlation coefficients, respectively (Cohen, 1992).

Reliability: To ascertain evidence for test-retest, inter-rater and intra-rater reliability, intraclass correlation coefficients (ICC), two-way random single measures for absolute agreement (ICC 2,1), with 95% confidence intervals (95%CI), were used to evaluate the level of agreement of week 1 and week 2 scores and of rater scores. A reflect and square root transformation was used where data was non-parametric. For presentation purposes, these variables were transformed for analysis and back transformed. Intraclass correlation coefficients below .50 indicate poor reliability, those between .50 and .75 indicate moderate reliability, and those above .75 indicate good reliability (Portney & Watkins, 1993). ICC results that indicated moderate reliability ($<.75$) were further examined using a t-test to investigate if there was a statistically significant mean difference between scores.

7.4 Results

Table 11 provides age and sex characteristics of participants that took part in the DC for phase 2 and 3 of the study. On the basis of missing demographic characteristics, 95 participants from the surveillance data were excluded from all construct validity analyses ($n=4260$), except for the PCA and CFA ($n=4,355$).

Table 11. Age (mean \pm SD) and sex (%) of participants who took part in the Dragon Challenge in study phase 2 and 3

	Boys	Girls	Total
<u>Construct validity</u>			
<i>Primary School Level</i>			
Age (years)	10.9 \pm 0.5	10.9 \pm 0.5	10.9 \pm 0.5
n (%)	765 (51.9)	709 (48.1)	1,474 (100)
<i>Secondary School Level</i>			
Age (years)	11.7 \pm 0.3	11.6 \pm 0.3	11.7 \pm 0.3
n (%)	1,362 (48.9)	1,424 (51.1)	2,786 (100)
<i>Total</i>			
Age (years)	11.4 \pm 0.5	11.4 \pm 0.5	11.4 \pm 0.5
n (%)	2,127 (49.9)	2,133 (50.1)	4,260 (100) †
<u>Concurrent validity</u>			
Age (years)	12.8 \pm 1.5	12.1 \pm 1.6	12.5 \pm 1.6
n (%)	25 (55.6)	20 (44.4)	45 (100)
<u>Test-retest reliability</u>			
Age (years)	12.7 \pm 1.6	12.3 \pm 1.5	12.5 \pm 1.5
n (%)	22 (50.0)	22 (50.0)	44 (100)
<u>Inter-rater reliability</u>			
<i>Expert Assessor vs Newly Trained Assessor</i>			
Age (years)	11.6 \pm 1.6	12.0 \pm 2.1	11.8 \pm 1.8
n (%)	7 (46.7)	8 (53.3)	15 (100)
<i>Expert Assessor vs Trained Assessor</i>			
Age (years)	13.9 \pm 0.5	13.0 \pm 0.6	13.5 \pm 0.7
n (%)	6 (50)	6 (50)	12 (100)
<u>Inter-rater reliability and Intra-rater reliability (video analysis)</u>			
<i>3 x Expert Assessors</i>			
Age (years)	11.3 \pm 1.0	11.4 \pm 1.1	11.3 \pm 1.0
n (%)	6 (50)	6 (50)	12 (100)

Note: † On the basis of missing sex, 95 participants from the surveillance data were excluded from all construct validity analyses, except for the PCA and CFA. For these analyses n=4,355.
Expert assessors: >50 hours of DC training and in situ experience; Trained assessor: 20 hours of DC training and in situ experience; Newly trained assessor: 5 hours of DC training.

7.4.1 Construct Validity

Mean scores and standard deviations for DC surveillance data, broken down by sex and school level, are presented in Table 12. There were no statistically significant interactions between sex and school level on DC scores. Therefore, analyses of main effects for each variable were performed. Boys scored higher than girls for all score categories, except stability skills, and secondary school level children scored higher than primary school level children on all score categories apart from time score. The proportion of children who successfully demonstrated each DC criterion, as well as statistically significant sex and school level differences, highlighted by the Chi-squared test, are shown in Table 13.

Table 12. Descriptive statistics (mean \pm SD) for Dragon Challenge (surveillance data) score categories

Score Category	Score Range	Boys (n=2,127)	Girls (n=2,133)	Primary (n=1,474)	Secondary (n=2,786)	Total (n=4,260)
DC Total Score	0-54	33.8 \pm 8.6**	31.1 \pm 8.3	31.7 \pm 8.3	32.8 \pm 8.6**	32.4 \pm 8.5
Technique Score	0-18	10.9 \pm 3.7**	9.6 \pm 3.8	9.9 \pm 3.9	10.4 \pm 3.8**	10.2 \pm 3.8
Outcome Score	0-18	11.0 \pm 3.8**	10.5 \pm 3.6	10.3 \pm 3.6	11.0 \pm 3.7**	10.8 \pm 3.7
Time Score	0-18	11.9 \pm 2.5**	11.0 \pm 2.6	11.5 \pm 2.4	11.4 \pm 2.7	11.4 \pm 2.6
Stability Score	0-12	6.2 \pm 3.3	6.6 \pm 3.3**	6.1 \pm 3.3	6.6 \pm 3.3**	6.4 \pm 3.3
Object Control Score	0-12	7.6 \pm 3.2**	5.5 \pm 3.1	6.3 \pm 3.3	6.7 \pm 3.3**	6.5 \pm 3.3
Locomotor Score	0-12	8.1 \pm 2.9	8.0 \pm 2.8	7.8 \pm 2.9	8.2 \pm 2.8**	8.1 \pm 2.9

Note: Stability skills = sum of technique and outcome criteria in tasks 1-3; Object Control skills = sum of technique and outcome criteria in tasks 4-6; Locomotion skills = sum of technique and outcome criteria in tasks 7-9. Differences examined using two-way analysis of variance (ANOVA) test.

* = significant sex/school level difference ($p < 0.05$)

** = significant sex/school level difference ($p < 0.001$)

Primary = Primary school-aged children

Secondary = Secondary school-aged children/young people

Table 13. Proportion (%) of children successfully demonstrating each Dragon Challenge criterion (surveillance/normative data)

DC Task		All (n=4,260)	Boys (n=2,127)	Girls (n=2,133)	Primary (n=1,474)	Secondary (n=2,786)
1. Balance bench						
1.1'	Moves without hesitation up to turn	85.5	83.8	87.1*	84.5	86.0
1.2'	Body posture stable	39.0	37.0	40.9*	39.5	38.7
1.3 [◊]	Walks length of beam, completes full turn at 3/4 mark without falling off, dismounts at end zone	42.7	41.7	43.6	42.7	42.6
2. Core Agility						
2.1'	Hands & legs extended & held with tension, with shoulders & feet off the floor	37.3	31.4	43.2**	33.0	39.6**
2.2'	Controlled & fluent transition through shapes	41.1	37.9	44.3**	41.0	41.1
2.3 [◊]	Completes 4 positions in correct order, rotating both ways	75.4	71.8	78.9**	70.5	77.9**
3. Wobble Spot						
3.1'	Non-support foot does not touch support leg/foot/wobble spot/floor	50.5	50.3	50.8	46.0	52.9**
3.2'	Body & head are stable/still	48.9	48.3	49.5	44.5	51.3**
3.3 [◊]	Completes 5 bean bag passes around body whilst balancing on wobble spot on one leg	50.8	50.5	51.1	46.3	53.2**
4. Overarm throw						
4.1'	Throwing arm moves in a backward arc to initiate throw	57.6	73.2**	42.0	56.2	58.3
4.2'	Steps with the foot opposite throwing hand towards target	73.1	86.6**	59.7	71.7	73.9
4.3 [◊]	Overarm throw directly hits target	47.9	53.5**	42.3	44.2	49.8*
5. Basketball Dribble						
5.1'	Pushes ball with fingertips	61.4	75.7**	47.1	57.7	63.3**
5.2'	Controlled directional dribbling	71.1	77.2**	65.0	67.1	73.2**
5.3 [◊]	Dribbles around all spots using either hand. Cannot catch ball/use two hands simultaneously	64.2	69.9**	58.5	62.4	65.1
6. Catch						
6.1'	Feet move in line with rebound	62.9	73.4**	52.5	60.8	64.1*
6.2'	Catches ball with hands only	32.3	40.7**	24.0	31.0	33.0
6.3 [◊]	Successful catch off rebound net	35.6	44.4**	26.9	34.8	36.0
7. T-Agility						
7.1'	Plants & drives off outside foot	29.6	33.3**	25.9	27.8	30.5
7.2'	Side-stepping on balls of feet	50.0	51.2	48.9	45.8	52.3**
7.3 [◊]	Moves through all points of 'T' facing forwards	58.6	59.5	57.8	52.9	61.7**
8. Jumping Patterns						
8.1'	Arms drive over first hurdle	72.2	71.9	72.5	72.9	71.9
8.2'	Rhythmical pattern throughout	64.2	62.2	66.1*	60.0	66.4**
8.3 [◊]	Completes jumping pattern sequence correctly. No contact with hurdles	65.5	62.4	68.6**	63.7	66.5
9. Sprint						
9.1'	Drives off balls of feet, leaning forwards	70.2	74.2**	66.3	69.8	70.5
9.2'	Arms bent, driving forward & backwards	76.6	79.1**	74.1	78.3	75.7
9.3 [◊]	Runs through start gate & then through to finish	97.0	97.4	96.6	97.0	97.0

Note.

◊ = product/outcome characteristic/quality indicator (outcome of movement)

▪ = process/technique characteristic/quality indicator (technique or movement form)

* = significant sex/school level difference (p < 0.05)

** = significant sex/school level difference (p < 0.001)

Primary = Primary school-aged children

Secondary = Secondary school-aged children/young people

PCA on DC criteria scores: PCA was found to be suitable according to the correlation matrix, overall KMO (.76) and Bartlett's test of sphericity ($p < 0.001$). The PCA revealed nine components that had eigenvalues greater than one, 5.11, 2.53, 2.01, 1.83, 1.54, 1.42, 1.37, 1.19, 1.15, and which explained 18.94%, 9.39%, 7.46%, 6.76%, 5.71%, 5.24%, 5.09%, 4.40%, 4.26%, respectively. Visual inspection of the scree plot also indicated that nine factors should be retained. This nine-component solution explained 67.24% of the total variance and the rotated solution exhibited a simple structure. The interpretation of the data was consistent with the skill combinations the DC was designed to measure, with strong loadings of balance bench criteria scores on component one, core agility criteria scores on component two, wobble spot criteria scores on component three, overarm throw criteria scores on component four, basketball dribble criteria scores on component five, catch criteria scores on component six, t-agility criteria scores on component seven, jumping patterns criteria scores on component eight, sprint criteria scores on component nine. Component loadings of the rotated solution (Table 14) were all >0.4 .

Table 14. Rotated Component Matrix from Principal Component Analysis on Dragon Challenge criteria score

DC Task Criteria	Component								
	1	2	3	4	5	6	7	8	9
Balance Bench Technique 1	.473	.018	.103	.010	.094	.009	.022	.178	.136
Balance Bench Technique 2	.951	.075	.057	.043	.008	.031	.043	.003	.021
Balance Bench Outcome	.952	.061	.065	.040	.025	.042	.041	.016	.020
Core Agility Technique 1	.088	.744	.079	.028	.022	.002	.084	.107	.092
Core Agility Technique 2	.062	.798	.055	.042	.075	.037	.022	.096	.052
Core Agility Outcome	-.006	.661	.035	-.007	.082	.055	.089	.057	.044
Wobble Spot Technique 1	.088	.070	.974	.050	.056	.053	.048	.094	.062
Wobble Spot Technique 2	.087	.075	.963	.048	.056	.045	.043	.101	.066
Wobble Spot Outcome	.087	.068	.977	.051	.051	.049	.046	.095	.063
Overarm Throw Technique 1	-.023	-.015	.044	.755	.152	.076	.134	.044	.140
Overarm Throw Technique 2	.003	.019	.026	.764	.084	.101	.003	.009	.024
Overarm Throw Outcome	.074	.039	.038	.544	.058	.039	.012	.072	-.004
Basketball Dribble Technique 1	.021	.026	.032	.243	.674	.164	.058	.039	.102
Basketball Dribble Technique 2	.070	.113	.045	.102	.857	.109	.079	.085	.039
Basketball Dribble Outcome	.050	.074	.068	.029	.800	.067	.076	.087	.083
Catch Technique 1	.006	.074	.055	.142	.182	.676	.126	.058	.033
Catch Technique 2	.043	.018	.039	.060	.077	.931	.037	.051	.044
Catch Outcome	.035	.022	.040	.059	.075	.945	.030	.035	.044
T-Agility Technique 1	.030	.147	.044	.190	.075	.117	.608	.151	.160
T-Agility Technique 2	.046	.060	.042	.012	.065	.034	.819	.045	.060
T-Agility Outcome	.028	.036	.034	-.011	.066	.046	.822	.061	-.011
Jumping Patterns Technique 1	.078	.102	.059	.102	.081	.030	.125	.430	.350
Jumping Patterns Technique 2	.076	.127	.132	.068	.097	.075	.093	.851	.059
Jumping Patterns Outcome	.082	.116	.098	.038	.065	.052	.084	.871	.052
Sprint Technique 1	.045	.049	.073	.175	.106	.061	.116	.201	.689
Sprint Technique 2	.050	.053	.048	.103	.064	.032	.049	.122	.768
Sprint Outcome	.053	.062	.028	-.091	.026	.017	-.001	-.073	.604

Note. Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization. Rotation converged in 6 iterations.

CFA on the DC criteria scores: Based on the PCA results, CFA was conducted to confirm the nine-factor structure, as well as to examine whether the nine latent factors loaded onto a higher order factor (physical competence). Following the addition of three correlations between error terms within the same factor, the fit for the hypothesised model (Figure 5), was good (CFI, 1.00; TLI, 1.00; RMSEA, 0.038; 90%

confidence interval 0.037 - 0.040). Factor loadings ranged from 0.45 - 0.99, showing that the factor validity was acceptable to excellent.

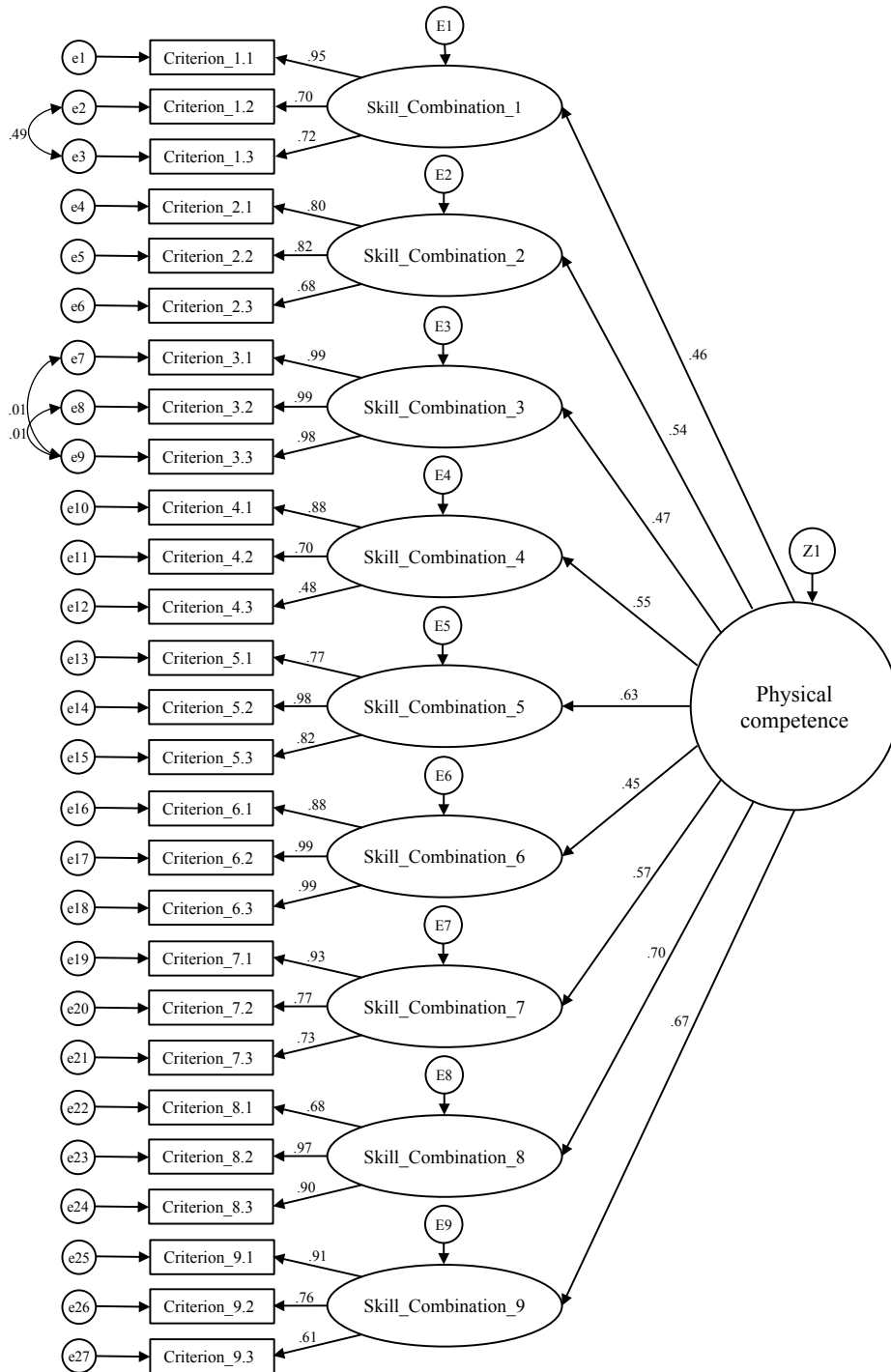


Figure 5. Factor structure of the Dragon Challenge

7.4.2 Concurrent Validity

Results for concurrent validity show that there was a significant high positive correlation between DC total score (35.9 ± 8.5) and ‘combined TGMD-2 and SSA overall skill score’ (72.5 ± 10.9 ; $r(43) = .86$, $r^2 = .74$, $p < 0.001$). Relationships for sub-category scores between DC and TGMD-2 and SSA skills scores, across stability tasks (7.2 ± 3.2 , 7.8 ± 3.7 ; $r(43) = .46$, $p = 0.001$), object control tasks (8.0 ± 3.4 , 32.5 ± 6.9 ; $r(43) = .83$, $p < 0.001$) and locomotor tasks (8.5 ± 2.5 , 32.2 ± 3.4 ; $r(43) = .60$, $p < 0.001$), showed significant moderate to high positive correlations. Finally, there was a significant high positive correlation between DC score (35.93 ± 8.54) and TGMD-2 ‘overall skill score’ (64.71 ± 8.66 ; $r(43) = .81$, $r^2 = .66$, $p < 0.001$).

7.4.3 Reliability

Test-Retest Reliability: The DC total score showed good test-retest reliability across the one-week interval (ICC = 0.80; 95%CI: 0.63, 0.90; $p < 0.001$). Evidence for test-retest reliability was good for technique scores (ICC = 0.77; 95%CI: 0.58, 0.88; $p < 0.001$), and high-moderate for time scores (ICC = 0.74; 95%CI: 0.57, 0.85; $p < 0.001$) and for outcome scores (ICC = 0.71; 95%CI: 0.52, 0.83; $p < 0.001$). Follow up t-tests revealed no significant mean difference in time score between test (12.18 points) and retest (12.93 points) scores ($t = .837$, $p = 0.41$) and no statistically significant mean difference in outcome score between the test (11.95 points) and retest (12.00 points) scores ($t = .103$, $p = 0.92$).

Further, test-retest reliability for skill sub-categories was good for object control skills score (ICC = 0.80; 95%CI: 0.67, 0.89; $p < 0.001$), high-moderate for locomotor skills score (ICC = 0.68; 95%CI: 0.49, 0.81; $p < 0.001$), and moderate for stability skills score (ICC = 0.60; 95%CI: 0.38, 0.76; $p < 0.001$). No significant mean difference was found in locomotor skills score between test (8.43 points) and retest (8.59 points) scores ($t = .525$, $p = 0.60$), nor in stability skills score between test (7.14 points) and retest (6.61 points) scores ($t = -1.25$, $p = 0.22$).

Inter-Rater and Intra-Rater Reliability: Inter-rater and intra-rater reliability on all comparison levels (Table 15) showed significant relationships and were classed as good (all ICCs $> .85$).

Table 15. Inter- and intra-rater reliability results for Dragon Challenge scores and sub-category scores

Reliability Test	Intraclass	95% CI		Strength of ICC
	Correlation	Lower	Upper	
Inter-rater Reliability				
Expert Assessor vs. Newly Trained Assessor				
Dragon Challenge Total Score	.950 **	.859	.983	Good
Technique Score	.839 **	.592	.942	Good
Outcome Score	.916 **	.742	.972	Good
Time Score ♦	-	-	-	-
Stability Skills Score	.787 **	.479	.923	Good
Object Control Skills Score	.945 **	.847	.981	Good
Locomotor Skills Score	.903 **	.742	.966	Good
Expert Assessor vs. Trained Assessor				
Dragon Challenge Total Score	.986 **	.951	.996	Good
Technique Score	.987 **	.957	.996	Good
Outcome Score	.920 **	.647	.979	Good
Time Score ♦	-	-	-	-
Stability Skills Score	.941 **	.792	.983	Good
Object Control Skills Score	.972 **	.907	.992	Good
Locomotor Skills Score	.964 **	.882	.990	Good
3 x Expert Assessors				
Dragon Challenge Total Score	.942 **	.837	.982	Good
Technique Score	.889 **	.718	.964	Good
Outcome Score	.899 **	.758	.967	Good
Time Score	.990 **	.973	.997	Good
Stability Skills Score	.850 **	.666	.949	Good
Object Control Skills Score	.918 **	.803	.973	Good
Locomotor Skills Score	.904 **	.753	.969	Good
Intra-rater Reliability				
Dragon Challenge Total Score				
Expert Assessor 1	1.000	-	-	Good
Expert Assessor 2	.990 **	.967	.997	Good
Expert Assessor 3	.999 **	.997	1.00	Good
Technique Score				
Expert Assessor 1	1.000	-	-	Good
Expert Assessor 2	.977 **	.904	.994	Good
Expert Assessor 3	.995 **	.984	.999	Good
Outcome Score				
Expert Assessor 1	1.000	-	-	Good
Expert Assessor 2	.947 **	.830	.984	Good
Expert Assessor 3	.989 **	.965	.997	Good
Time Score				
Expert Assessor 1	1.000	-	-	Good
Expert Assessor 2	1.000	-	-	Good
Expert Assessor 3	.991 **	.968	.997	Good
Stability Skills Score				
Expert Assessor 1	1.000	-	-	Good
Expert Assessor 2	.963 **	.878	.989	Good
Expert Assessor 3	.997 **	.991	.999	Good
Object Control Skills Score				
Expert Assessor 1	1.000	-	-	Good
Expert Assessor 2	.987 **	.955	.996	Good
Expert Assessor 3	.991 **	.969	.997	Good
Locomotor Skills Score				
Expert Assessor 1	1.000	-	-	Good
Expert Assessor 2	.962 **	.867	.989	Good
Expert Assessor 3	.975 **	.916	.993	Good

Note: * = $p < 0.05$; ** = $p < 0.001$. ♦ Time Score for the Expert Assessor vs. Newly Trained Assessor & Expert Assessor vs. Trained Assessor was not examined as times for each participant did not differ between assessors.

7.5 Discussion

Many current measures that inform physical competency as part of physical literacy assessments (Giblin et al., 2014; Robinson & Randall, 2017), in children and adolescents (Bruininks & Bruininks, 2005; Cairney et al., 2018; Henderson et al., 2007; Physical and Health Education Canada (PHE Canada), 2014; Ulrich, 2000), use isolated movement skills. Assessing discrete movement skills in isolation fails to account for the utilisation of combined and complex movement skills observed during physical activity and play, and needed to demonstrate physical competence and physical literacy (Whitehead, 2010). This study therefore aimed to develop the DC, a land-based dynamic measure of movement capacities/skills and movement patterns to assess elements of physical competence for 10-14 year olds.

The DC consists of nine tasks completed in a timed circuit, incorporating the utilisation of fundamental, combined and complex movement skills/capacities, to produce refined/complex and specific movement patterns. The DC can be used for assessment for learning (summative and/or formative), and as a national surveillance tool, that can be aligned to physical literacy programmes and physical education curriculum. The assessment criteria for the DC includes both technique (process) and outcome (product) indicators of movement performance, to provide a more complete picture of physical competence levels than currently used assessments that include primarily product- or process-based criteria (Bruininks & Bruininks, 2005; Cairney et al., 2018; Henderson et al., 2007; Physical and Health Education Canada (PHE Canada), 2014; Ulrich, 2000). Given that the DC is completed in a continuous circuit, tasks are dynamic, sequential and include additional layers of complexity in a more open 'authentic' environment than many existing measures that assess skills in isolation (Bruininks & Bruininks, 2005; Cairney et al., 2018; Henderson et al., 2007; Physical and Health Education Canada (PHE Canada), 2014; Ulrich, 2000). The DC is internally paced by the participants, whom are required to perform the tasks competently as fast as they can, thereby requiring a speed-accuracy trade-off. Although not directly measured, children also need to apply awareness of space, effort, and relationships to objects, goals, and boundaries to complete the challenge. Thus, within the DC, children are required to demonstrate movement concepts and attributes expected to be displayed by a physically competent child, for example, "movement with poise, economy and confidence in a wide variety of challenging situations" and "sensitive perception in 'reading' all aspects of the physical environment, anticipating movement needs or possibilities and responding appropriately to these, with intelligence and imagination" (Whitehead, 2010). Therefore, given the paucity of dynamic mea-

asures of movement skills/capacities and varying complexities of movement patterns to inform physical competence in children aged 10-14 years, this study fills a critical gap in the current literature in this field.

7.5.1 Construct Validity

Boys obtained significantly higher DC total, time, technique and outcome scores (Table 12). When broken down into sub-categories for comparison purposes, boys scored significantly higher than girls for tasks primarily utilising object control skills, with more detailed analysis (Table 13) showing that significantly more boys demonstrated proficiency at each of the assessment criteria for the overarm throw, basketball dribble and catch. These sex differences seem to be in line with numerous studies that have shown that boys outperform girls at object control skills (Barnett, van Beurden, Morgan, Brooks, & Beard, 2010; Cairney et al., 2018; Hume et al., 2008). On the other hand, girls scored significantly higher than boys for tasks primarily utilising stability skills, with significantly more girls demonstrating proficiency at each of the assessment criteria for core agility, as well as two of the assessment criteria for balance bench (criterion 1.1, 1.2; Table 13). While literature regarding sex differences in stability skills is less prevalent, young girls have been shown to display greater aptitude in process-oriented balancing skills (Pienaar, van Reenen, & Weber, 2017). In line with many studies that report no sex difference in locomotor skills (Barnett et al., 2010; Cairney et al., 2018; Hume et al., 2008), no significant difference was found in score between boys and girls for the locomotor skills sub-category. Moreover, girls typically excel at hopping and skipping in comparison to boys (Duger, Bumin, Uyanik, Aki, & Kayihan, 1999), supporting our findings that significantly more girls were proficient in two of the jumping patterns criteria (criteria 8.2 and 8.3). Considering these findings within the context of sex differences, the DC data are aligned to current literature on physical competence and movement skill competence.

Not only did secondary school level children obtain significantly higher DC total, technique and outcome scores compared to primary school level children, but they also scored significantly higher for object control skills, locomotor skills, and stability skills. Given that gross motor skill is developmental by age and stage, these results are standard within the literature (Gallahue et al., 2012). It is worth noting, however, that there was no significant difference in time score between primary and secondary school children. This was unexpected as previous studies have shown that running speed increases with age in children (Duger et al., 1999), although this discrepancy may be explained by the speed-accuracy trade-off made by children when completing

the DC. Thus, the higher accuracy of the secondary school level children at the DC tasks would have resulted in them taking longer to complete the tasks than the less accurate primary school level children. In summary, the findings in relation to sex and age differences are consistent with the literature.

Since the factor structure showed good model fit (Figure 5), it is reasonable to conclude that, unlike existing measures of physical competence (NSW Department of Education and Training, 2000; Rudd et al., 2015; Ulrich, 2000), the DC does not measure movement skills in isolated skill categories (i.e., stability, object control, locomotor skills), but rather requires the application of different combinations of movement skills for each task. Thus, the good fit of the model adds support to the design of the DC, as each task was selected to include the utilisation of skills from multiple movement categories to produce a series of movement patterns, and to the contention that the DC includes combined and complex movement skills. Additionally, the adequate factor loadings of each criterion scores onto its respective latent factor suggests that each criterion score is a good indicator, giving strength to the choice of criteria in the DC scoring system. Finally, as each of the nine first order latent factors (skill combinations) loaded onto a higher order latent factor (physical competence), it suggests that the combination of skills required by each DC task is needed for children to be physically competent. It must be noted, however, that physical competence is a multidimensional concept, therefore there are additional aspects of physical competence that are not represented in this model, for example, combinations of movement skills in different settings (water, air, ice), or movement forms (Jurbala, 2015; Whitehead, 2010).

7.5.2 Concurrent Validity

The DC total score showed a significant high positive relationship with the ‘combined TGMD-2 and SSA overall skill score’ and with ‘TGMD-2 overall skill score’, demonstrating strong concurrent validity between the assessments. When broken down across sub-categories, there was a significant high relationship between object control task scores in the DC and TGMD-2, whereas the DC stability and locomotor task scores showed only significant moderate relationships with those included in the TGMD-2 and SSA. While the stability and locomotor skills in the two assessments were matched for comparison purposes, the tasks required by the TGMD-2 and SSA compared to the DC were not identical. Moreover, as evidenced by the CFA on DC criteria scores, each of the DC tasks require a unique combination of movement skills/capacities to perform the refined/complex and specific movement patterns.

Therefore, the differences in stability and locomotor tasks in the TGMD-2 and SSA compared to the DC probably contributed to lowering the correlation of these subcategories. Nevertheless, all relationships, both in total scores and in subcategory scores, between the tools were significant moderate to strong, indicating that the DC ranks children in similar order to previously-validated tools.

7.5.3 Reliability

Test-retest reliability for both DC total and technique scores, was good across a one-week interval. However, time and outcome scores only showed high-moderate and moderate test-retest reliability, respectively. This may also be reflective of the speed-accuracy trade-off associated with the DC assessment tasks, with children perhaps making different decisions as to which to prioritise when performing the DC on multiple occasions. Upon further investigation, there was no significant difference in mean outcome or time scores between the test and retest, providing support that no learning effect was present. Since DC total score showed good test-retest reliability over a one-week interval, and all other scores showed moderate-to-good test-retest reliability, with statistics at least as strong as those for other measurement tools (Bruininks & Bruininks, 2005; Henderson et al., 2007; Longmuir et al., 2017; Ulrich, 2000; Wiart & Darrah, 2001), then the tenet that the DC is a stable measure is supported.

Inter-rater reliability was good for each of the DC total, time, technique, outcome, and sub-category scores when comparing three separate expert standard assessors' score. These levels of inter-rater reliability are similar to those of the TGMD-2, BOT-2 and MABC-2, but stronger than those of the CAMSA measurement tool (Bruininks & Bruininks, 2005; Henderson et al., 2007; Longmuir et al., 2017; Ulrich, 2000; Wiart & Darrah, 2001). Inter-rater reliability was also good for the DC total, technique, outcome, and subcategory scores, both when comparing the level of agreement of expert assessor's scores and newly-trained assessor's scores and when comparing the level of agreement of expert assessor's scores and trained assessor's scores. There was stronger reliability between the expert assessor and trained assessor than between the expert assessor and newly-trained assessor in all scores. This suggests that the additional field time that the trained assessor undertook compared to the newly-trained assessor may have resulted in more reliable assessments. Taken together, the inter-rater reliability results may imply that only one skilled assessor is needed to achieve a reliable assessment of participants taking part in the DC. Moreover, each of the three expert assessors' DC total, time, technique, outcome, and sub-category scores showed good intra-rater reliability, consistent with the levels of intra-rater reliability

of other measurement tools (Bruininks & Bruininks, 2005; Henderson et al., 2007; Longmuir et al., 2017; Ulrich, 2000; Wiart & Darrah, 2001), suggesting that the current DC assessment criteria are sufficiently clear to allow an accurate assessment of a participant in one viewing.

7.5.4 Feasibility

There are currently no guidelines for determining the optimal duration of an assessment tool, therefore the purpose, information yielded, and time for completion should all be considered when examining assessment feasibility. Assessing a child in the DC required at least one assessor and administrator, with an additional assistant to supervise the non-participating children, in line with most other assessments (Bruininks & Bruininks, 2005; Henderson et al., 2007; Longmuir et al., 2017; Ulrich, 2000). While this may seem burdensome, the balance between developing sufficient data for surveillance and adequate detailed insight to provide feedback and promote learning was achieved using this approach.

Children typically only took between 90 and 240 seconds to complete the DC, and an overall estimated assessment time of 10 minutes per child. Large sports halls can facilitate multiple concurrent DC circuits, thus decreasing time to assess larger numbers of children. However, the trade-off is that more assessors and administrators are required with multiple set-ups. In many previously-validated movement skill assessments (Bruininks & Bruininks, 2005; Cairney et al., 2018; Henderson et al., 2007; Physical and Health Education Canada (PHE Canada), 2014; Ulrich, 2000; Wiart & Darrah, 2001), an average of 15-60 minute assessment time per child was required. Although some of these assessments were initially created for differing circumstances (e.g., developmental coordination disorder), they have all been used to assess the physical aspects of physical literacy, in an educational setting (Giblin et al., 2014; Robinson & Randall, 2017). In comparison to these assessments, the DC assessment time per child is considerably less, providing evidence that the DC is a time-efficient measure. Conversely, the CAMSA (Longmuir et al., 2017), requires less time to complete (set up time = 5-7 mins; assessment time = 25 min for 20 children) than the DC. This is due, at least in part, to the incorporation of more tasks and indeed performance criteria in the DC. It is therefore postulated that longer assessment times to yield more information are reasonable.

The DC produced important information on a child's movement skills/capacities and varying complexities of movement patterns to inform physical competence and phys-

ical literacy, and so, as in other assessments within schools (English, Maths and Science exams), time and effort needs to be applied for progressive learning. The decreased assessment time associated with the DC compared to the many previously-validated assessments (Bruininks & Bruininks, 2005; Cairney et al., 2018; Henderson et al., 2007; Physical and Health Education Canada (PHE Canada), 2014; Ulrich, 2000; Wiart & Darrah, 2001), increases its feasibility as a population-level surveillance tool. Furthermore, in this study we have demonstrated that we can collect data on a national sample of children ($n = 4,355$), supporting our premise that DC can be used as an assessment for learning and a national surveillance tool.

7.5.5 Limitations and Future Directions

It is important to note that whilst, in comparison to many other existing assessments, the DC is more inclusive of the constructs of Whitehead's interpretations of physical competence (Whitehead, 2010), it does not provide a complete assessment of physical competence. Specifically, the DC does not reflect physical competence in terms of different varieties of contexts and durations of activities, activity settings (i.e., water, air, ice) (Jurbala, 2015; Whitehead, 2010), or different movement forms (i.e., adventure, aesthetic, athletic, competitive, fitness and health, interactional/relational) (Whitehead, 2010). However, many land-based measures assume the transferability of movement capacities/skills and movement patterns assessed in the measures, to other contexts (Giblin et al., 2014; Robinson & Randall, 2017). This may also be the case for the DC, but future studies may wish to investigate the use of the DC to predict the participation in differing movement forms and activity settings. The authors of this study also acknowledge that although the DC generally showed good concurrent validity with the TGMD-2 and SSA, a gold standard measure that is more dynamic and includes more aspects of combined and complex movement skills, rather than individual skills in isolation, may be more appropriate for comparisons. However, at the time of study design there was no gold standard assessment that assessed such movement skills. Furthermore, as a compromise for being able to use the DC at a population-level, some criterion that were typically considered critical movement features (e.g., hip then shoulder rotation for the overarm throw), were not incorporated into the assessment criteria due to the difficulty of observation in real-time during protocol development.

Although discriminant and clinical use of the DC was not a planned outcome in the current study, further analysis of the surveillance data ($n = 4,355$), reported in a separate DC surveillance report, found that the DC was able to significantly differentiate

between children with and without an additional or special learning needs, across all DC scores (Stratton, Foweather, & Hughes, 2017). However, additional investigations are required to develop the DC so that is fully inclusive, irrespective of disability. Moreover, the high percentage of success for both boys and girls on criterion 9.3 (Table 13), suggests that a ceiling effect may be present for this product criterion. Therefore, an adjustment of this criterion, perhaps with the use of Rasch analysis (Zhu & Cole, 1996), may be warranted. Finally, since the tasks included in the DC were selected to be a developmentally-appropriate assessment of physical competence for children in developed countries with similar physical education curricular and sport programmes, future studies should examine cultural differences to evaluate whether the tasks chosen are also valid in jurisdictions with different physical education and sport programmes.

7.6 Conclusion

The DC was designed as a tool to measure elements of physical competence, representing a more ecological measurement of fundamental, combined, and complex movement skills in one assessment. These skills are combined in the DC to form complex movement patterns in a more authentic environment and can be measured in a time-efficient manner. The DC is novel in that it offers a dynamic land-based measure to inform physical competence for formative and summative assessment purposes, as well as for national surveillance, with accurate data collected from a national sample of over 4,300 children in Wales. Our results demonstrate that the DC is a valid and reliable measure in children aged 10-14 years. Further investigation into the potential of the DC to reflect physical competence in terms of different contexts, durations, and activity settings, as well as the development of measures of the remaining physical literacy domains, should be of focus to construct a full physical literacy measurement model.

7.7 Summary: Study 4

The first aim of this chapter was to develop a dynamic measure of physical competence that requires a participant to demonstrate fundamental, combined and complex movement skills, and assessors to score both processes and products (Dragon Challenge; DC). The second aim was to assess the psychometric properties of the DC in 10-14 year old children.

In support of construct validity, boys ($p < 0.001$) and secondary school children ($p <$

0.001) obtained higher DC total scores than girls and primary school children, respectively. A principal component analysis revealed a nine-component solution, with the three criteria scores for each individual DC task loading onto their own distinct component. This nine-factor structure was confirmed using a confirmatory factor analysis. Results for concurrent validity showed that there was a high positive correlation between DC total score and TGMD-2 and SSA overall score ($r(43) = .86, p < 0.001$). DC total score showed good test-retest reliability (ICC = 0.80; 95%CI: 0.63, 0.90; $p < 0.001$). Inter- and intra-rater reliability on all comparison levels was good (all ICCs $> .85$).

Overall, this study showed that the DC is a valid and reliable tool to measure elements of physical competence in children aged 10-14 years.

Thesis Map

	Study		Outcomes
1	Results from the Active Healthy Kids Wales 2016 Report Card on Physical Activity for Children and Youth	<i>Aim</i> <i>Key Findings</i>	To consolidate and translate research related to physical activity among children and youth in Wales and to synthesise national surveillance data from several surveys in order to assign grades to physical activity/inactivity behaviours and influences indicators, as well as to examine trends or inequalities in the data. Grades were assigned as follows; overall physical activity levels, D+; organized sport participation, C; active and outdoor play, C; active transportation, C; sedentary behaviours, D-; physical literacy, INC; family and peer influences, D+; school, B; community and the built environment, C; and national government policy, strategies and investments, B-.
2	Ten-year Secular Changes in Selected Health and Fitness Parameters of 10-11 Years Old Swansea School Children – 2003-2013	<i>Aim</i> <i>Key Findings</i>	To highlight the secular changes in selected health and fitness measures (body mass index, prevalence of overweight and obesity, and grip strength) in 10-11 year old Swansea school children, using data obtained in 2003 and 2013. BMI z-scores, as well as prevalence of overweight and obesity, decreased significantly between 2003 and 2013 for both boys and girls. After BMI z-scores adjustment, grip strength decreased significantly for boys, but not for girls.
3	A Cross-Sectional Study on the Socio-economic and Sex Differences in Health-Related Fitness Measures in School Children	<i>Aim</i> <i>Key Findings</i>	To investigate socio-economic and sex differences in selected health-related fitness measures (body mass index, MSRT, grip strength) in 9-12-year-old children. Regardless of sex, children in the middle quintile had a significantly higher mean BMI z-score than their least deprived counterparts. There was a significant increase in grip strength and 20m MSRT between most and least deprived quintiles. Significant differences in 20m MSRT score were more apparent with increases in socio-economic status in boys.
4	A Dynamic Assessment of Children's Physical Competence: The Dragon Challenge	<i>Aim</i> <i>Key Findings</i>	1. To develop a dynamic measure of physical competence that requires a participant to demonstrate fundamental, combined and complex movement skills, and assessors to score both processes and products (Dragon Challenge). 2. To assess the psychometric properties of the Dragon Challenge in 10-14 year old children. The DC is a valid and reliable tool to measure elements of physical competence in children aged 10-14 years.

5	Youth Physical Competence Promotion Model: A Quantitative Investigation into Modifiable Factors	<p><i>Aim</i> To quantify the direct and indirect relationships between enabling, predisposing and reinforcing factors on physical competence and to investigate potential sex, weight status, and school level differences.</p> <p><i>Key Findings</i></p>
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8 Study 5

8.1 Youth Physical Competence Promotion Model: A Quantitative Investigation into Modifiable Factors

* This chapter is under review for publication:

Tyler, R., Mackintosh, K. A., Fowweather, L., Edwards, L. & Stratton, G. (2018). Youth Physical Competence Promotion Model: A Quantitative Investigation into Modifiable Factors. *Scandinavian Journal of Medicine & Science in Sports (under review)*.

8.2 Introduction

Physical competence, defined as “the sufficiency in movement vocabulary, movement capacities and developed movement patterns plus the deployment of these in a range of movement forms” (p204, Whitehead, 2010), plays an important role in the growth and development of children (Clark & Metcalfe, 2002; Gallahue et al., 2012; Stodden et al., 2008; Whitehead, 2010). Movement capacities, or movement skills, are imperative to develop, and indeed enhance, physical competence (Whitehead, 2010). Moreover, movement skills consist of three interrelated constructs: fundamental movement skills (FMS; balance, core stability, coordination, speed variation, flexibility, control, proprioception, and power), combined movement (poise, fluency, precision, dexterity, and equilibrium), and complex movement (bilateral coordination, inter-limb coordination, hand-eye coordination, turning, twisting and rhythmic movements, and control of acceleration/deceleration) (Clark & Metcalfe, 2002; Gallahue et al., 2012; Whitehead, 2010). Whilst FMS develops rapidly from the age of 3 years, children have the potential for FMS mastery by 7-8 years (Clark & Metcalfe, 2002; Gallahue et al., 2012). Movement patterns, described as general (e.g., sending, striking, receiving, running, jumping, rotating), refined (e.g., throwing, dribbling, catching, sprinting, hopping, turning) and specific (i.e. sport-specific movement patterns), are amalgamations of movements that stem from the selection and application of movement skills (Clark & Metcalfe, 2002; Gallahue et al., 2012; Whitehead, 2010). More refined and specific movement patterns are achieved when FMS, combined movement skills and complex movement skills are utilised simultaneously (Clark & Metcalfe, 2002; Gallahue et al., 2012; Whitehead, 2010). Therefore, the development of combined and complex movement skills is speculated to be imperative to increasing levels of physical competence in children over 8 years old (Clark & Metcalfe, 2002; Gallahue et al., 2012; Tyler et al., 2018; Whitehead, 2010).

There is a vast array of evidence identifying physical competence as an important component of physical literacy, and, as such, a critical precursor for increasing positive health trajectories, particularly physical activity, across the lifespan (Barnett, Lai, et al., 2016; Edwards et al., 2016; Hulteen et al., 2018; Robinson et al., 2015; Stodden et al., 2008; Whitehead, 2010). Specifically, systematic reviews and longitudinal studies have reported strong evidence for positive associations between physical competence and physical activity levels (Barnett et al., 2009; Holfelder & Schott, 2014; Lopes et al., 2011; Lubans et al., 2010), health-related fitness (Barnett, van Beurden, et al., 2008; Cattuzzo et al., 2016; Robinson et al., 2015) and perceived competence (Lubans et al., 2010; Robinson et al., 2015), as well as an inverse association with weight status (D'Hondt et al., 2014; Lubans et al., 2010; Robinson et al., 2015), in paediatric populations. Furthermore, studies have shown that enhanced physical competence during childhood tracks across the lifespan by leading to higher levels of physical activity and health-related fitness during adolescence (Barnett et al., 2009; Barnett, van Beurden, et al., 2008; Lopes et al., 2011; Robinson et al., 2015), and by supporting functional independence, general health and quality of life in later life, as well as reducing the risk of all-cause mortality (Hulteen et al., 2018; Paterson & Warburton, 2010; Sigmundsson et al., 2016). Thus, enhanced physical competence in children and young people is foundational for physical activity promotion and associated health benefits, with transferable value throughout the life course.

Ecological models provide a framework of potential influencing factors on health-related behaviours and are useful in emphasising social and psychological influences and environmental contexts (Barnett, Lai, et al., 2016). The Youth Physical Activity Promotion Model (YPAP-M) (Welk, 1999) offers an ecological conceptual model framing factors that may enable (e.g., movement skills/physical competence, health-related fitness, environmental attributes, and access), predispose (e.g., perceived competence and self-efficacy) or reinforce (e.g., parental physical activity and family, peer and coach influence) physical activity in children. Although research has investigated the mediating variable framework of the YPAP-M (Chen et al., 2014), the examination of the influencing factors on physical competence, guided by the model, remains to be explored. Further, few studies have investigated both psychological influences and environmental factors on physical competence (Barnett, Lai, et al., 2016). Therefore, the development of an ecological model with physical competence as the endogenous variable would afford new insight and an in-depth understanding of the multiple influences on physical competence. Although the association between phys-

ical competence and other factors such as physical activity, health-related fitness, and perceived competence, are expected to be reciprocal (Robinson et al., 2015; Stodden et al., 2008), such a model would enable the investigation of factors that could be specifically modified to increase physical competence. Such a targeted approach could therefore inform intervention development with the objective to promote physical competence in children, as well as explain effects or lack of effects in current intervention strategies.

The aim of the current cross-sectional study was to quantify the direct and indirect relationships between enabling, predisposing and reinforcing ecological factors on physical competence and to investigate potential sex, weight status, and school level differences in the model.

8.3 Participants and Methods

Following written informed head teacher and parent consent and participant assent, 429 children (52% boys; aged 11.1 ± 0.6 years; 87% white British) from 11 socio-demographically representative primary and secondary schools (Welsh index of multiple deprivation score 23-1898) (Noble et al., 2006) in South Wales, UK, participated in the study between 2015-2018. As part of the serial Swan-Linx programme (Sheldrick et al., 2018; Taylor et al., 2004; Tyler, Mackintosh, Palmer, et al., 2015), participants completed a selection of anthropometric and health-related fitness measures, three questionnaires, and the Dragon Challenge, a previously validated measure of physical competence in 10-14 year old children (Tyler et al., 2018). Ethical approval was obtained from the Institutional Research Ethics Committee [PG/2014/007; PG/2014/037; PG/2016/003].

8.3.1 Anthropometrics and Health-Related Fitness Measures

Using standard anthropometric techniques (Lohman et al., 1988), stature and body mass were measured to the nearest 0.001m and 0.1kg, using a portable stadiometer [Seca 213, Seca Ltd, Birmingham, UK] and electronic weighing scales [Seca 876, Seca Ltd, Birmingham, UK], respectively. Body Mass Index (BMI) was calculated and age- and sex-specific BMI cut-points were used to classify overweight and obese participants (Cole et al., 2000). Participants completed two functional health-related fitness tests from the EUROFIT Test Battery (Council of Europe, 1993), the 20m Multistage Shuttle Run Test (20m MSRT), as measure of cardiorespiratory fitness, and the Handgrip Strength Test, as a measure of muscular strength.

8.3.2 Questionnaires

Children completed a 29-item health and lifestyle online questionnaire (Child Health and Activity Tool; CHAT) (see Appendix III), akin to the paper-based *SportsLinx* Lifestyle Survey (Taylor et al., 2004). Children reported the number of days they had engaged in moderate-to-vigorous physical activity (MVPA), described as “any activity or sport where your heart beats faster, you breathed faster and you felt warmer”, for ≥ 60 min·day⁻¹ in the last week. Children also detailed the number of organised sports clubs they participated in outside of school. Surrounding physical activity facilities were reported by children as the number of areas close to their home that they could play or take part in physical activity in, such as a garden, grassy area/playing field, playground, park, street, leisure/sport centre or school. Children further reported the number of times a week their parent/s or guardian/s engaged in physical activity (0 days = 0, 1-2 days = 1, 3-4 days = 2, 5 or more days = 3). Children chose to report both parents/guardians or a single parent/guardian that they live with. Where participants reported two parents/guardians, the parent/guardian with the highest number of physically active times per week was retained. Additionally, participants reported the persons they most prominently participated in physical activity and sport with during and outside of school time (i.e., on their own (= 0) or with parents/guardians, siblings, friends, coaches/teachers/other (= 1)).

Benefits (desired outcomes from taking part) and barriers (perceived blocks or hindrances to taking part) to exercise were measured using a nine-item benefits and ten-item barriers subscale from the Children’s Perceived Benefits/Barriers to Exercise Questionnaire (Garcia et al., 1995) (see Appendix VII), using a five-point Likert-type scale, with responses ranging from 1 (disagree a lot) to 5 (agree a lot). A benefits/barriers differential score was calculated by subtracting the mean barriers’ score from mean benefits’ score, with higher scores indicating greater perceived benefits compared to perceived barriers to exercise.

Perceived adequacy, the perception of capability to achieve some acceptable standard of success, and perceived predilection, the likelihood that one would select a physical activity when given the choice, were measured using a seven-item adequacy and nine-item predilection subscale from the Children’s Self-perceptions of Adequacy in and Predilection for Physical Activity Questionnaire (Hay, 1992) (see Appendix VIII). Each item consisted of two mutually exclusive descriptions and, akin to a four-point Likert scale, children decided which of the two descriptions were most like them and whether the selected description was “sort of” or “really” true for them. The

most inactive or inadequate response was scored as one and the most active/adequate response a four (Hay, 1992). A cumulative score for both adequacy and predilection was calculated from the responses.

8.3.3 Dragon Challenge

Details of the Dragon Challenge have been reported elsewhere (Tyler et al., 2018). Briefly, the Dragon Challenge consists of nine tasks (Balance Bench, Core Agility, Wobble Spot, Overarm Throw, Basketball Dribble, Catch, Jumping Patterns, T-Agility, and Sprint) which require the application of a different combination of fundamental, combined and complex movement skills, to form refined and specific movement patterns (Tyler et al., 2018). The Dragon Challenge was administered and assessed using the established methodology (Tyler et al., 2018). A cumulative score (= 0-4) for each task was calculated by summing the technique scores and twice the outcome score, with four showing high physical competence at that task (Tyler et al., 2018).

8.3.4 Statistical Analyses

Descriptive statistics are presented as mean \pm SD. All statistical tests were completed using SPSS and SPSS AMOS, version 25 [IBM SPSS Statistics Inc., Chicago, IL, USA], with statistical significance set at $p < 0.05$. Missing data ($n = 684$, 6.9%) were imputed using an expectation-maximisation algorithm (Nelwamondo, Mohamed, & Marwala, 2007). A Confirmatory Factor Analysis (CFA) was performed to assess the fit of the measured variables into four hypothesised latent factors (i.e., enabling, reinforcing, predisposing and physical competence). Specifically, the 20m MSRT and the handgrip strength test, as well as responses to questions from the CHAT on MVPA, sport participation and available surrounding physical activity facilities were included as indicators of the enabling factor; the benefits/barriers differential score, the adequacy score, and the predilection score were included as indicators of the predisposing factor; responses to questions on parental/guardian physical activity levels and persons whom participate in physical activity and sport with the participant were included as indicators of the reinforcing factor; and cumulative scores for each Dragon Challenge task were included as indicators of the physical competence factor (Tyler et al., 2018). By default, the factor loading of the first indicator of a latent factor was fixed to 1. Error terms from the indicator variables were allowed to co-vary within the same factor. Comparative fit index (CFI), Goodness of fit index (GFI), Incremental fit index (IFI), Root mean square error of approximation (RMSEA) and Standardized root mean square residual (SRMR) were used to assess model fit, with CFI, GFI, and IFI of >0.90 , RMSEA of <0.05 and SRMR of <0.09 indicating a good fit (Hu &

Bentler, 1999; Wang, Fan, & Wilson, 1996). SEM was then used to evaluate the relationships between enabling, reinforcing, and predisposing latent variables on the physical competence latent variable. The fit was tested at a global level using CFI, GFI, IFI, and RMSEA. Direct effects were measured using direct path coefficients between latent variables. In the case of a mediating latent factor, the indirect effect was measured by taking the product of the two direct effects between the three latent factors. Multi-group comparisons were made using Chi-squared difference tests to determine whether path relationships differed based on the value of a moderator: sex (boys vs. girls), weight status (healthy vs. overweight/obese), and school level (primary vs. secondary). Changes in the CFIs (Δ CFI) were also calculated for multi-group comparisons, with a value of Δ CFI less than or equal to -0.01 indicating measurement invariance (Cheung & Rensvold, 2002). Paths that were non-significant at an overall level, as well as for all values of the moderators, were removed from the final SEM.

8.4 Results

Mean and standard deviations of the measured variables are presented in Table 16.

Table 16. Descriptive statistics (mean \pm SD) of Study 5 measured variables

Variables	Boys	Girls	All
MVPA (0-7 days)	2.4 \pm 1.2	2.2 \pm 1.1	2.3 \pm 1.2
Sport Participation (number of sports)	2.7 \pm 2.7	2.3 \pm 2.1	2.5 \pm 2.4
Surrounding PA Facilities (0-8 facilities)	3.0 \pm 2.0	3.2 \pm 2.0	3.1 \pm 2.0
Grip Strength (kg)	17.7 \pm 3.9	17.1 \pm 3.8	17.4 \pm 3.8
20m MSRT (shuttles)	31.9 \pm 18.1	22.5 \pm 11.9	27.4 \pm 16.1
Out of School PA/Sport with (0-1)	0.9 \pm 0.3	0.8 \pm 0.4	0.9 \pm 0.3
School PA/Sport with (0-1)	0.9 \pm 0.2	0.9 \pm 0.2	0.9 \pm 0.2
Parents PA Levels (0-3)	1.5 \pm 0.9	1.7 \pm 0.9	1.6 \pm 0.9
Predilection (9-36)	28.3 \pm 4.5	28.2 \pm 5.3	28.2 \pm 4.9
Benefits/Barriers to PA (-41-35)	1.4 \pm 0.9	1.3 \pm 0.8	1.4 \pm 0.8
Adequacy (7-28)	21.1 \pm 3.6	20.8 \pm 3.7	20.9 \pm 3.6
Balance Bench (0-4)	1.4 \pm 1.1	1.6 \pm 1.2	1.5 \pm 1.1
Core Agility (0-4)	1.3 \pm 0.9	1.5 \pm 1.0	1.4 \pm 1.0
Wobble Spot (0-4)	1.3 \pm 1.5	1.4 \pm 1.5	1.4 \pm 1.5
Overarm Throw (0-4)	2.1 \pm 0.9	1.3 \pm 1.0	1.7 \pm 1.0
Basketball Dribble (0-4)	2.3 \pm 1.0	1.7 \pm 1.2	2.0 \pm 1.1
Catch (0-4)	1.5 \pm 1.3	0.9 \pm 1.1	1.2 \pm 1.3
T-Agility (0-4)	1.3 \pm 1.1	1.2 \pm 1.0	1.2 \pm 1.1
Jumping Patterns (0-4)	2.0 \pm 1.0	2.0 \pm 1.0	2.0 \pm 1.0
Sprint (0-4)	2.5 \pm 0.8	2.3 \pm 0.9	2.4 \pm 0.8

Note. MVPA = Moderate-to-vigorous physical activity; PA = Physical activity; 20m MSRT = 20m Multistage Shuttle Run Test

Confirmatory Factor Analysis: The fit for the hypothesised CFA (Figure 6) was good (CFI, 0.927; GFI, 0.945; IFI, 0.928; RMSEA, 0.035 90% CI 0.026 - 0.044; SRMR, 0.050), after the addition of three correlations between error terms within the same factor.

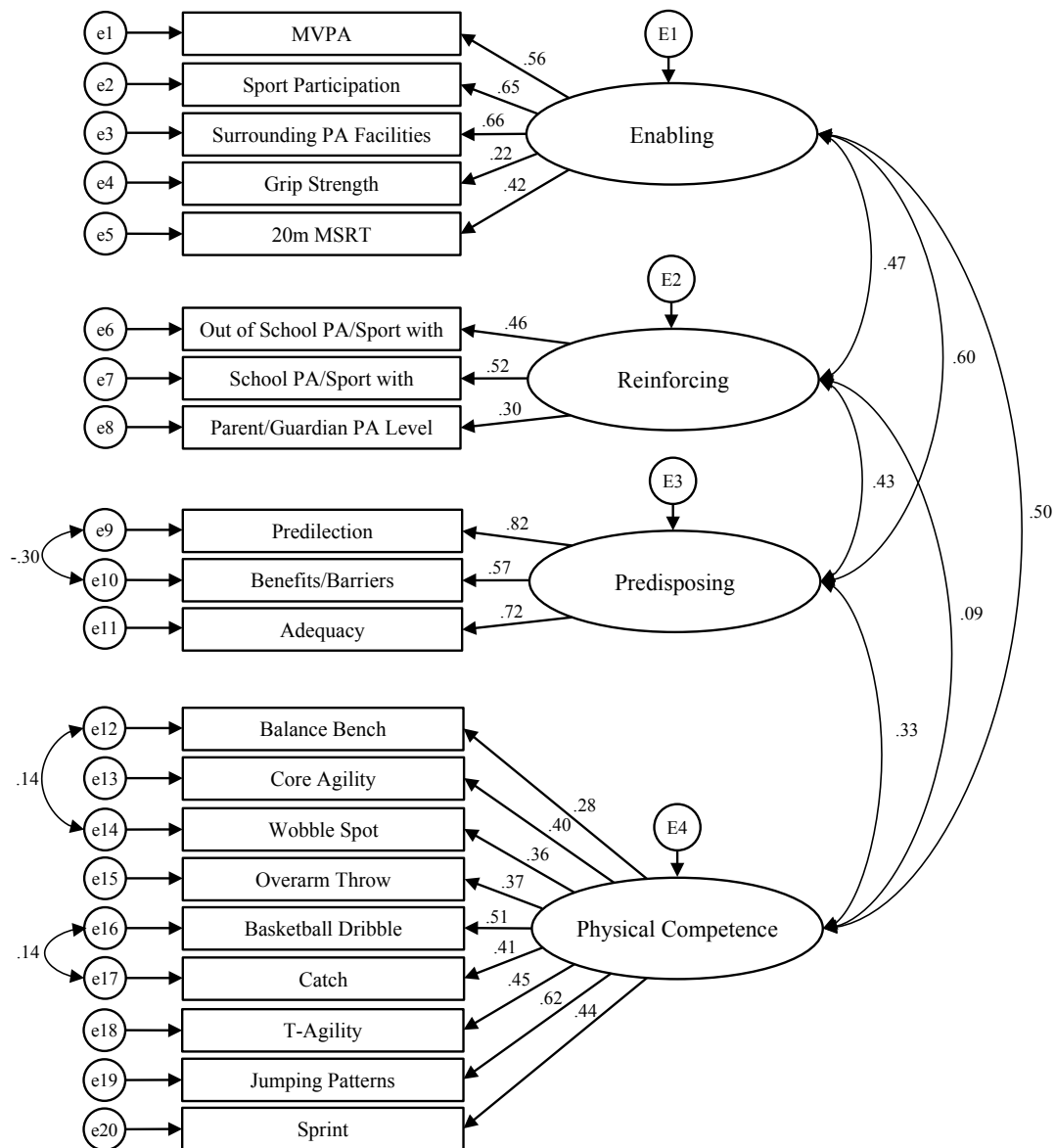


Figure 6. Confirmatory Factor Analysis of the measured variables into four hypothesised latent factors

Structural Equation Model: The hypothesised SEM is shown in Figure 7. The paths from (i) the reinforcing factor to the physical competence factor and (ii) the predisposing factor to the physical competence factor were not significant ($p > 0.05$). Moreover, these relationships did not differ significantly based on the value of any of the moderators (i.e., boys vs. girls, healthy vs. overweight/obese, primary vs. secondary school level), and so both paths were removed in the final model. *Post-hoc* power analysis identified sufficiency to detect significant effects (statistical power >0.8).

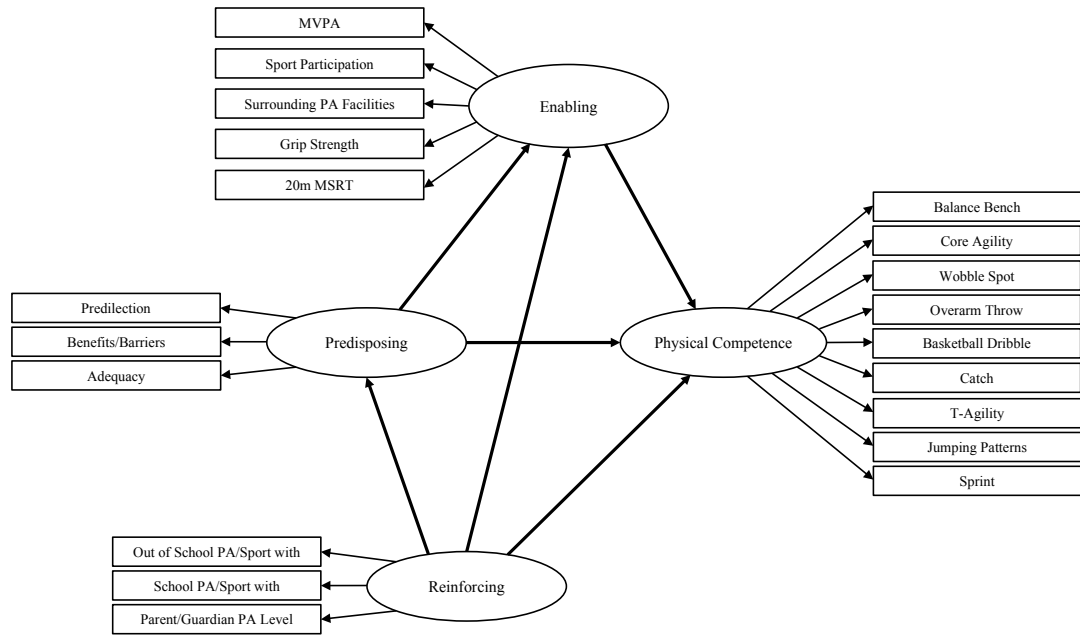


Figure 7. Hypothesised Structural Equation Model

The final SEM (Figure 8) demonstrated a good fit on a global level (CFI, 0.925; GFI, 0.944; IFI, 0.927; RMSEA, 0.035 90% CI 0.026 - 0.044; SRMR, 0.050). The model revealed that the reinforcing factor was directly related to the predisposing ($\beta = 0.42$, $p < 0.001$) and enabling factors ($\beta = 0.22$, $p = 0.031$). An indirect relationship was found between the reinforcing and physical competence factors, mediated by the enabling factor ($\beta = 0.11$, $p = 0.025$). The predisposing factor was found to have a direct effect on the enabling factor ($\beta = 0.51$, $p < 0.001$), and an indirect effect on physical competence mediated by the enabling factor ($\beta = 0.26$, $p < 0.001$). The enabling factor had a direct effect on the physical competence factor ($\beta = 0.50$, $p < 0.001$). Multi-group comparisons showed that each of these direct effects did not differ ($p > 0.05$) by sex (Δ CFI, -0.021), weight status (Δ CFI, -0.014), or school level (Δ CFI, -0.017).

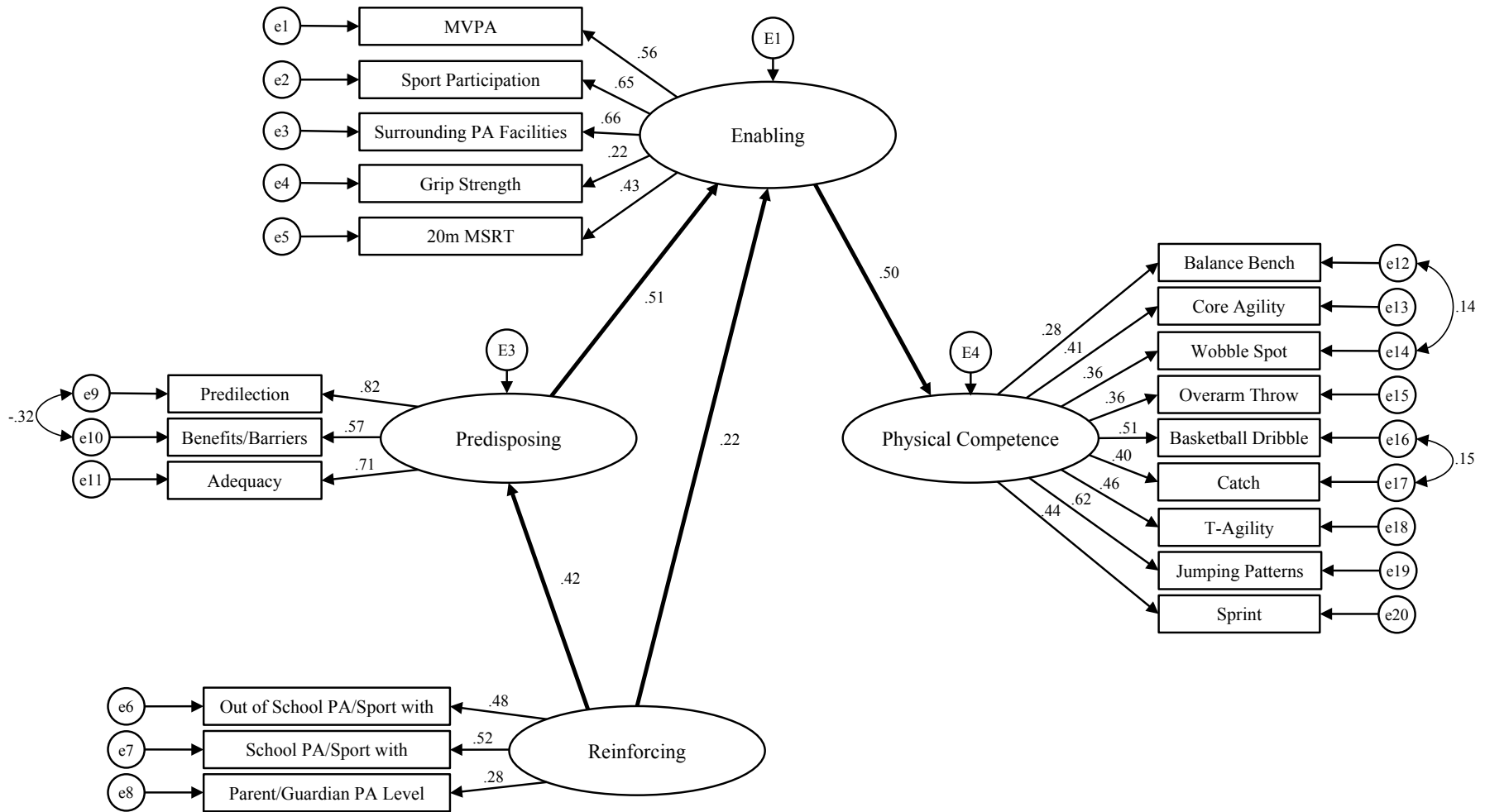


Figure 8. Final Structural Equation Model evaluating the relationships between enabling, reinforcing, predisposing and physical competence latent variables

8.5 Discussion

This is the first study to report the direct and indirect relationships between enabling, predisposing, and reinforcing factors on physical competence. This study presents an ecological model with physical competence as the endogenous variable to provide understanding of the multiple influences on such an outcome (Barnett, Lai, et al., 2016). Results from the CFA showed that the fit of the measured variables into the four hypothesised latent factors based on the YPAP-M (Welk, 1999) was good, confirming that the selected measures were associated with the appropriate latent factor.

The finding that the enabling factor had a direct effect on the physical competence factor purports that an increase in the enabling factor resulted in an increase in physical competence, and thus an improvement in competence in movement skills and advanced movement patterns. In accord with systematic reviews, there was a positive association between physical competence and MVPA (Barnett, Lai, et al., 2016; Barnett et al., 2009; Holfelder & Schott, 2014; Lopes et al., 2011; Lubans et al., 2010; Robinson et al., 2015), sport participation (Barnett, Lai, et al., 2016; Henrique et al., 2016; Holfelder & Schott, 2014; Robinson et al., 2015) and aspects of health-related fitness (Barnett, van Beurden, et al., 2008; Cattuzzo et al., 2016; Robinson et al., 2015; Stodden, Gao, Goodway, & Langendorfer, 2014). Further, research suggests that a positive feedback loop exists, in which children with greater levels of physical activity and sport participation develop better physical competence and fitness, consequently further increasing engagement (Robinson et al., 2015; Stodden et al., 2008). Whilst environmental and access factors have been previously reported to support physical activity (Bauman et al., 2012; Welk, 1999), little evidence has shown the impact on physical competence (Barnett, Lai, et al., 2016). It is therefore noteworthy that available surrounding physical activity facilities loaded onto the enabling factor, which was positively associated with physical competence. Overall, the finding that the enabling factor had a direct effect on physical competence supports previous literature (Barnett, Lai, et al., 2016; Barnett et al., 2009; Barnett, van Beurden, et al., 2008; Cattuzzo et al., 2016; Henrique et al., 2016; Holfelder & Schott, 2014; Lopes et al., 2011; Lubans et al., 2010; Robinson et al., 2015; Stodden et al., 2014), as well as provides further evidence of an association between physical activity, sport participation, fitness, and surrounding facilities and physical competence.

In line with previous research that has displayed positive associations between parental influence and family support (reinforcing variables), and physical activity levels and fitness (enabling variables), in children and adolescents (Bauman et al., 2012; Welk,

1999), the direct relationship between the reinforcing and enabling factor further supports the importance of parental/guardian modelling and friends and family encouragement. Conversely, few studies have demonstrated that reinforcing variables can simultaneously influence predisposing variables (Chen et al., 2014). Therefore, the proposed model is of importance since it shows that an increase in the reinforcing factor resulted in an increase in perceived benefits to, adequacy in, and predilection to physical activity (predisposing factor). Given that previous literature has shown a parental influence on movement skills competence (Cools, De Martelaer, Samaey, & Andries, 2011), it was hypothesised that the reinforcing factor would also have a direct relationship on the physical competence factor, though this direct relationship was not apparent in the current findings. Rather, results showed an indirect relationship between the reinforcing factor and physical competence factor, mediated by the enabling factor. Consequently, increasing the reinforcing factor (i.e., social support and modelling) may result in improvements in enabling measured variables as well as physical competence. Overall, the findings in the current study regarding the reinforcing factor provide evidence for the impact of psychosocial variables on biological, environmental, behavioural, and psychological variables, as well as indirectly on physical competence levels.

Congruent with previous research, whereby higher levels of self-efficacy, perceived competence, and overall physical competence were related to higher levels of physical activity (Babic et al., 2014; Bauman et al., 2012), the SEM showed that the predisposing factor had a direct effect on the enabling factor. While it was hypothesised that the predisposing factor may have a direct relationship on the physical competence factor, an indirect effect, mediated by the enabling factor, was found. Indeed, previous research has shown that perceived competence has a mediating effect on the association between physical competence and physical activity in children and adolescents (Barnett, Morgan, van Beurden, Ball, & Lubans, 2011; Barnett, Morgan, van Beurden, & Beard, 2008). This study therefore provides further support to the contention that an increase in the predisposing factor will result in an increase in physical activity, sport participation, and health-related fitness, and subsequently an increase in levels of physical competence.

Overall, previous research supports the synergistic relationships of biological, environmental, psychosocial and behavioural factors on the evolution and continued development of physical competence across the lifespan (Barnett, Lai, et al., 2016; Hulteen et al., 2018; Robinson et al., 2015; Stodden et al., 2008). The current study

further supports the strength of these relationships, particularly in terms of promoting physical competence in an ecological model that can be used to inform interventions. One such intervention strategy would be to promote physical activity, sport participation, health-related fitness, and available surrounding physical activity facilities, given the direct effect of the enabling factor on physical competence in the current results. Moreover, whilst both the reinforcing and predisposing factor only had a direct effect on the enabling factor, the indirect effect of these factors on physical competence, indicates that an increase in either reinforcing or predisposing factor was indirectly associated with an increase in physical competence. Thus, interventions to promote physical competence could also focus on enhancing social support mechanisms such as parental/guardian physical activity levels, the number of persons whom take part in physical activity and sport with children, and children's perceived benefits to, adequacy in, and predilection to physical activity, while decreasing children's perceived barriers to physical activity. Contrary to previous findings that show increasing age, healthy weight status and being male are correlates for certain aspects of physical competence (Barnett, Lai, et al., 2016), multi-group comparisons did not display these differences. Consequently, the SEM revealed an ecological model that can be used to inform interventions for the improvement of physical competence in children via multiple pathways regardless of age, weight status, and sex.

8.5.1 Strengths and Limitations

The use of SEM in the current study provides a novel approach to identifying modifiable factors that can increase physical competence in children, allowing the investigation of the concurrent influences of multiple variables. Indeed, SEM explicitly models measurement error, thereby providing more accurate relationships among latent factors, a frequently cited limitation of many studies (Beran & Violato, 2010). Furthermore, the assessment of fundamental, combined and complex movement skills and varying complexities of movement patterns provides a more inclusive measure to inform physical competence (Tyler et al., 2018; Whitehead, 2010).

Whilst there are numerous strengths, the current study is not without limitations. Specifically, the measures chosen to best predict each latent variable in the model were selected from the measures involved in the Swan-Linx programme, and therefore other quantitative measures (e.g., accelerometer data rather than self-report physical activity) may have increased the strength of the model. Future research could also expand the measures used to assess enabling and reinforcing factors (e.g., reinforcing factors could include encouragement for physical competence from peers and parents

or other aspects of social support). Further, an expectation-maximisation algorithm was used to impute missing data and, although this imputation method has previously been validated (Nelwamondo et al., 2007), the lack of a complete data set may have influenced study findings. Finally, although no differences were found between primary and secondary school level children, it is possible that age differences may be apparent with a larger age-range, or that biological age may account for greater variation.

8.6 Conclusion

In conclusion, the present study found that the enabling factor had a direct effect, whilst the reinforcing and predisposing factors had an indirect effect, on physical competence. Each direct and indirect effect did not differ by school level (primary school vs. secondary school), weight status (healthy vs. overweight and obese) or sex (boys vs. girls), supporting the contention that the model is applicable across many groups of primary and secondary level school children. These findings are the first to be set in this framework and reveal that there are multiple potential pathways that could inform future interventions that aim to promote physical competence.

8.7 Summary: Study 5

The aims of this study were to quantify the relationships between enabling, predisposing and reinforcing ecological factors on physical competence and investigate potential sex, weight status, and school level differences.

Cardiorespiratory fitness (20m Multistage Shuttle Run), muscular strength (Handgrip Strength) and online questionnaire (Child Health and Activity Tool; CHAT) data on moderate-to-vigorous physical activity, sport participation and available surrounding physical activity facilities were included as enabling variables. Three predisposing variables were determined from self-report data on benefits/barriers to exercise, adequacy, and predilection. Parental/guardian physical activity levels and persons whom participate in physical activity and sport with the participant (CHAT) were selected as reinforcing variables. Physical competence was determined from cumulative scores for Dragon Challenge tasks.

Physical competence was directly affected by the enabling factor ($\beta=0.50$, $p<0.001$) but indirectly affected by reinforcing and predisposing factors, mediated by the enabling factor ($\beta=0.11$, $p=0.025$; $\beta=0.26$, $p<0.001$). Multi-group comparisons showed

that each of these effects did not differ by sex, weight status or school level ($p>0.05$).

Physical competence is an important component of physical literacy in children and this study demonstrated that enabling factors (e.g., fitness, physical activity) are crucial for its development. Reinforcing and predisposing factors are themselves indirectly associated with physical competence, highlighting alternate pathways for improvements. This is the first study to quantify an ecological model with physical competence as the endogenous variable and is key to interventions that aim to promote physical competence.

Thesis Map

	Study		Outcomes
1	Results from the Active Healthy Kids Wales 2016 Report Card on Physical Activity for Children and Youth	<p><i>Aim</i></p> <p><i>Key Findings</i></p>	<p>To consolidate and translate research related to physical activity among children and youth in Wales and to synthesise national surveillance data from several surveys in order to assign grades to physical activity/inactivity behaviours and influences indicators, as well as to examine trends or inequalities in the data. Grades were assigned as follows; overall physical activity levels, D+; organized sport participation, C; active and outdoor play, C; active transportation, C; sedentary behaviours, D-; physical literacy, INC; family and peer influences, D+; school, B; community and the built environment, C; and national government policy, strategies and investments, B-.</p>
2	Ten-year Secular Changes in Selected Health and Fitness Parameters of 10-11 Years Old Swansea School Children – 2003-2013	<p><i>Aim</i></p> <p><i>Key Findings</i></p>	<p>To highlight the secular changes in selected health and fitness measures (body mass index, prevalence of overweight and obesity, and grip strength) in 10-11 year old Swansea school children, using data obtained in 2003 and 2013. BMI z-scores, as well as prevalence of overweight and obesity, decreased significantly between 2003 and 2013 for both boys and girls. After BMI z-scores adjustment, grip strength decreased significantly for boys, but not for girls.</p>

3	A Cross-Sectional Study on the Socio-economic and Sex Differences in Health-Related Fitness Measures in School Children	<p>Aim</p> <p>Key Findings</p>	<p>To investigate socio-economic and sex differences in selected health-related fitness measures (body mass index, MSRT, grip strength) in 9-12-year-old children.</p> <p>Regardless of sex, children in the middle quintile had a significantly higher mean BMI z-score than their least deprived counterparts. There was a significant increase in grip strength and 20m MSRT between most and least deprived quintiles. Significant differences in 20m MSRT score were more apparent with increases in socio-economic status in boys.</p>
4	A Dynamic Assessment of Children's Physical Competence: The Dragon Challenge	<p>Aim</p> <p>Key Findings</p>	<p>1. To develop a dynamic measure of physical competence that requires a participant to demonstrate fundamental, combined and complex movement skills, and assessors to score both processes and products (Dragon Challenge). 2. To assess the psychometric properties of the Dragon Challenge in 10-14 year old children.</p> <p>The DC is a valid and reliable tool to measure elements of physical competence in children aged 10-14 years.</p>

5	<p>Youth Physical Competence Promotion Model: A Quantitative Investigation into Modifiable Factors</p>	<p><i>Aim</i></p> <p><i>Key Findings</i></p>	<p>To quantify the direct and indirect relationships between enabling, predisposing and reinforcing factors on physical competence and to investigate potential sex, weight status, and school level differences.</p> <p>The final SEM (Figure 8) demonstrated a good fit. The enabling factor had a direct effect, whilst the reinforcing and predisposing factors had an indirect effect, on physical competence. Each direct and indirect effect did not differ by school level, weight status or sex. Thus, the ecological model revealed multiple potential pathways that could inform future interventions that aim to promote physical competence.</p>
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9 Thesis Synthesis

The overall aim of the thesis was to investigate the health, fitness, lifestyle and physical competency levels and inequalities of school children in Wales. This thesis is a result of an iterative process, with each study addressing a gap/rationale or future direction brought forward by the previous studies. The novelty of this thesis stands in the five studies conducted within. The monitoring of health-related fitness measures and physical competence, as well as the surveillance of physical activity behaviours and influences affords new findings to the current evidence base on children's present and future health and provides insight for policies and interventions across many sectors (e.g., health, sport and recreation, education, transportation and land-use planning). In addition, the development of a new dynamic land-based measure of physical competence, which is valid and reliable in children, as well as the quantification of an ecological model with physical competence as the endogenous variable, provides novel means of physical competence assessment and promotion.

9.1 Physical activity behaviours and influences and health-related fitness

Physical activity is associated with numerous positive physiological, psychosocial and cognitive health benefits in children (Biddle & Asare, 2011; Boreham & McKay, 2011; Janssen & Leblanc, 2010), including the prevention of emerging health risk factors (Andersen et al., 2011; Janssen & Leblanc, 2010). It has been suggested that physical activity levels and behaviours should be a focus for surveillance, and trends in physical activity across multiple domains should be monitored at the individual, social, environmental, and societal levels for policy and intervention development (Bauman et al., 2012; Hallal et al., 2012; Kohl et al., 2012; Sallis et al., 2016). Furthermore, it has been postulated that assessing products or outcomes of physical activity, such as physical fitness, can provide an indication of the quantity and quality of physical activity (Guinhouya, 2012). Studies 1, 2 and 3 were developed following these recommendations.

Collectively, Studies 1, 2 and 3 demonstrated that despite the existence of theoretically grounded policies, programmes, and infrastructure, only 20 to 39% of children and young people in Wales met the government recommendation of at least 60 minutes of moderate-to-vigorous intensity physical activity (MVPA) every day of the week. Moreover, sedentary behaviour was high (>65% of children and young people spent 2+ hours a day in sedentary behaviours) and physical activity behaviours and influ-

ences, including play, sport participation, active transportation and family and peer influences, low. In addition, sedentary behaviour and physical activity levels were one of the highest and lowest, respectively, globally (Inchley et al., 2016; Tyler et al., 2016). Cardiorespiratory fitness and muscular strength levels in children were low to moderate in comparison to international norms (Tomkinson, Carver, et al., 2017; Tomkinson, Lang, Tremblay, et al., 2017) and the prevalence of overweight and obesity high. Analysis of trends and inequalities in physical activity behaviours and influences and health-related fitness in Studies 1, 2 and 3 found no significant change MVPA from 2006 to 2014, although an upward trend in the frequency of organised sport participation between 2011, 2013 and 2015 was apparent. Further, between 2003 and 2013, body mass index (BMI) z-scores decreased significantly even though the prevalence of overweight and obesity recorded in 2013 remained high. Grip strength also decreased significantly for boys, but not for girls. The decreases in both BMI z-score and grip strength could, in part, be explained by the decrease in participation in extracurricular sports in children between 2002 and 2013 (Sport Wales, 2015c). In terms of inequalities, boys were more active than girls across all age and socio-economic status groups. However, there were no significant differences in MVPA by socio-economic status, unlike sport participation. Boys also had a significantly higher grip strength and achieved a significantly greater 20m multistage shuttle run test score than girls. Finally, regardless of sex, children in the middle Welsh Index of Multiple Deprivation (WIMD) quintile had a significantly higher mean BMI z-score, and most deprived children had significantly lower muscular strength and cardiorespiratory fitness, than their least deprived counterparts.

Taken together, Studies 1, 2 and 3 showed that physical activity behaviours and influences and overall health-related fitness levels were low, and inequalities existed across socio-economic status and sex in children and young people in Wales. Previous literature has shown that school-based interventions play an important role in promoting and improving physical fitness (Minatto, Barbosa Filho, Berria, & Petroski, 2016). Therefore, targeted intervention strategies aiming to improve children and young people's physical activity and fitness and greater investments are needed, particularly in areas of high deprivation and in girls, so that future generations receive the health and developmental benefits associated with physical activity and fitness.

9.2 Physical competence monitoring and promotion

Other than health-related fitness as an outcome measure of children and young people's physical activity levels, the development of motor skills and physical compe-

tence should be viewed as an additional and independent psychomotor factor related to physical activity that requires specific analyses (Guinhouya, 2012). Physical competence plays an important role in the growth and development of children (Clark & Metcalfe, 2002; Gallahue et al., 2012; Stodden et al., 2008; Whitehead, 2010). Further, there is a vast array of evidence identifying physical competence as an important component of physical literacy, and, as such, a critical precursor for increasing positive health trajectories, particularly physical activity and health-related fitness, across the lifespan (Barnett, Lai, et al., 2016; Edwards et al., 2016; Hulteen et al., 2018; Robinson et al., 2015; Stodden et al., 2008; Whitehead, 2010). To develop successful targeted interventions to improve physical competence, capturing the current levels of physical competence in children is required (Study 4). Moreover, the prioritisation of key psychosocial, behavioural, physical and environmental factors is needed to promote physical competence in children (Study 5).

Due to the emphasis placed on physical literacy by Sport Wales and the Education Department of Welsh Government, physical literacy, including physical competence, was an indicator considered in Study 1. However, this indicator received an inconclusive grade based off the on-going development of a measurement tool for physical competence in older age children. Study 4 addressed this gap by developing a dynamic measure of physical competence (Dragon Challenge). Many previous measures that inform physical competency as part of physical literacy assessments (Giblin et al., 2014; Robinson & Randall, 2017), in children and adolescents (Bruininks & Bruininks, 2005; Cairney et al., 2018; Henderson et al., 2007; Physical and Health Education Canada (PHE Canada), 2014; Ulrich, 2000), use isolated movement skills, which limits transferability and applicability to multi-skill and sport environments and ignores perception-action coupling. The Dragon Challenge, however, includes 9 tasks completed in a timed circuit, and incorporates fundamental, combined and complex movement skills/capacities in a series of refined/complex and specific movement patterns. The Dragon Challenge can be used for assessment for learning (summative and/or formative) by teachers, coaches and health professionals, and because of its time efficiency as a national surveillance tool, that can be aligned to physical literacy programmes and physical education curriculum. The finalised assessment criteria for the Dragon Challenge included both technique (process) and outcome (product) indicators of movement performance, to provide a more complete picture of physical competence levels than currently used assessments that include primarily product- or process-based criteria (Bruininks & Bruininks, 2005; Cairney et al., 2018; Henderson et al., 2007; Physical and Health Education Canada (PHE Canada), 2014; Ulrich,

2000). Favourable results in support of concurrent validity, as well as, good test-retest and inter- and intra-rater reliability were found, showing that the Dragon Challenge has sufficient psychometric properties. Therefore, given the paucity of dynamic measures of movement skills and varying complexities of movement patterns to inform physical competence in children, Study 4 filled a critical gap in the current literature in this field. The Dragon Challenge pilot data and initial results presented in Study 1, as well as the descriptive statistics of Dragon Challenge scores and successful demonstration of each Dragon Challenge criterion displayed in Study 4, suggest that continued investment in developing skilled movements in children is required.

Study 4 also confirmed that each of the nine first order latent factors (skill combinations) loaded onto a higher order latent factor (physical competence), purporting that the combination of skills required by each Dragon Challenge task is needed for children to be physically competent. Therefore, to promote physical competence in children, all types of movement skills should aim to be enhanced. To further develop successful targeted interventions, an appropriate conceptual promotion model should be utilised to prioritise the key characteristics of the target group and to produce a comprehensive and structured assessment of needs and barriers to physical competence (Green et al., 1980; Welk, 1999). The development of the Dragon Challenge provided the opportunity to investigate such a model, with physical competence as the endogenous variable. Study 5 resulted in the first reported model that quantified the direct and indirect relationships between ecological factors on physical competence. Previous research supports the synergistic relationships of biological, environmental, psychosocial and behavioural factors on the evolution and continued development of physical competence across the lifespan (Barnett, Lai, et al., 2016; Hulteen et al., 2018; Robinson et al., 2015; Stodden et al., 2008). The results from Study 5 further supported the strength of these relationships, and the promotion of physical competence in a single model.

Congruent with past studies, whereby higher levels of self-efficacy, perceived competence and overall physical competence were related to higher levels of physical activity (Babic et al., 2014; Bauman et al., 2012), the results of Study 5 suggest that augmenting predisposing variables will result in an increase in physical activity, sport participation, and health-related fitness, and subsequently an increase in levels of physical competence. Moreover, in line with previous research that has found positive associations between parental influence and family support (reinforcing variables), and physical activity levels and fitness (enabling variables), in children and

adolescents (Bauman et al., 2012; Welk, 1999), the direct relationship between the reinforcing and enabling factor, and the indirect relationship between reinforcing and physical competence highlights the importance of parental/guardian modelling and friends and family encouragement. This finding is also consistent with the results from the first study in this thesis that reported a parental/peer influence on children's participation in sport. Finally, given that Study 5 showed a strong direct effect of the enabling factor on physical competence, and Studies 1, 2 and 3 show that levels of physical activity and health-related fitness in children in Wales are low, it is clear that a concerted effort is needed to increase cardiorespiratory fitness, muscular strength, MVPA, sport participation and access to physical activity facilities. This effort is necessary not just for the decrease in potential health risk factors, but also for healthy growth and development of children.

9.3 Strengths and limitations

The major strength of this thesis is the novelty of Studies 2-5, which build on the position established in Study 1. Studies 2 and 3 were the first to highlight the secular changes in selected health-related fitness measures and the inequalities in selected health-related fitness across socio-economic and sex, in children in Wales, respectively. Study 3 was the first to compare the health-related fitness levels of children in Wales to international normative values. Study 5 was the first to quantify an ecological framework to promote physical competence. Moreover, the novelty of the thesis also stands in the systematic development of a new dynamic land-based measure of physical competence in Study 4. Through the use of an in-depth analysis of a large nationally representative dataset and robust methodology guided by the COSMIN (Consensus-based Standards for the selection of health Measurement Instruments), Study 4 produced a vigorous evaluation of the psychometric properties of the Dragon Challenge that would achieve a quality level of good to excellent on the COSMIN rating system (Mokkink et al., 2010).

Although there are numerous strengths, the empirical work in the thesis is not without limitations. Whilst the process behind Study 1 was built on a robust approach and completed results were obtained for 10 out of 11 indicators on physical activity behaviours and influences, there were significant gaps unveiled in the available data and inconsistency across tools used to generate the data to produce the Active Healthy Kids Wales Report Card. A more complete database may have produced different results. Additionally, the results of the Report Card are based off the overall consensus of an expert group, therefore introducing potential subjectivity within the grades.

The relatively small sample size (512 participants in 2003; 414 participants in 2013) in Study 2 may have limited statistical power, and thus increased the possibility of making a type II error. Furthermore, the participants in Study 2 were from schools situated in the same electoral wards (areas), and therefore the findings may not be representative of all children in Swansea/ Wales. The nested nature of the data (i.e. participants nested within schools) was a limitation common to both Studies 2 and 3, due to the independence assumption of ANOVAs/ANCOVAs. However, Study 3 did attempt to overcome this by computing an ICC which demonstrated little statistical dependency in the data, suggesting that the largest proportion of variance lay among participants rather than the school clusters. In Study 4, the tasks included in the Dragon Challenge were selected to be a developmentally-appropriate assessment of physical competence for children in developed countries with similar physical education curricular and sport programmes, therefore may limit the generalisability of the tool due to between country and cultural differences. Future studies may wish to evaluate whether the tasks chosen are also valid in jurisdictions with different physical education and sport programmes. In Study 5 an expectation-maximisation algorithm was used to impute missing data and, although this imputation method has previously been validated (Nelwamondo et al., 2007), the lack of a complete data set may have influenced study findings. Furthermore, the measures selected to best predict each latent variable in the model in Study 5 were selected from the measures involved in the Swan-Linx programme, and therefore other quantitative measures (e.g., accelerometer data rather than self-report physical activity) may have increased the strength of the model. Future research may aim to include more objective measures of physical fitness (e.g., VO_2 peak assessments) and body composition (e.g., skinfolds and circumferences, or dual-energy X-ray absorptiometry (DEXA), to assess fat and fat-free mass and percentage body fat) and objective assessments of physical activity (e.g., accelerometers). However, capturing this information on large sample sizes would be expensive and time intensive.

9.4 Future directions

This thesis indicates that existing health monitoring systems in Wales ought to include health-related fitness tests and the Dragon Challenge. Surveillance and monitoring of physical activity, fitness and physical competence in children and young people, as well as investigations between subgroups (e.g., age, sex, ethnicity, and socio-economic status), should be conducted routinely to analyse trends and inequalities over time. The dissemination of these results and knowledge transfer will assist with informing delivery and assess the impact of health promotion strategies and in-

vestments.

Overall, greater investment is needed to promote children and young people's physical activity (Study 1), physical fitness (Studies 2 and 3) and physical competence (Studies 1, 4 and 5) to reduce the spiralling social and economic burden of inactivity, and so that future generations gain associated health and developmental benefits. Given that components of health-related fitness are related to health in differing ways, focused services and interventions should work to not only improve cardiorespiratory fitness levels, but also muscular strength. An important additional aim should be to close the gap in inequalities, particularly in areas of high deprivation and in girls.

Study 5 set and quantified an ecological framework with the use of the YPAP-M to promote physical competence, revealing multiple potential pathways, regardless of age, weight status and sex, that could inform future interventions. Administrative and policy diagnosis (Gielen et al., 2008; Green et al., 1980; Welk, 1999), including the assessment of resources, budgets and organisations, should be used to refine interventions or promotional strategies that are likely to be effective based on this model. Focused interventions should also integrate process, impact and outcome evaluations to measure the effectiveness of the implemented intervention (Gielen et al., 2008; Green et al., 1980; Welk, 1999).

Future research should investigate the potential of the Dragon Challenge as a measurement tool to indicate levels of physical competence in terms of different contexts, durations and activity settings. Whilst the Dragon Challenge is more inclusive of the constructs of Whitehead's interpretations of physical competence (Whitehead, 2010), it may not provide a complete assessment of physical competence. Specifically, the Dragon Challenge does not reflect physical competence in terms of different varieties of contexts and durations of activities, activity settings (i.e., water, air, ice; Jurbala, 2015; Whitehead, 2010), or different movement forms (i.e., adventure, aesthetic, athletic, competitive, fitness and health, interactional/relational; Whitehead, 2010). However, many land-based measures assume the transferability of movement skills and movement patterns assessed to other contexts (Giblin et al., 2014; Robinson & Randall, 2017). This may also be the case for the Dragon Challenge, but future studies could investigate the ability of the Dragon Challenge to reflect competence in differing movement forms and activity settings. Finally, the development of measures of the remaining physical literacy domains (affective and cognitive) through a mixed-method approach (e.g., observations, questionnaires, interviews) should also

be of focus to construct a full physical literacy measurement model.

9.5 Final comments and reflection

This thesis successfully investigated the health, fitness, lifestyle and physical competency levels and inequalities of school children in Wales. Study 1 comprised of a collaboration of a group of experts to grade physical activity indicators with the use of surveillance data to provide insight for policies and interventions across many sectors (e.g., health, sport and recreation, education, transportation and land-use planning) across Wales. Whilst an indicator for physical fitness was not included in Study 1, health-related fitness is a key determinant of physical activity and has been shown to be a stronger marker and predictor of health outcomes and future health than physical activity and will therefore be considered in forthcoming report cards. As such, Studies 2 and 3 investigated health-related fitness in children in Wales. In particular, Study 2 highlighted the secular changes in selected health and fitness measures, using data obtained in 2003 and 2013. With the use of a large dataset, Study 3 investigated socio-economic and sex differences in selected health-related fitness measures to predict inequalities in current and future health outcomes. Given the importance of the development of physical competence in children and young people, and the emphasis placed on physical literacy by Welsh Government (Study 1), Study 4 summarised the work conducted in collaboration with paediatric exercise science academics, practitioners, and professionals from schools and community sport in co-designing a measure of physical competence in children. This process culminated in the Dragon Challenge, which was aligned to physical education and sport, coaching, school and community programmes that aimed to promote physical literacy. The Dragon Challenge offers a dynamic measure of physical competence for formative and summative assessment purposes, as well as for national surveillance, with data collected from a national sample of over 4,300 children in Wales. Moreover, the Dragon Challenge approach was used to develop an ecological model (Study 5) to provide insight for interventions to promote physical competence that can be used by schools, families, communities, practitioners and academics. Overall the results from each of the studies in this thesis can be used to inform the content and delivery of health education interventions and programmes, and to inform future research projects. This thesis advocates for a balance of physical activity (quantity and exposure) and fitness and physical competency (quality and outcome).

10 References

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11 Appendices

Appendix I: Surveillance Surveys on Physical Activity and Sedentary Behaviour of Children in Wales (Study 1)

The annual Welsh Health Survey (Welsh Government, 2015c), provides information about the health and health-related lifestyles of people living in Wales. It covers a range of health-related topics, including health status, lifestyle and health behaviours (including physical activity), and health service use. The survey data is collected through a combination of methods. Namely, household data is collected in face-to-face interviews, whereas individual data is collected using paper questionnaires. Each adult (16+ years) in the household was given a questionnaire to complete. Two questionnaires were designed for parents to complete on behalf of children aged 0 to 3, and children aged 4 to 12; a third questionnaire was given to children aged 13 to 15 to complete on their own behalf.

<http://gov.wales/statistics-and-research/welsh-health-survey/?lang=en>

The Health Behaviour in School Children (HBSC) survey (every 4 years – most recent 2013/14) (Welsh Government, 2015a), collected data on 9,055 secondary school children (aged 11-16 in school years 7 to 11) in Wales. The survey was carried out through interviewer administered paper self-completion sessions in class. The survey focuses on and provides data on key indicators of health or health behaviour in young people in Wales under the headings: social context of health; health outcomes; health behaviours; and risk behaviours.

<http://gov.wales/statistics-and-research/health-behaviour-school-aged-children/?lang=en>

The School Sport Survey conducted by Sport Wales (Sport Wales, 2015c), has the greatest reach of all surveys completed in Wales. In the 2015 survey, 115,398 Year 3-11 pupils in 1,000 schools took part in the survey, and 1,094 teachers completed a School Sport Survey provision questionnaire. The survey monitors and tracks trends in sports participation – covering both community and school participation and tracks

the provision of PE and school sport, as well as teachers' and pupils' attitudes to PE and sport.

<http://sportwales.org.uk/research--policy/surveys-and-statistics/school-sport-survey.aspx>

The Further Education Survey is also conducted by Sport Wales (Sport Wales, 2015b). This survey was the first survey of students in further education colleges in Wales. In 2015, 4,568 students (aged 16 to 20+ years) completed the online questionnaire, obtaining data on core measures of well-being and frequency of sport participation. This survey is like the School Sport Survey, collecting data on participation in sport and physical activity, volunteering, and attitudes to sport. This allows the School Sport Survey and Further Education Survey to be combined and data to cover children and young people from 7 through to 20+ years.

<http://sport.wales/research--policy/surveys-and-statistics/statistics.aspx>

The National Survey for Wales (Welsh Government, 2015b), is a face-to-face survey of people across Wales. Each year over 14,000 people aged 16 and over were asked for their opinions on a wide range of issues affecting them and their local area. Interviewers randomly selected one adult (aged 16+) in each household, and carried out a 25-minute face-to-face interview. In the most recent 2014/15 survey, a total of 14,285 interviews were achieved. Proxy data on health and related areas are available which includes data on the environment, active travel and health.

<http://gov.wales/statistics-and-research/national-survey/?lang=en>

The Welsh Health Survey 2015

One question asks how health condition(s) affects individual carrying out functional physical activities and ADL

1. Walking (over past 7 days)

Across how many days did you walk for 10 mins at a time?

How much time did you spend walking on one of these days?

Describe walking pace?

Was the effort used for 10 minutes walking enough to make you sweat, increase HR etc.?

2. Moderate physical activity (over past 7 days)

How many days last week did you engage in moderate physical activity lasting at least 10 mins?

How much time on average did you spend doing moderate activity on one of those days?

3. Vigorous physical activity (over past 7 days)

How many days last week did you engage in vigorous physical activity lasting at least 10 mins?

How much time on average did you spend doing vigorous physical activity on one of those days?

4. Sitting time (over past 7 days)

How much time over the last 7 days did you spend sitting on an average week day?

How much time over the last 7 days did you spend sitting on an average weekend day?

.....

Health Behaviour in School-aged Children in Wales 2013-2014

1. Over the past 7 days, on how many of the days were you physically active for 60 minutes or more?
2. What is the main transport mode to and from school? (active transport).
3. Out of school, how many hours do you spend doing physical activity that makes you out of breath or sweat?

.....

School Sport Survey 2015 (similar questions for Further Education Survey 2015)

SPORTS

This section is about sport you do when you are **not in PE lessons**

1. Which of these sports have you done since you have been in [year]?
2. Which of these sports have you done since you have been in [year]?

FOR ALL SPORTS TICKED ABOVE

- a. Have you played _____ in a **school club** (at lunchtime, after school, or at breakfast club), since you have been in Year X?
- b. Have you played _____ in a **club not at school** since you have been in Year X?
- c. Have you played **basketball anywhere else** since you have been in Year X? This could be at home, or with your friends, or in the park or at a leisure centre for example.

For pupils in Years 5-6 ONLY. Years 3 and 4 do not get asked questions about frequency of participation in individual sports

School clubs:

1. About how often did you play (sport) in a **school club**, since you have been in Year X? **(at a lunchtime club, after school club or at breakfast club)**

Clubs not at school:

1. About how often did you play (sport) in a **club not at school**, since you have been in Year X?

Overall Participation in Sport:

1. Overall, since you have been in [Q2], about how often have you taken part in sport **in a school club? (at lunchtime, after school, or at breakfast club)**
2. Overall, since you have been in [Q2], about how often have you taken part in sport **in a club not at school?** This could be a sports club, or a community club or a leisure centre club for example

Competitive sport:

1. Since you have been in {x}, have you represented your school in a sports match or competition against another school?

Sports clubs:

1. Are you a member of a **sports club**?

Places you do sport:

1. Have you used any of these for sport or exercise, since you have been in [Q2a]? Please tick all that apply.

Leisure centres (If yes to leisure centre above)

- Since you have been in [x], how often did you visit a sports or leisure centre to do an activity outside of school time?

Sports you would like to do:

1. Which sports, if any, would you like to do more of? Please tick all that apply.
- **I would do more sport if...** Please tick all that apply.

Family and friends:

1. Do your family or friends take part in sport? Please tick all that apply.
2. Who do you take part in sport with? Please tick all that apply.

Well-being:

1. How much do you think PE lessons and sport help you to have a healthy lifestyle?
- How often do you feel comfortable taking part in **PE lessons and school sport**?
 - How **confident** are you in trying new activities?
 - How often do you feel that pupils' ideas about PE and school sport are listened to?
 - How much do you enjoy **PE lessons**?
 - How much do you enjoy doing sport at **after-school or lunchtime clubs**?
 - How much do you enjoy doing sport when you are **not at school**? This could be at a club or a leisure centre for example

Leisure time:

1. Which of these do you do when **not in school**?

ALL ANSWERS SELECTED IN Q31 LISTED AS ANSWER OPTIONS BELOW

2. In a normal week, which **three** of these things do you spend the most time doing, when you are **not at school**? Please tick up to **three** activities.

3. Why do you do (sport)? Please tick all that apply.
4. Why do you do (sport)? Please write in the box below.

Travel to school:

1. On a normal day, how do you get to school?
 - Walk
 - By car
 - By taxi
 - By bus
 - Cycle
 - Scooter or skate
 - Other
2. On a normal day, how long does it usually take to travel from your home to school?
 - Less than 5 minutes
 - 6 to 9 minutes
 - 10 to 15 minutes
 - 16 to 19 minutes
 - 20 to 24 minutes
 - 25 to 29 minutes
 - 30 minutes or more

.....

National Survey of Wales 2014 - 2015

1. Active travel (children) – how do they get to primary/secondary school, how long is the journey?
2. Active travel – only focuses on walking or cycling to and from work, shops or to visit friends

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Appendix II: Swan-Linx Standard Operating Procedure and Training Tool



Field Measures of Health and Fitness in Children

Standard Operating Procedure and Training Tool



Field Fitness Test Batteries

There have been many methods to assess the different components of fitness in children over the past few decades. Numerous studies have used a battery of field fitness tests to assess fitness in children in a relatively non-invasive, cost effective and simple manner (Ekblom et al., 2005). This has allowed fitness testing to evolve from focusing on sporting performance to assessing health-related outcomes (Freedson et al., 2000). There are many fitness testing batteries that have been used, including; AAHPER (American Alliance for Health and Physical Education and Recreation), Youth Fitness Test, YMCA Fitness Test and FITNESSGRAM (Freedson et al., 2000) in the US. In Europe, possibly the most widely used fitness test battery is EUROFIT (Adam, Klissouras, Ravazollo, Renson & Tuzworth, 1988). EUROFIT was developed by the council of Europe and provides data on several components of skill and health related fitness. It includes simple measures of CRF, agility, hand-eye coordination, BMI, upper body strength, muscular endurance and balance.

SwanLinx “Fitness Fun Day”: Field Based Motor Fitness Assessment Methods

Testing methods used during the Fitness Fun Day are based on the same methods used by SportsLinx in Liverpool since 1998. The primary schools are invited to participate in the project and assigned a date and time to attend the Indoor Training Centre (ITC) at Swansea University. All children had the option to withdraw from any part of the study at any time. Data collection started in 2012 and this year 3000 children will have taken part. Ethics and the protection of data are paramount to us and Swanlinx adheres to the principles set out in the Helsinki Declaration of 1972. To this end Head teachers gave written informed consent, parents gave passive consent and children written informed assent. The study was approved by institutional research ethics committee (ref number PG14/2014/007).

Standard Operating Procedure for SwanLinx Fitness Fun Days

Prior to the fitness fun day:

- 1) Initial contact with the school (2-3 months before proposed testing period)**
 - **Arrange to meet PE coordinator or head teacher at the school.**
 - **Preparation:**
 - Print off a copy of the feedback template, copies of the information sheets and consent forms, and reports on fitness, obesity and lifestyle to provide to teachers.
 - **Meeting Objectives:**
 - Convince school to take part in the project. (Do this by explaining what is involved in the project, the aims of the project and what the school will gain from taking part)
 - **What needs to be explained during the meeting:**
 - The project aims to determine the health, fitness, diet and lifestyle of children aged 9-11 in Swansea.
 - The project has been running in Liverpool since 1996 where over 80000 children have taken part. The project is now being started in Swansea.
 - The project involves a fitness fun day at Swansea University's Indoor Training Centre (ITC) and an online questionnaire.
 - The fitness fun day takes half a day (approximately two and a half hours). It takes place in a morning or afternoon session (9.30-12 or 12.30-3).
 - The project is free to take part in; we only ask that you cover the costs for your transport to and from the ITC.
 - The fitness fun day involves the children doing a sit & reach test, handgrip strength test, 10x5m shuttle run, standing broad jump, speed bounce and the 20m Multistage Shuttle Run (bleep test). The children also have their weight, height and sitting height taken. The children are all given numbers and the data is all stored securely. Only the anonymous data will be used.
 - The children will then complete an online questionnaire called CHAT (Child's Health and Activity Tool). It asks questions about their lifestyle, diet, physical activity and mental wellbeing.
 - The school will be given access to the anonymous data for curriculum and educational use. The City & County of Swansea will also deliver a taster session on the sports that the children would most like to try, which is something gathered from the questionnaire.
 - **What needs to be found out during the meeting:**
 - Find out if the school would like to take part.
 - Find out the ICT facilities at the school.
 - Find out the number of children in Years 5 and 6.

- Find out if there are any dates that the school definitely can't attend a fitness fun day.
 - Ask to be provided with copy of the school registers.
- 2) Find out dates that the City & County of Swansea are unable to attend.**
- 3) Find potential dates from ITC for fitness fun day (2 months prior)**
- **Find out what potential dates are available:**
 - Indoor Training Centre contact number – 01792 602400
 - Speak to Andrew Griffiths (manager) at the Indoor Training Centre
 - Morning session: 8.30-12
 - Afternoon session: 12-3.30
 - All day (2 schools): 8.30-3.30
 - **State that you need access to all of the ITC.**
 - **State the equipment that you will need access to:**
 - Speed bounce foam wedges and mats
 - Standing long jump mat and board
 - Marking cones
- 4) Propose the potential dates to the schools, confirm at the ITC.**
- 5) Reserve equipment from Swansea University Sports Science Physiology Laboratory**
- **Complete a Lab and Equipment Requirement form and return to Wendy Clark or Rebecca Dietzig (w.a.clark@swansea.ac.uk; r.e.dietzig@swansea.ac.uk)**
 - Confirm booking, contact number – 01792 602028
 - **Equipment needed:**
 - Sit & Reach box
 - Handgrip Dynamometer (x2)
 - Weighing Scales
 - Height Stadiometer
 - Sitting Height Stadiometer
 - Clip boards (x9)
 - 30m Measuring Tape
 - Stopwatches (x6)
 - Sound system (confirm with AYP team)
 - **In addition:**
 - Numbers (labels)
 - Testing Sheets
 - Extra consent forms
 - Copy of testing protocols
 - Introduction Speech
 - Folders for Consent forms
 - SOPs (Fitness fun day & CHAT)
 - Confirm number of helpers (should be at least between 11-15 people – preferably between 14-19)
 - Confirm with school about arrival time and venue

6) Arrange for help Young Ambassadors

- Contact Gavin Lewis to arrange for help on the fitness fun day from Young Ambassadors (8-10)

7) Reserve PA system from City & County of Swansea and ensure copy of the 20m Multistage Shuttle Run CD works.

8) Print off copies of the head teacher, parent and children information sheets and consent/assent forms.

- Include several extras of each to provide to school.

9) Make copies of recording sheets and test protocols for each of the tests.

10) Write numbers on sticky labels to give to the children.

During the fitness fun day:

- **Introductory Speech:**

“Thank you for coming down to the university today.

First of all I need to go over the safety for this morning.

In the case of a fire, the doors are clearly marked and you will remain with your groups and leave your bags and follow us outside to the assembly point.

If you need the toilet at any point then please let one of the research team or YAs or your teacher know, the same if you need to get a drink.

Also if you begin to feel ill or injure yourself let one of us know.

I’ll tell you a little bit about the study before we get started.

The study is looking at the health and fitness of 9-11 year old children in Swansea.

You guys are one of the many schools to take part in the study this year, which is really exciting, and eventually every primary school will be tested in Swansea.

You guys have come down here today to do a series of fitness activities. Some of you may have done some of them before, and some of you won’t have. These include 10x5m sprint, sit and reach, handgrip strength, speed bounce, standing long jump and the bleep test.

You will also have your weight, height and sitting height measured.

In a moment you will all be given a number. This is the number that you give to the researchers or YAs at each station. So you don’t have to worry about giving your name. All of the data is kept private so we can’t look at somebody’s score and say “oh Charlie got 50 in the bleep test” it will simply have his number.

If there is anything you don’t want to do then just say and you don’t have to do it, we won’t pressure you or anything. Also you don’t need to tell your friends how you did in each activity; it’s not a competition between each other we just want you to do the best you can do.

Now if I’m going to split you into 3 groups.”

Anthropometric measures

Explaining the anthropometric measures to children:

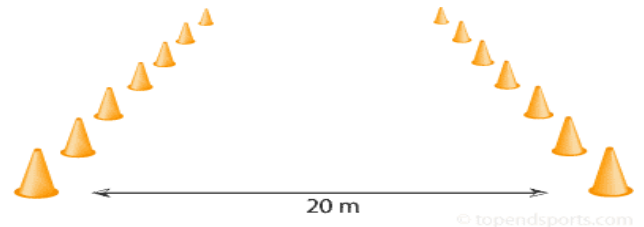
	<u>Assessment item</u>		
	<u>Height</u>	<u>Weight</u>	<u>Sitting height</u>
What will you do?	You will have to stand as straight as possible with your shoes off then breath in to get your best height	Stand on the scales without shoes and wearing a t-shirt and shorts/gym wear	Sit on the special table and have your height measured from the bottom of your bottom to the top of your head
Why?	We want to record how much you are growing and compare some of your other results to your height	We want to record how much you are growing and compare some of your other results to your weight	We can use this to work out how long your kegs are and how you are maturing physically
What will it tell you?	This will tell you how tall you are in cms and metres. If you measure your height every 3 months it will let you know how fast you are growing	How heavy you are.	How long your legs are. How long your upper body is.
Is it competitive?	Not at all, it is your measure and you can't change it	No not at all. But you can have a healthy weight by eating healthy food and being active for at least 60 mins per day	Not at all, it is your measure and you can't change it
How will you feel after it?	Hopefully you will feel good knowing how tall you are	Some people are worried about their weight and what they weigh. Nobody should be scared about their weight	Hopefully you will feel good knowing how your height is split between the length of your legs and upper body
How can you help others?	Make sure that you help other people by respecting them so they can keep their results to themselves	Make sure that you help other people by respecting them so they can keep their results to themselves	Make sure that you help other people do the test and keep their results to themselves
Hints for instructors	Make sure that children know that they can't change their height. Tell them to breath in, keep their head level and make themselves as long as possible	It is really important to make sure that you reinforce you are what you weigh, this is your weight.	Make sure that children know that they can't change their height. Tell them to breath in and make themselves as long as possible

20m Multistage Fitness Test (Shuttle Run)

The 20m multistage fitness test (MSFT) is a commonly used maximal running **aerobic fitness test**. It is also known as the 20 meter shuttle run test, beep or bleep test.

Equipment:

- 20m Measuring tape
- Marking cones
- Beep test CD
- CD player
- Recording sheets
- Flat non-slip surface



Personnel:

If there are two beep tests running side by side need minimum of 2 people for each test.

- ~5 people

Procedure:

This test involves continuous running between two lines 20m apart in time to recorded beeps. The subjects stand behind one of the lines facing the second line, and begin running when instructed by the CD recording. The speed at the start is quite slow. The subject continues running between the two lines, turning when signalled by the recorded beeps. After about one minute, a sound indicates an increase in speed, and the beeps will be closer together. This continues each minute (level). If the line is reached before the beep sounds, the subject must wait until the beep sounds before continuing. If the line is not reached before the beep sounds, the subject is given a warning and must continue to run to the line, then turn and try to catch up with the pace within the next 'beep'. The test is stopped if the subject fails to reach the line (within 2 meters) for two consecutive beeps.

Scoring:

The athlete's score is the number of shuttles (20m) reached before they were unable to keep up with the recording. Record the **last lap completed** (not necessarily the lap stopped at).

Explaining the 20m MSFT to children:

	<u>Assessment item</u>
	20m shuttle run (bleep test)
What will you do?	You will be asked to run back and forth over a 20 metre distance in time with a beep
Why?	We want to know how your fitness level is. This type of fitness puts more demands on your heart lungs and legs and your ability to keep going. We know that this is related to your health
What will it tell you?	You will run as far as you can and you will know how many 20 metre shuttles (runs) that you completed. If you do 20 shuttles that means you have completed 400m We know that a healthy fitness score is 25 shuttles for girls and 33 for boys
Is it competitive?	The most important thing about this task is that you do your best and work as hard as you can. We know how hard you are working. IT IS NOT A RACE
How will you feel after it?	You should feel very tired initially and your heart rate and breathing will be much faster BUT you will recover very quickly. IF you have done your best you will feel a sense of achievement for you.
How can you help others?	When you have finished you will get a break to recover. This will happen quickly. Before you cool right down we aim to keep everybody involved by joining all those who are left running. You may want to join in next to a friend to help them do their best. In. You could even run with a friend to help motivate them
Hints for instructors	This test has been criticized for not recording accurate results. This is due to low motivation levels of children and not setting the test up in a +ve cooperative atmosphere. When children stop and get their breath back they all need to go back in and help out a mate. At the very end the person with the best score should not be running alone

Speed Bounce

Speed Bounce events are part of the Sportshall series designed for the indoor use of school age competitors. This event is an exciting test of an athletes speed, rhythm and coordination, involving double footed jumps over a foam wedge.

Equipment:

- Stopwatch
- Foam wedge
- Recording sheets



Personnel:

- ~3 people

Procedure:

Participants must wear suitable footwear. **Not to be completed in bare feet.**

- Speed Bounce is a two-footed jump in which the participant must take off and land on both feet. – The participant’s feet should leave the mat simultaneously and land on the mat simultaneously.
- The athlete should cross the wedge as many times as possible within 30 seconds.
- If an incorrect technique is used, the participant is stopped, offered an explanation as to the correct technique, and then allowed a fresh trial after an adequate rest period.
- An official should call out when 10 seconds are remaining.
- The number of **correct bounces** is counted. It is not an offence to clip or brush the wedge.
- A practice trial is allowed – about 5 to 10 bounces provide an ideal opportunity to spot potential problems with technique.
- Two trials are allowed.

Scoring:

Two officials should count the “correct” bounces. They should then liaise and agree on the number completed within the 30 second period.

Explaining the speed bounce to children:

	<u>Assessment item</u>
	Speed Bounce
What will you do?	2 footed jump back and forth as many times in 30 seconds
Why?	This tells us how well coordinated you are and how you can keep this going when you're tired
What will it tell you?	How fit you are when doing something that requires you to jump quickly in along burst
Is it competitive?	Yes it is. Motivate yourself to keep going when you're tired. Tell yourself to do your best
How will you feel after it?	You should feel very warm and tired in your legs. If you don't you will not have done your best!
How can you help others?	Help motivate them if they want you to.
Hints for instructors	This is definitely related to sport and dance performance and relates to how well coordinated a child is. It is important to ask children to coordinate their arms and legs and keep their head as central over the barrier as possible. Motivate them by using the group to shout them on but only if the child wants them to.

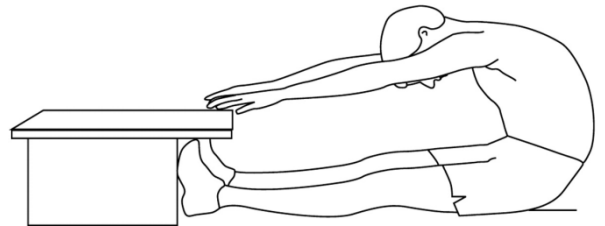
Sit & Reach

The sit and reach test is a common measure of flexibility, and specifically measures the flexibility of the lower back and hamstring muscles. This test is important as tightness in this area is implicated in lumbar lordosis, forward pelvic tilt and lower back pain.

The basic outline of the sit and reach test is described below.

Equipment:

- Sit & Reach box
- Recording sheets



Personnel:

- ~1-2 people

Procedure:

This test involves sitting on the floor with legs stretched out straight ahead. Shoes should be removed. The soles of the feet are placed flat against the box, shoulder-width apart. Both knees should be locked and pressed flat to the floor - the tester may assist by holding them down. With the palms facing downwards, and the hands on top of each other or side by side, the participant reaches forward along the measuring line as far as possible. Ensure that the hands remain at the same level, not one reaching further forward than the other. After some practice reaches, the subject reaches out and holds that position for one-two seconds while the distance is recorded. Make sure there are no jerky movements.

Scoring:

The score is recorded to the nearest centimetre as the distance reached by the hand.

Explaining the sit and reach to children:

	<u>Assessment item</u>
	Sit and Reach
What will you do?	This tells you how far you can stretch and how flexible and bendy you are
Why?	Muscles that stretch well are healthier. As you get older you will be less likely to have back pain or get injured playing sport if you have good flexibility
What will it tell you?	This tells you if you can touch your toes. You will have to stretch (make longer) the muscles at the back of the legs and in the lower part of your back
Is it competitive?	No, this is not competitive. In fact you should stretch forward slowly. You should make sure that you are warm when you do it.
How will you feel after it?	You might feel a little discomfort on the back of the legs but this is because you are making the muscles in the legs and backs stretch as far as they can safely go.
How can you help others?	By following the proper instructions and stretching as far as you can.
Hints for instructors	Make sure that you talk to children that muscles become more stretchable when they are warm. Also mention some activities that require a lot of flexibility, dance, gymnastics, swimming, but that all activities need balanced flexibility to protect joints.

Handgrip Dynamometer Strength Test

The purpose of the handgrip strength test is to measure the maximum isometric strength of the hand and forearm muscles. Handgrip strength is important for any sport in which the hands are used for catching, throwing or lifting. Also, as a general rule people with strong hands tend to be strong elsewhere, so this test is often used as a general test of strength.

Equipment:

- Handgrip Dynamometer
- Recording sheets

Personnel:

- ~1-2 people



Procedure:

- The handle of the dynamometer should be adjusted if required - the base should rest on first metacarpal (heel of palm), while the handle should rest on middle of four fingers.
- The participant holds the dynamometer in the hand to be tested with the arm held (extended) above their head
- When ready the subject squeezes the dynamometer with maximum effort (maintained for 3-5 seconds), they bring down their arm to their side in a smooth motion. → The extended arm being swung from above the head to by the side during the squeezing motion.
- No other body movement is allowed.
- **Make sure both hands are measured**

Scoring:

Record the reading for each hand

Explaining the handgrip to children:

	<u>Assessment item</u>
	Handgrip
What will you do?	You will adjust instrument to suit your hand size and then grip it as tight as you can.
Why?	This a measure of your basic strength
What will it tell you?	It tells you how hard you can grip things and how strong you are
Is it competitive?	Yes you can be competitive against yourself, try as hard as you can, even shout aaaaah when you do it if you want....it could improve your score. It's also good to compete your right hand against your left.....which one is stronger?
How will you feel after it?	You will feel that you have exercised the muscles in your lower arms
How can you help others?	Help motivate them if they want you to. Say c'mon squeeze!! Go for it and so on!
Hints for instructors	Each kg recorded is about the same as a bag of sugar. Tell the children how bags of sugar they can lift with their fingertips. Or let them compare left and right side.....Who can get an exact match? Also what percentage of their body weight could they lift? So if the get 15 on handgrip and they are 30kgs in weight they can lift half their bodyweight with their fingertips.....amazing!!

10 x 5m Shuttle Run Test

The 10 x 5m shuttle run test is a test of speed and agility.

Equipment:

- A flat non-slip surface
- Stopwatch
- Measuring Tape
- Marker cones
- Recording sheets



Personnel:

- ~2-3 people

Procedure

- Marker cones and/or lines are placed five meters apart.
- Start with a foot at one marker.
- When instructed by the timer, the participant runs to the opposite marker, turns and returns to the starting line.
- This is repeated five times without stopping (covering 50 meters total).
- At each marker both feet must **fully cross the line**.

Scoring

Record the **total time** taken to complete the 50 m course.

Record to two decimal places → e.g. 17.35

Explaining the 10 x 5m Shuttle Run to children:

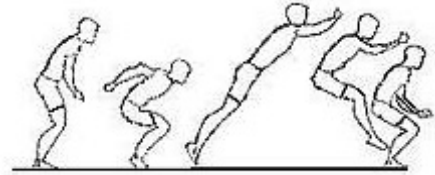
	<u>Assessment item</u>
	10 x 5m Shuttle Run
What will you do?	You will sprint back and forth over a 5m distance 10 times
Why?	This tells us how agile you are and how quickly you can change direction when running at speed
What will it tell you?	Whether you are fast AND agile and how you may use this in sport or dance
Is it competitive?	Yes compete against yourself and try to turn as quickly as possible to achieve your best time
How will you feel after it?	You should feel a little tired but also great after running so fast- as fast as you can
How can you help others?	<p style="text-align: center;">Help motivate them if they want you to.</p> <p style="text-align: center;">You could even run with a friend to help motivate them</p>
Hints for instructors	<p style="text-align: center;">This is a measure of speed and agility and crucial for successful performance in sport and dance.</p> <p style="text-align: center;">Key is to show children how to turn quickly by turning the head to look back in the direction they want to go when they get to the line.</p> <p style="text-align: center;">Also run children in pairs if they want to be competitive.</p>

Standing Broad Jump

The Standing Broad Jump, also called the Standing Long Jump, is a common and easy to administer test to measure the explosive power of the participant's legs.

Equipment:

- Long Jump Landing Mat
- Recording sheets



Personnel:

- ~1-2 people

Procedure:

- The participant stands behind a line marked on the ground with feet slightly apart.
- A two foot take-off and landing is used, with swinging of the arms and bending of the knees to provide forward drive.
- The participant attempts to jump as far as possible, landing on both feet without falling backwards.
- Three attempts are allowed.

Scoring:

The measurement is taken from take-off line to the nearest point of contact on the landing (back of the heels).

Record the **longest distance jumped**, the best of three attempts.

Explaining the Standing Long Jump to children:

	<u>Assessment item</u>
	Standing Long Jump
What will you do?	You will jump 2-footed as far as you can
Why?	We want to measure your leg power
What will it tell you?	How far you can jump and how springy you are. This is good for sports and dance that require leg power
Is it competitive?	Yes it is. Make as big an effort as you can. Can you jump your own height?
How will you feel after it?	You should feel good and springy and you should have a few attempts to jump as far as you can
How can you help others?	Help motivate them if they want you to.
Hints for instructors	<p>Being powerful is important for all sports and dance. Tell children to use their arms well. What % of their height can they jump? How far can they jump when they keep their arms behind their back for the whole jump? The difference between hands behind back and not shows how well they use their arms to transfer momentum into the jump</p>

EXAMPLE DATA COLLECTION SHEETS:

(NAME OF PRIMARY SCHOOL)

20m Multistage Fitness Test Recording Sheet

<u>Participant Number</u>	<u>Last Lap Completed</u>	<u>Notes</u>
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

(NAME OF PRIMARY SCHOOL)

Speed Bounce Recording Sheet

<u>Participant Number</u>	<u># of Correct Bounces (Trial 1)</u>	<u># of Correct Bounces (Trial 2)</u>
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

(NAME OF PRIMARY SCHOOL)

Sit & Reach Recording Sheet

<u>Participant Number</u>	<u>Distance Reached (to the nearest CM)</u>
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	

EXAMPLE DATA COLLECTION SHEETS:

(NAME OF PRIMARY SCHOOL)

Handgrip Dynamometer Strength Test Recording Sheet

<u>Participant Number</u>	<u>Left Hand Reading</u>	<u>Right Hand Reading</u>
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

(NAME OF PRIMARY SCHOOL)

10 x 5m Shuttle Run Test Recording Sheet

<u>Participant Number</u>	<u>Time Taken to complete 50m</u>
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	

(NAME OF PRIMARY SCHOOL)

Standing Broad Jump Recording Sheet

<u>Participant Number</u>	<u>1st Jump</u>	<u>2nd Jump</u>	<u>3rd Jump</u>	<u>Best Jump</u>
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

EXAMPLE DATA COLLECTION SHEETS:

(NAME OF PRIMARY SCHOOL)

Weight, Height and Sitting Height Recording Sheet

<u>Participant No.</u>	<u>Height (cm)</u>		<u>Sitting Height (cm)</u>		<u>Weight (kg)</u>
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					


Appendix III: Child Health and Activity Tool: Online Questionnaire

Personal Details:

First Name:

Surname:

School:

Gender: Boy 

Girl 

Date of

Birth: Year:

Month:

Day:

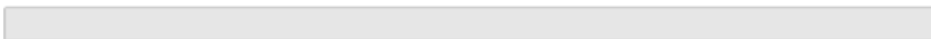
Postcode:

Do you consider yourself to have a disability?

Yes No

- Wheelchair user Physical disability Visual impairment
 Hearing impairment Learning difficulty Other

0%

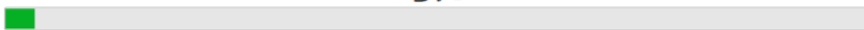


Forward →



Firstly, think carefully about what you did YESTERDAY and then answer the following questions....

3%



← Back

Forward →

1. What time did you get up YESTERDAY?

- 05.00
- 05.30
- 06.00
- 06.30
- 07.00
- 07.30
- 08.00
- 08.30
- 09.00
- Other Time:



2. What did you eat for breakfast YESTERDAY?



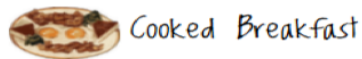
Nothing



Toast



Cereal



Cooked Breakfast



Snacks



Yoghurt



Fruit



Other

3. What did you have to drink for breakfast?

Nothing

Water

Milk

Fruit juice e.g. Orange juice, apple juice etc

Squash

Energy drink e.g. Lucozade Sport, Powerade, Red Bull

Fizzy Drink e.g. Coke, Sprite

Diet fizzy drink e.g. Diet Coke, Diet Fanta

Other:



4. a) BEFORE LESSONS STARTED YESTERDAY, how long did you spend doing sports or exercise? ↓



This includes doing any activities or playing sports where your heart beat faster, you breathed faster and you felt warmer



No time at all	10 minutes	20 minutes	30 minutes	40 minutes	50 minutes	1 hour	More than 1 hour
----------------	------------	------------	------------	------------	------------	--------	------------------

b) BEFORE LESSONS STARTED YESTERDAY, how long did you spend sitting down watching TV/playing computer games/using IPAD or internet? ↓



No time at all	10 minutes	20 minutes	30 minutes	40 minutes	50 minutes	1 hour	More than 1 hour
----------------	------------	------------	------------	------------	------------	--------	------------------

c) BEFORE LESSONS STARTED YESTERDAY, how long did you spend doing homework/reading? ↓



No time at all	10 minutes	20 minutes	30 minutes	40 minutes	50 minutes	1 hour	More than 1 hour
----------------	------------	------------	------------	------------	------------	--------	------------------

5. How did you get to school YESTERDAY morning?



On the bus



On bike



In the car/taxi



Walked



Ran/jogged



Scooter




Skateboarded/Rollerbladed


Did you travel with an adult?


- Yes
- No

6. What did you do for most of your MORNING break YESTERDAY? Please only tick one option.


This includes sitting down talking to friends, watching TV, reading, doing homework and using the computer


 Sat around inside or outside

This includes doing any activities or playing sports where your heart beats fast, you breathed faster and you felt warmer 


 Ran around

 Stood around


This includes doing any activities or playing sports where your heart beats fast, you breathed faster and you felt warmer 


 Ran around

 Stood around

 Walked around

7. a) What did you have to eat for lunch?


 School Dinner


 Packed Lunch


 Nothing


b) What did you have to drink for lunch?


 Water

 Fruit Juice


 Fizzy Drink

 Diet Fizzy Drink

 Squash

 Energy Drink

 Milk

 Nothing



8. Apart from eating your food, what did you do for MOST of your lunchtime YESTERDAY? Please only tick one option.

This includes sitting down talking to friends, watching TV, reading, doing homework and using the computer



Sat around inside or outside

This includes doing any activities or playing sports where your heart beats fast, you breathed faster and you felt warmer



Ran around



Stood around



Walked around



9. What did you do for most of your afternoon break YESTERDAY?



Didn't have an afternoon break

This includes sitting down talking to friends, watching TV, reading, doing homework and using the computer



Sat around inside or outside

This includes doing any activities or playing sports where your heart beats fast, you breathed faster and you felt warmer



Ran around



Stood around



Walked around

10. How did you get home YESTERDAY?



On the bus



On bike



In the car/taxi



Walked



Ran/jogged



Scooter



Skateboarded/Rollerbladed

Did you travel with an adult?

- Yes
- No



11. a) AFTER SCHOOL YESTERDAY, how long did you spend doing sports or exercise? ↓



This includes doing any activities or playing sports where your heart beat faster, you breathed faster and you felt warmer



No time at all	10 minutes	20 minutes	30 minutes	40 minutes	50 minutes	1 hour
Between 1 and 2 hours	Between 2 and 3 hours	More than 3 hours				

b) AFTER SCHOOL YESTERDAY, how long did you spend sitting down watching TV/playing computer games/using IPAD or internet? ↓

Many TV programmes such as The Simpsons are 30 minutes long.



No time at all	10 minutes	20 minutes	30 minutes	40 minutes	50 minutes	1 hour
Between 1 and 2 hours	Between 2 and 3 hours	More than 3 hours				

c) AFTER SCHOOL YESTERDAY, how long did you spend doing homework/reading? ↓



No time at all	10 minutes	20 minutes	30 minutes	40 minutes	50 minutes	1 hour
Between 1 and 2 hours	Between 2 and 3 hours	More than 3 hours				

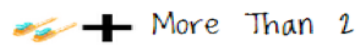
12. How many portions of fruit and vegetables did you eat yesterday?



1 portion is about a HANDFUL of vegetables or a piece of fruit. REMEMBER potatoes do NOT count

- 0
 1
 2
 3
 4
 5
 6
 7

13. How many times did you brush your teeth yesterday?



14. What time did you go to sleep?



- | | |
|----------------------------|-----------------------------------|
| <input type="radio"/> 7pm | <input type="radio"/> 7.30pm |
| <input type="radio"/> 8pm | <input type="radio"/> 8.30pm |
| <input type="radio"/> 9pm | <input type="radio"/> 9.30pm |
| <input type="radio"/> 10pm | <input type="radio"/> 10.30pm |
| <input type="radio"/> 11pm | <input type="radio"/> 11.30pm |
| <input type="radio"/> 12am | <input type="radio"/> Other Time: |

Well done you are half way through!



50%



15. Now think about what you did in the last WEEK.....(INCLUDING THE WEEKEND)



This includes doing any activities or playing sports where your heart beats fast, you breathed faster and you felt warmer

a) How many days of the week did you do sports or exercise for at least an hour in total?

- 0 1 2 3
 4 5 6 7 Days



b) How many days of the week did you watch TV/play on consoles/use IPAD/use the internet etc for 2 or more hours a day?

- 0 1 2 3
 4 5 6 7 Days



c) How many days of the week did you feel tired?

- 0 1 2 3
 4 5 6 7 Days



d) How many days of the week did you feel like you could concentrate/focus well in class?

- 0
- 1
- 2
- 3
- 4
- 5 Days



e) How many days of the week did you drink at least one fizzy drink e.g. coke, fanta, sprite?

- 0
- 1
- 2
- 3
- 4
- 5
- 6
- 7 Days



f) How many days of the week did you drink at least one DIET fizzy drink e.g. Diet coke, diet fanta?

- 0
- 1
- 2
- 3
- 4
- 5
- 6
- 7 Days



g) How many days of the week did you eat at least one sugary snack e.g. sweets/chocolate/cake?

- 0
- 1
- 2
- 3
- 4
- 5
- 6
- 7 Days



h) How many days of the week did you eat take away foods e.g. McDonalds, KFC, chinese?

- 0 1 2 3
- 4 5 6 7 Days



i) How many days of the week did you eat fish?

- 0 1 2 3
- 4 5 6 7 Days

16. What type of bread do you eat?



I don't eat bread



White



Brown/wholemeal



50:50

17. What type of milk do you drink?



I don't drink milk



Whole milk




Semi-skimmed milk



Skimmed milk

18. What sport clubs or physical activities do you take part in at least once a week?

IN SCHOOL: (this does not include PE)

- | | |
|--|---|
|  Nothing |  Athletics |
|  Badminton |  Basketball |
|  Cricket |  Dance |
|  Football |  Golf |
|  Gymnastics |  Hockey |
|  Netball |  Rounders |
|  Rugby |  Swimming |
|  Tennis |  Other |

OUT OF SCHOOL:

- | | |
|--|--|
|  Nothing |  Athletics |
|  Badminton |  Basketball |
|  Cricket |  Cycling |
|  Dance |  Football |
|  Golf |  Gymnastics |
|  Hockey |  Martial Arts |
|  Netball |  Rock Climbing |
|  Rounders |  Rugby |
|  Skateboard |  Swimming |
|  Tennis |  Trampolining |
|  Water Sports |  Other |

19. Are you a member of cubs, brownies, guides or scouts?



20. WHO do you usually take part in physical activity or sport with?

IN SCHOOL=



On your own



With Friends



With Parents/Guardians



With Brother/Sister



Other:

OUT OF SCHOOL=



On your own



With Friends



With Parents/Guardians



With Brother/Sister



Other:

21. How many times a week do your parents/guardians do exercise or sport (This includes going for a run or going to the gym)?


Parent/Guardian 1:  Female  Male

- Not at all
- 1-2
- 3-4
- 5 or more

Parent/Guardian 2:  Female  Male
(Optional)


- Not at all
- 1-2
- 3-4
- 5 or more

22. Where can you play at home/in the surrounding area that you can walk to?

 Nowhere


 Backyard


 Garden

 Grassy area/playing field

 Playground

 Park

 On the street

 Leisure/sport centre

 School

23. Which of these physical activities or sports would you like to do more of?



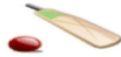
Athletics



Netball



Rugby



Cricket



Tennis



Dance



Swimming



None of these



Other

24. What physical activities or sports would you like to take part in that you have not tried before?

25. Can you ride a bike?



Yes



No

26. a) Can you swim?



Yes



No

26. b) Can you swim 25 metres?



Yes



No

27 How do you feel about:

a) Your health: 😞 😞 😞 😊 😊

b) Your fitness: 😞 😞 😞 😊 😊

c) Your school: 😞 😞 😞 😊 😊

d) Your family: 😞 😞 😞 😊 😊

e) Your friends: 😞 😞 😞 😊 😊

28. Now tell us whether you agree or disagree with the following

a) I am doing well at school:

Strongly disagree	Disagree	Don't agree or disagree	Agree	Strongly agree
×	×		✓	✓

b) I have lots of choice over things which are important to me

Strongly disagree	Disagree	Don't agree or disagree	Agree	Strongly agree
×	×		✓	✓

c) There are lots of things I am good at

Strongly disagree	Disagree	Don't agree or disagree	Agree	Strongly agree
×	×		✓	✓

29. What do you think could be done in your local area to improve the health of children?



Well done, you've completed the questionnaire.
Thank you!

[Start again](#)

100%



Appendix IV: Standard Operating Procedure for Child Health and Activity Tool



Standard Operating Procedure **For** **Child Health and Activity Tool (CHAT)** **www.childactivity.co.uk**

1.0 INTRODUCTION

This section introduces the standard operating procedure (SOP) to administer the Child's Health and Activity Tool (CHAT). CHAT has been designed as an online health and lifestyle questionnaire for primary school children. The data collected from CHAT will be used alongside fitness test data to determine the health and fitness parameters of children. CHAT is compatible with iPads and laptops and is available in English and Welsh. This SOP will explain in detail how a researcher should administer CHAT to a class of children. The SOP includes instruction for:

1.1 Information prior to administering CHAT.

1.2 Administering CHAT.

1.3 Accessing the data after administering CHAT.

1.1 PRIOR TO ADMINISTERING CHAT

- 1) Date and time**
- 2) IT Facilities**
- 3) Postcodes**

1) Arrange date and time for questionnaire to take place

- Contact the school 2-3 weeks in advance of administering CHAT and gauge interest in taking part (phone call and standard recruitment email).
- Send out head teacher, parent and participant information sheets and consent forms to schools.
- CHAT can't be administered on a Monday or after a Bank Holiday due to questions asking what the children did yesterday (also avoid administering on weeks focused on health and exercise, such as walk or cycle to school week etc.).
- Find out how many classes will be completing CHAT.
- Find out the number of pupils in each class.
- Allow minimum of 45 minutes for a class to complete CHAT in one sitting. This allows for introduction and explanation, the children to complete CHAT, and thanks at the end.
- Remember to ask about break and lunchtime schedules.
- Ask the teacher beforehand if there is anything the children do once they finish CHAT as some children will finish sooner than others. These other activities may be educational online games or other work that they have been doing.

2) IT Facilities

- Ensure there are enough computers/iPads for all children in class to complete CHAT at the same time. Otherwise class will need to be split.
- Ask about the IT facilities that the school has. Does the school have Wi-Fi and use iPads or laptops or does it have an IT suite where the computers all have a local connection.

- If the children will be using iPads or laptops, ensure they will all have been charged beforehand and check wireless network connection and what usernames and passwords are required.
- If the IT facilities (IT suite, laptops, iPads) need to be booked make sure this is done in advance.
- Clarify that Google Chrome is the best internet browser to administer CHAT.

3) Postcodes:

- Ask the teacher to bring several copies of sheets with the children's postcodes.
- If unwilling to bring sheets then ask to bring student info folder from main office.
- Have all children who don't know their post code raise their hand at the start of CHAT and then wait for their teacher to come over and tell them.

1.2 ADMINISTERING CHAT

4) Introduction

5) If CHAT stops working

6) Start page

7) CHAT Questions 1-29

4) Introduction:

- Before administering CHAT explain what it is about.
 "It asks questions on how much exercise you did, what you ate, what time you went to sleep and how you feel about certain things. The first part follows a timeline of what you did yesterday from when you woke up to when you went to sleep. You can follow the clock at the top for idea of time. So, think carefully about what you did yesterday before answering. Some questions look similar but if you read it closely it's asking about different section of day (the clock on top helps with this). There are no right or wrong answers but it is important you answer all questions honestly. Read the question slowly to make sure you understand it properly and do not rush – it's not a race. If you don't understand a question, see if there is a speech bubble which normally explains a bit further. If you have read the speech bubble and still don't understand, put up your hand and wait for the teacher to explain. If ill or on holiday, think of the last normal school day when you were in school".
- Log on to www.childactivity.co.uk.
- Bilingual: Option to complete in welsh by clicking "cymraeg" in top right corner.

5) Problem

If CHAT freezes or will not let you go forward, try and click the refresh button by the web address. If this does not work or the pupil closes the CHAT window, they will have to start from the beginning. If they had got further than 3 or 4 questions, have a researcher take note of the child's previous progress, help them fill in the first page correctly and then click any answer for the questions that they had already completed. Once they reach where

CHAT had previously frozen, the child can carry on with completing CHAT. The data will then have to be edited manually by a researcher after CHAT is completed.

6) Start Page

If they don't know if they have a disability ask them to go through each of the disability options to see if any apply to them, if they don't have any then tell them to click no.

7) CHAT Questions 1-29

Question 1) *What time did you wake up?*

- Choose closest time or click other for more specific (choose time they woke up **not** got up).

Question 2) *What did you eat for breakfast?*

- Healthy and unhealthy cereal (if unsure click other at bottom and put the name of the cereal).
- Sometimes the other box will appear higher on the page.

Question 3) *What did you drink for breakfast?*

- Children can click more than one option.

Question 4) *Before school how long did you spend..*

a) *Doing sport or exercise?*

- Make sure children read the speech bubble (Brisk walking would count but not slow/normal walking).

b) *Sitting down watching TV/playing video games/using iPad/internet?*

- Ask them to use length of TV programmes as guide and to make sure they add up each sedentary activity.

c) *Doing homework or reading?*

- Reading after school has started does not count.

Questions 5) *How did you get to school?*

- If the children say they did more than one option, ask them which they spent the most of their journey doing.
- If they travelled with an adult, ask if they travelled most of the way with them? If so, then YES but if not then NO.

Question 6) *What did you do for most of your morning break?*

- Make sure the children read the speech bubbles above "sit around" and "ran around" for examples.

Question 7) *What did you have to..*

a) *Eat for lunch?*

b) *Drink for lunch*

Question 8) What did you do for most of lunchtime apart from eating food?

- Make sure children read the part of the question explaining that the period of time eating lunch does not count.
- Make sure the children read the speech bubbles above “sit around” and “ran around” for examples.

Question 9) What did you do for most of your afternoon break?

- Make sure the children read the speech bubbles above “sit around” and “ran around” for examples.

Questions 10) How did you travel home from school?

- If the children say they did more than one option, ask them which they spent the most of their journey doing.
- If they travelled with an adult, ask if they travelled most of the way with them. ? If so, then YES but if not then NO.

Question 11) After school how long did you spend..

a) Doing sport or exercise?

- Make sure children read the speech bubble (Brisk walking would count but not slow/normal walking).

b) Sitting down watching TV/playing video games/using iPad/internet?

- Ask them to use length of TV programmes as guide and to make sure they add up each sedentary activity.

c) Doing homework or reading?

Question 12) How many portions of fruit and vegetables did you eat yesterday?

- Remember potatoes don't count.
- Follow the link below to see what amount of fruit and vegetables counts as a portion:
http://www.nhs.uk/Livewell/5ADAY/Documents/Downloads/5ADAY_portion_guide.pdf.

Question 13) How many times did you brush your teeth yesterday?

- Remember to ask whether children brush their teeth at school as well.

Question 14) What time did you go to sleep?

- Choose closest time or click other for more specific (choose time they went to sleep not went to bed).

Question 15) How many days a week..

a) Did you do sport or exercise for 1 hour or more?

- Make sure children read the speech bubble

- Includes weekdays and weekends
- b) Did you watch TV/play on consoles/use iPad/use the internet for 2 hours or more?**
 - Make sure children realise it is 2 hours or more in total, not for each activity.
- c) Did you feel tired?**
 - Make sure children understand it means all day, not just drowsy in the morning or at night.
- d) Did you feel like you could concentrate/focus in class?**
 - If children don't understand concentrate/focus use alternatives. For example: "pay attention to what the teacher is saying during class."
- e) Did you drink one fizzy drink?**
 - Remember to remind the children this is how many days a week not how many fizzy drinks.
 - It only includes full sugar drinks, for example: Coca Cola not Coca Cola Diet or Coca Cola Zero.
- f) Did you drink one diet fizzy drink?**
 - Remember to remind the children this is how many days a week **not** how many diet fizzy drinks.
 - Includes zero sugar drinks such as Coca Cola Zero/Fanta Zero as well as diet fizzy drinks.
- g) Did you eat one sugary snack?**
 - Remember to remind the children this is how many days a week **not** how many sugary snacks.
 - This includes cakes, sweets and chocolate.
- h) Did you eat a takeaway?**
 - This includes all fast food takeaways.
- i) Did you eat fish?**
 - This includes all types of fish, including fresh, battered and tinned.

Question 16) What type of bread do you eat?

- If children have more than one type of bread, ask them to choose which one they have the most.

Question 17) What type of milk do you have?

- If children have more than one type of milk, ask them to choose which one they have the most.
- If they have rice/soy milk, select "I don't drink milk."

Question 18) What sports/activities do you take part in..

- a) In school?**
 - Children should only select sports/activities that are **not** part of the curriculum.

- They should only select sports/activities that are extra-curricular (such as school teams) or sports/activities that they do at breaktime/lunchtimes.
- The sports/activities should be something they take part in on a regular basis (such as once a week).

b) Outside of school?

- The sports/activities should be something they take part in on a regular basis (such as once a week).

Question 19) Are you a member of brownies/cubs/guides/scouts?

- If the children are not members at present, then click “No.”

Question 20) Who do you usually take part in physical activity or sport with..

a) In school?

- If children say they don’t take part in any physical activity or sport, then get them to select “other” and type “don’t do any” in.
- If children say they take part in physical activity or sport with more than one than one group or person, ask them to select the option they take part in physical activity or sport with most.

b) Outside of school?

- If children say they don’t take part in any physical activity or sport, then get them to select “other” and type “don’t do any” in.
- If children say they take part in physical activity or sport with more than one than one group or person, ask them to select the option they take part in physical activity or sport with most.

Question 21) How many time a week do your parents/guardians do exercise or sport?

- Select gender of first parent/guardian, then how many times a week they do exercise or sport.
- Second parent is optional.

Question 22) Where can you play at home or in surrounding area within walking distance?

- Children can select as many options as they like.
- School only counts as an option if the school’s grounds are open outside of school hours.
- Backyard just relates to non grassy space.
- Garden is a grassy space.

Question 23) Which of these physical activities or sports would you like to do more of?

- Children can select more than one option.

Question 24) What sports or physical activities would you like to take part in that you have not tried before?

- If children are having difficulty thinking of an answer, ask them “have you ever seen something on TV which you would like to try or on the Olympics or your friend/family has taken part in.”

Question 25) Can you ride a bike?

- Stabilisers don't count

Question 26)

a) Can you swim?

- This doesn't specify distance, but whether they can swim unaided without touching the sides.

b) Can you swim 25 metres?

- If children ask what this means, ask them if they have a 25m badge? If not ask them if they can swim a length on their own, unaided, without armbands not touching sides (not of the national pool though-this would be half the length of that).

Question 27) How do you feel about..

a) Your health?

- Health is overall condition of their body, including diet, fitness, free from illness etc.

b) Your fitness?

- This question relates to how children feel about their bodies when they are performing sports and exercise. For example, do they get out of breath easily etc?

c) Your school?

- How do children feel about how their school overall? This includes teachers, other children and their school performance.

d) Your family?

- How do children feel about their family? This includes parents and siblings.

e) Your friends?

- How do children feel about their friends in school and outside of the school.

Question 28) Do you agree or disagree with..

a) “I am doing well at school”

- This is asking about how children feel they are doing performing academically at school.

b) “I have lots of choice over things that are important to me”

- Ask the children what is important to them personally such as diet, sports, playing with friends, bedtime, what they watch on TV etc and whether they have much choice over it.

c) “There are lots of things I am good at”

- Give examples if needed. For example: school, musical instrument, sports etc.

Question 29) What do you think could be done to improve the health of children in your local area?

- If children are unsure, make suggestion, such as parks, cycle lanes, youth clubs, local sports clubs etc.

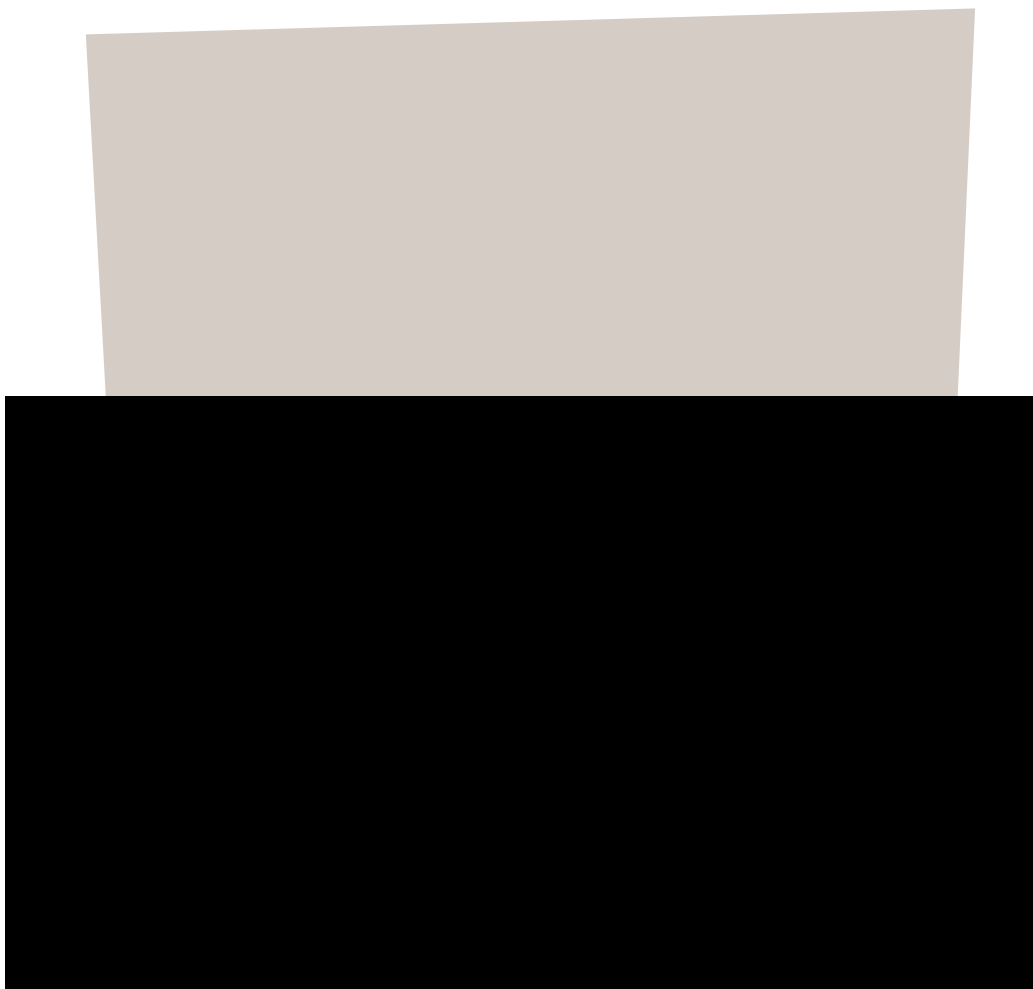
1.3 ACCESSING THE DATA AFTER ADMINISTERING CHAT

8) Accessing The Data After Administering CHAT

Steps:

- Log onto: <http://www.childactivity.co.uk/login.php>
- Username: AVAILABLE UPON REQUEST
- Password: AVAILABLE UPON REQUEST
- Click "Submit"
- Click "Download"
- Open up the Excel document.
- Copy and Paste school's data into new Excel document.

Appendix V: Dragon Challenge Manual



Cardiff, CF11 9SW

sportwales
chwaraeoncymsu



This manual has been produced by Professor Gareth Stratton (Swansea University) and Dr Lawrence Foweather (Edge Hill University) on behalf of Sport Wales.

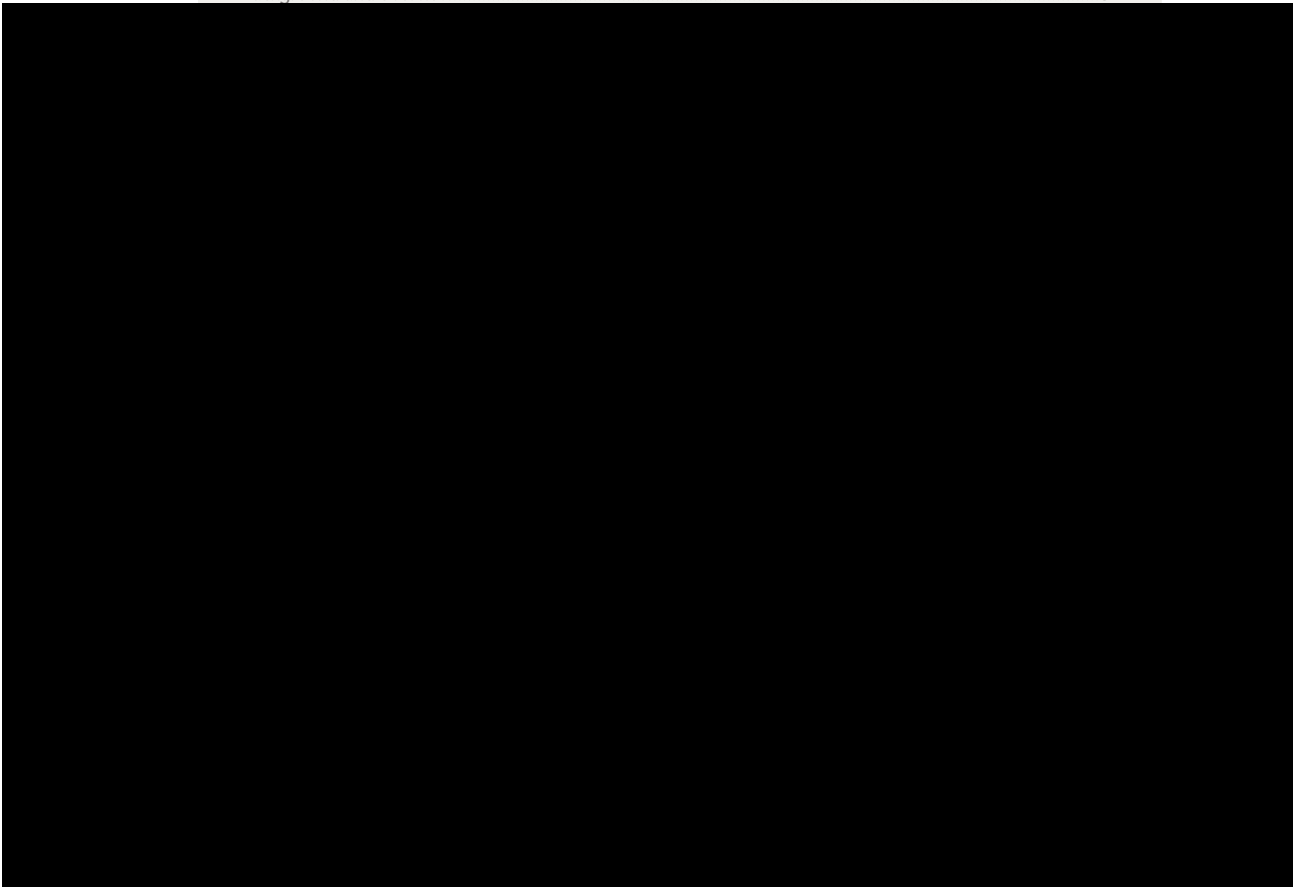
How to reference this manual:

Stratton G, Foweather, L, Rotchell J, English J, Hughes H (2015). Dragon Challenge V1.0 Manual. Sport Wales.



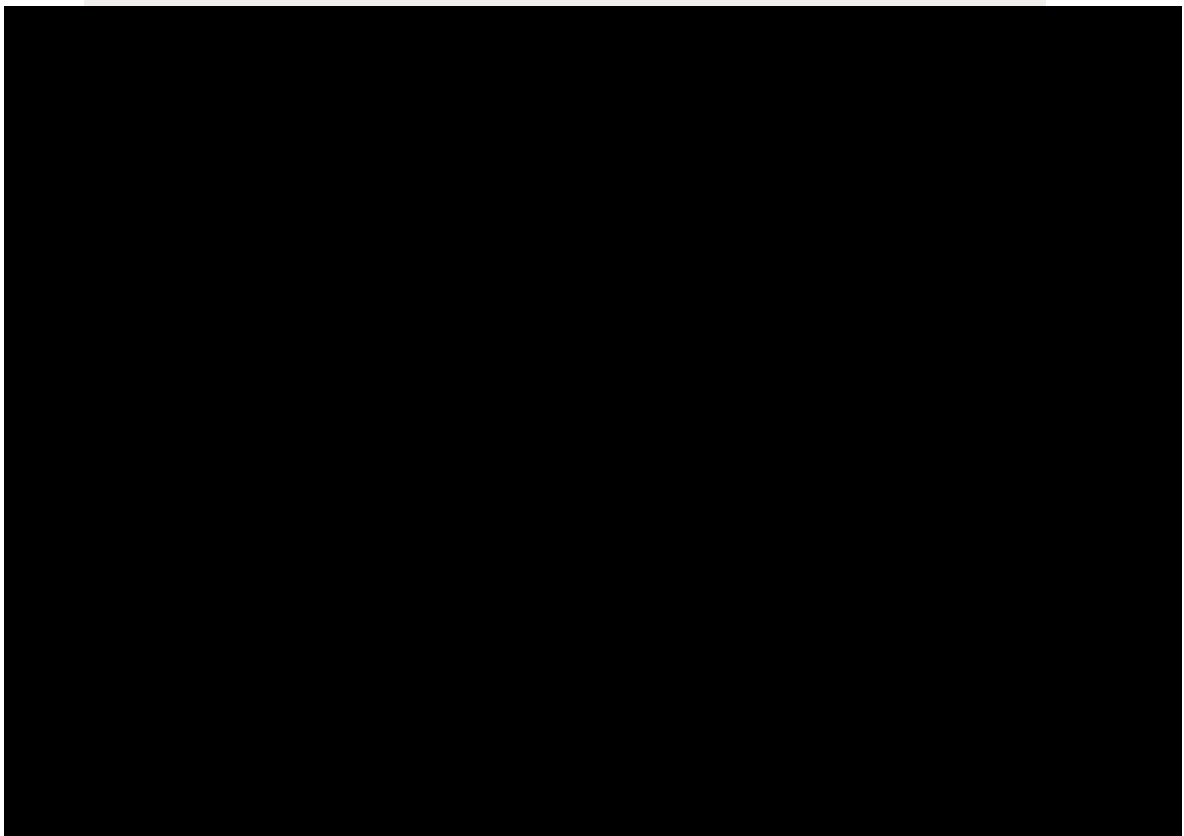
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Background and Overview

The clock is ticking. The health and well-being of our nation is at crisis point and there has never been a more critical time to ensure children have a healthy, positive development. The Welsh Government has long recognised that the quantity and quality of physical activity and physical literacy, respectively, is paramount to shaping the health and well-being of children; Wales was the first country to legislate for Play (2002), the first to introduce an "Active Travel Act" to its statute books (2014) and the first to consider physical literacy as being as important as

Physical competence is gradually acquired through a complex process of brain and neuromuscular development. The development of physical competence occurs sequentially, progressing from reflexive movements in the first few months of life to the acquisition of a broad repertoire of sport- and context specific movements in middle to late childhood, adolescence and adulthood (Gallahue et al., 2011). When a child is learning to read they first learn words such as cat, sat, mat. Similarly as a child learns physical skills they learn skills such as how to run, jump, throw and balance. Children then string words together into sentences and read them. In the same way, physical skills are linked together to create movement and perform activities such as riding a bike, swimming or performing the long jump.

The Importance of Developing Physical Competence

Physical or motor development is considered to be an important dimension of child development and in the development of cognition (Piaget, 1952). From an early age, the capacity to move gives children the ability to explore and interact with their physical world.

Research suggests that children and adolescents who develop high motor competence are more likely to participate in physical activity (Foweather et al., 2014; Holfelder & Schott, 2014; Lubans et al.,

sport from across Wales, the assessment tool was further developed and refined until Dragon Challenge Version 1.0 was finalised. It is expected that this version will be revised and updated according to the data and user feedback.

The Dragon Challenge is designed to be a dynamic and engaging assessment tool that provides a developmentally appropriate challenge of children's physical competence. The following sections outline the Dragon Challenge V1.0 and describe the tasks and preparatory procedures, the assessment process and criteria, as well as data management and the interpretation of results.

Description of the Dragon Challenge

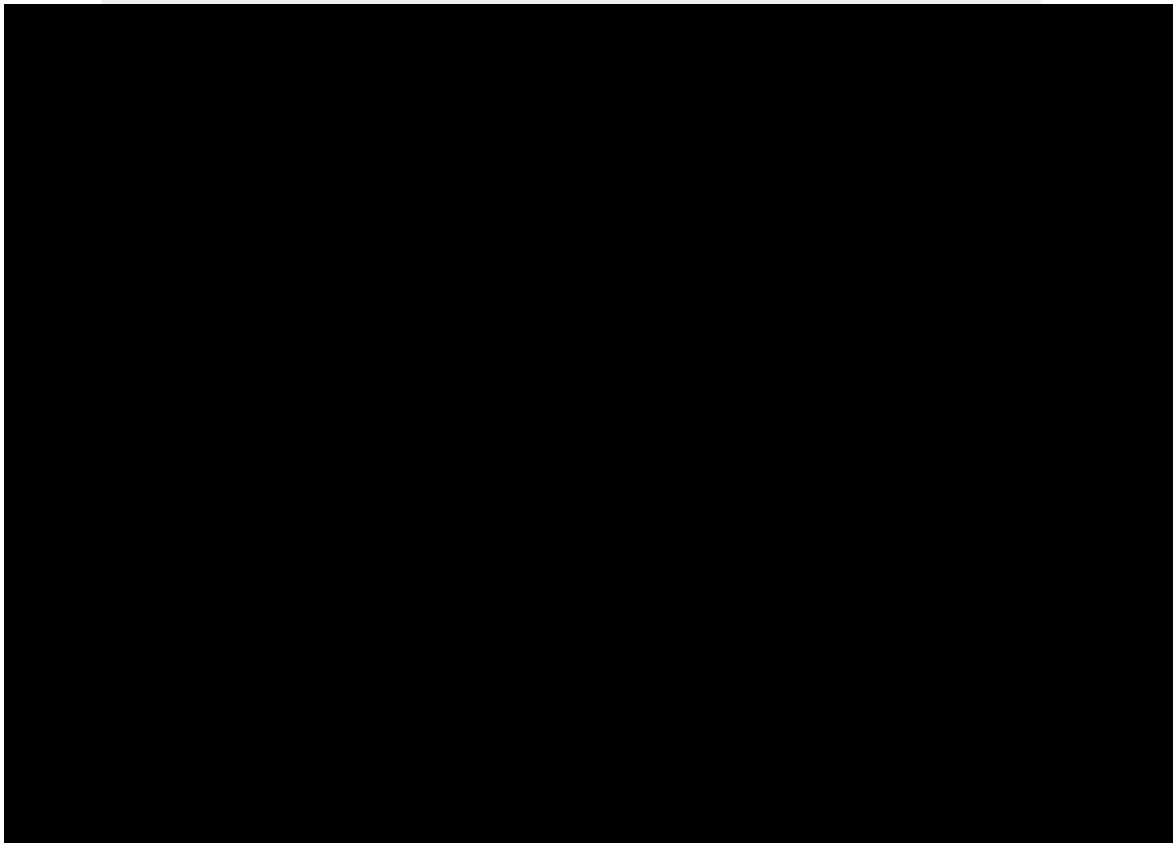
Mapped to Multi-Skill and Multi-Sport Activity Cards

Purpose

- The purpose of the Dragon Challenge is to assess children's physical competence.

Target Population

- Dragon Challenge has been designed for children in school years 6 and 7 (aged 10-12 years).



distance.

7. Jumping Patterns

Complete a jumping pattern sequence that includes a series of hops and jumps (2 footed jump over hurdle > 2 footed landing > 2 left hops > 2 right hops > 2 foot jump over hurdle > 2 footed landing).

8. T-Agility

Complete t-agility run, facing forwards throughout.

9. Accelerate-Sprint

10m acceleration to a sprint over finish line.

Table 2. Types of physical skills utilised during each Dragon Challenge assessment task

Task	Body Management	Locomotion	Manipulative
1. Balance Bench	●	○	
2. Core Agility	●		

Uses of the Dragon Challenge

The Dragon Challenge assessment has primarily been developed as a surveillance tool to assess patterns and trends in the levels of physical competence among children across Wales. Dragon Challenge data will also become a "Key Performance Indicator (KPI)" for Sport Wales "Every Child Hooked on Sport" and Physical Literacy strategies.

Preparing for the Dragon Challenge Assessment

This section discusses important matters that should be considered before administering the Dragon Challenge Assessment.

Video Resources

A series of training videos are available to familiarise instructors and assessors with the challenge and its constituent activities. Video material is presented in a real context and guidance on preparation,

Assessor (see page 29).

Administrators of the Dragon Challenge should also receive basic training. This may include practicing administering the Dragon Challenge while being observed by an experienced administrator. Gold Standard Assessors will be able to provide information on training.

Child Data

Each child's Dragon Challenge assessment data needs to be input into an excel data sheet by the assessor(s) (see pages x to x for a detailed overview of data organisation and management). In preparation for the assessment, schools will need to provide pertinent information relating to individual child characteristics including:

- **Date of birth**
- **School year**

The equipment required to run the Dragon Challenge is listed in Table 3. It is important that only the equipment listed is used and that guidelines relating to the air pressure of the basketball and wobble spot are adhered to; the assessment was standardised using this equipment and any change/improvisation may invalidate the results. Most of the equipment used can be found in primary or secondary schools or is available from Physical Literacy Programme for Schools teams. The availability of spare equipment such as balls and bean bags should also be considered. An iPad or other tablet is required and should be pre-loaded with the Dragon Challenge keynote/ppt. presentation slides that display the order of activities (see Appendix B and C).

Staffing

A team of two assessors and 1 administrator are required to run the Dragon Challenge. It is desirable that both males and females are represented on the team. At least one member of this team will need to give demonstrations. In groups, an additional member of staff (e.g. physical education teacher) will be needed to run activities to occupy children while they wait for their individual assessment. With additional staffing and space, multiple children can be assessed simultaneously.

2 x Small traffic cones

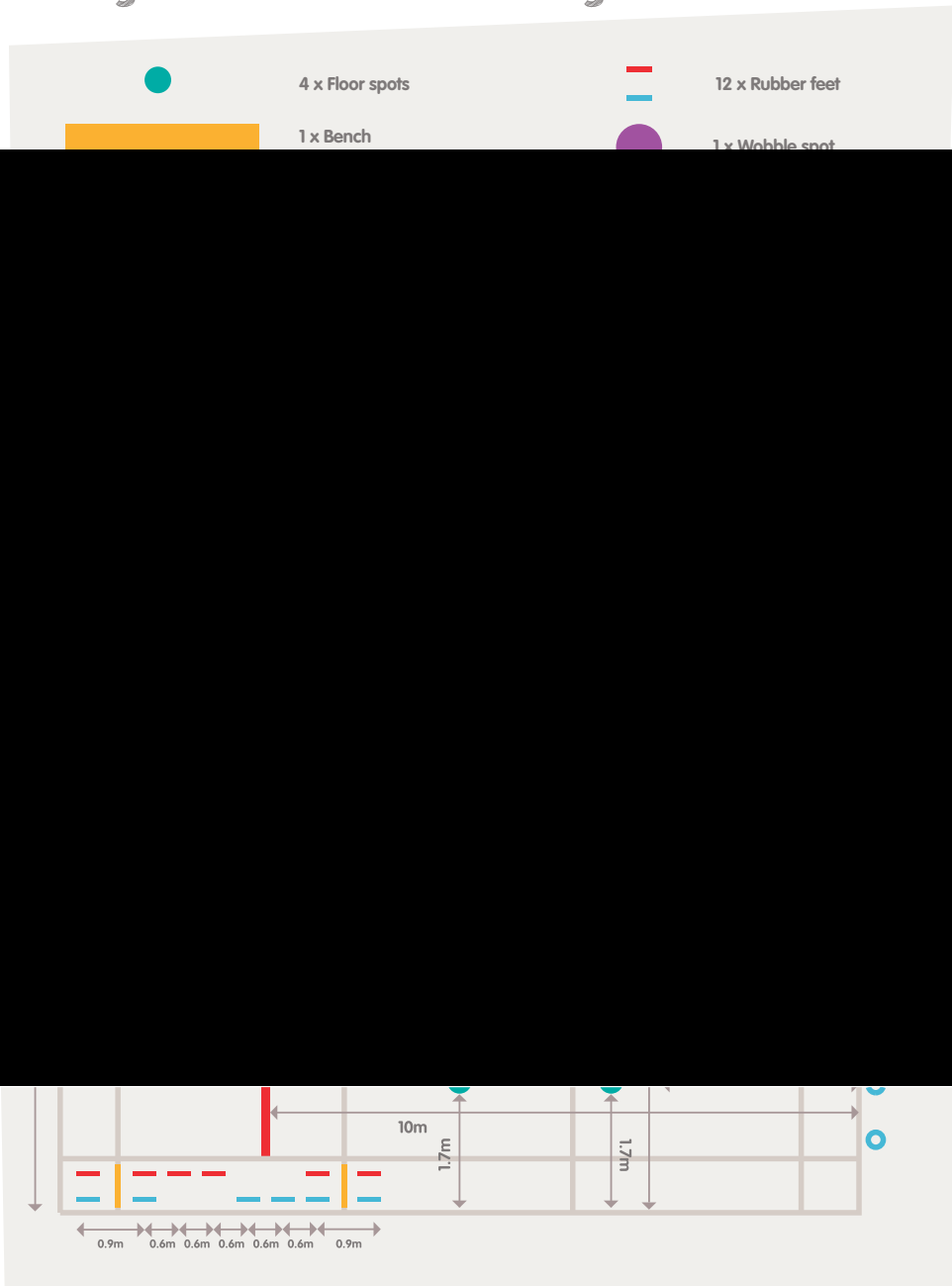
1 x Hula hoop

1 x Basketball (size 5; 0.5-0.6 bar; 7-9 PSI)

2 x Tennis balls

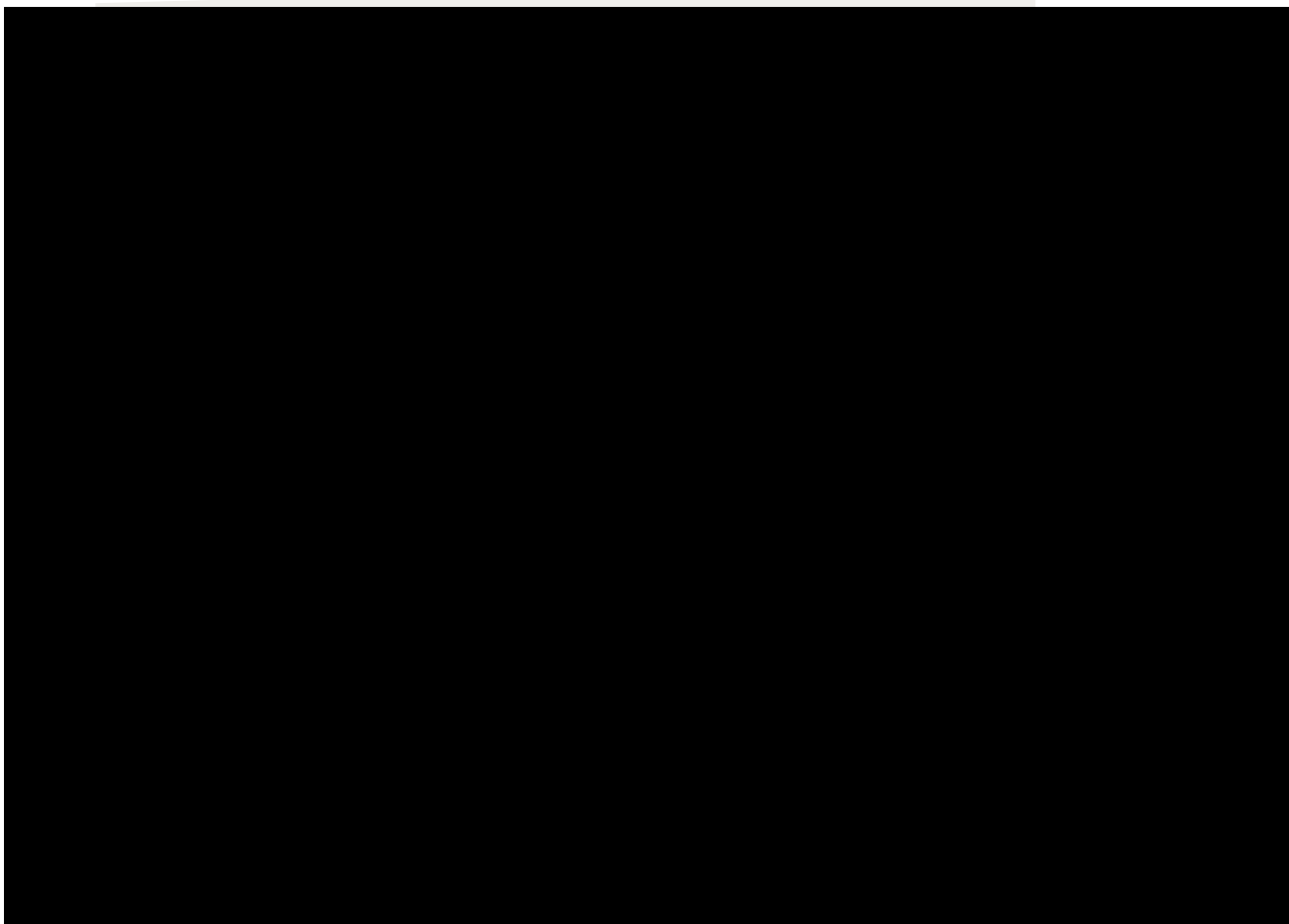
1 x iPad/tablet, fully charged and with Dragon Challenge presentations uploaded (Appendix B and C)

Figure 1a Floor Plan Legend



How to Administer the Dragon Challenge Assessment

This section provides directions for the administration of the Dragon Challenge. It is important that the Dragon Challenge is administered as specified so that a valid interpretation of a child's physical competence can be achieved and the results can be assessed across time. Therefore administrators should be trained in the live administration of Dragon Challenge. A range of video resources are available to support administrator training and development (see Appendix 3).

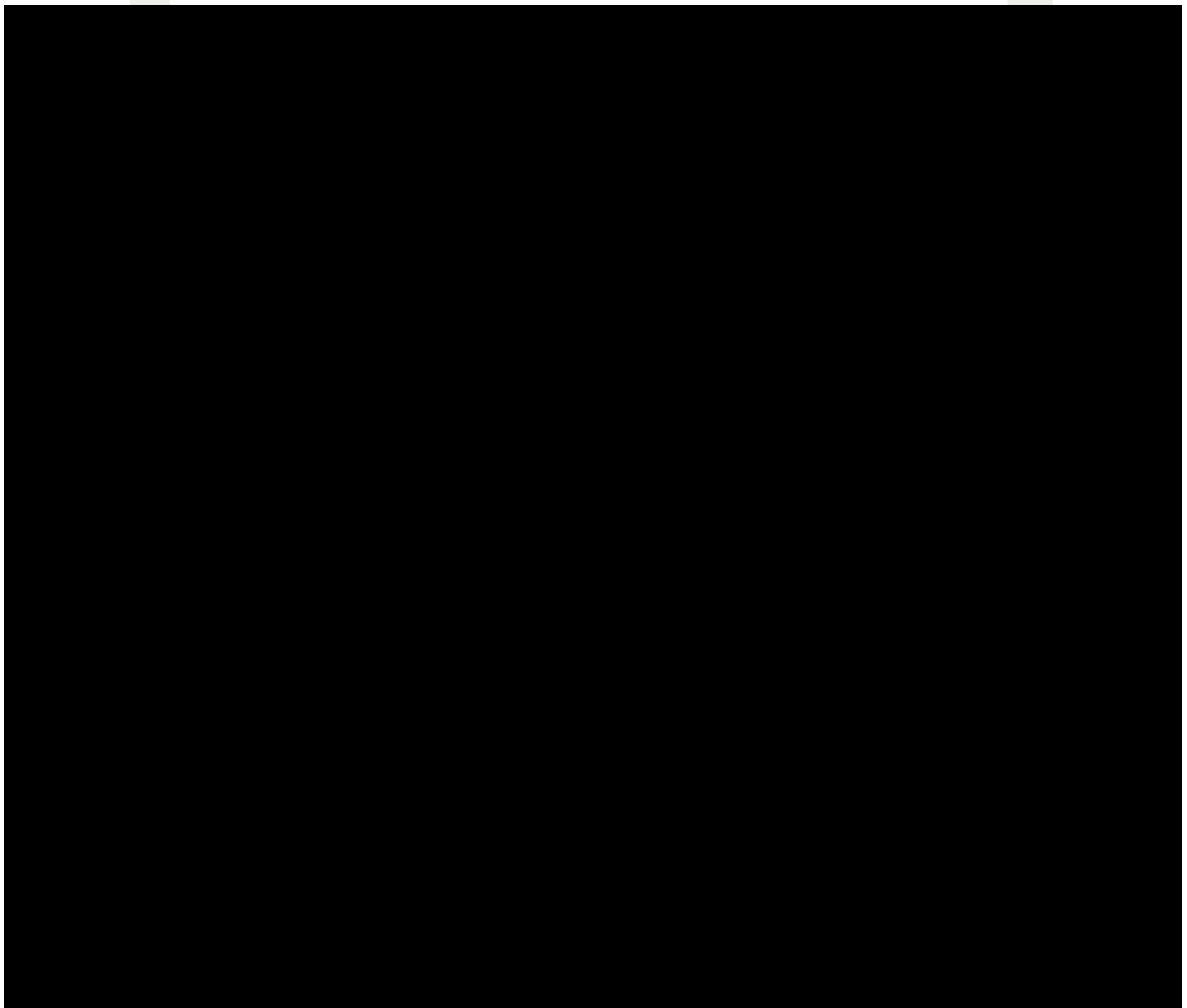


Let's run through the activities so you know what to do! (Move onto Step 3 – Demonstrations)

Box 1. Script for introducing the Dragon Challenge to children

Step 3 - Demonstration of Dragon Challenge

After the introduction, children then receive a practical demonstration of the Dragon Challenge activities. An assessor, administrator or specially recruited individual can demonstrate the activities. It is important that demonstrators perform each task accurately with sound technique. Demonstrations are important in ensuring that children understand the task requirements. However, they should not be used to teach or coach children.



Demonstrate arch only

"Let's see it all again...what do you notice about their shoulders? Did they touch the floor?" [answer: off the floor throughout]

Repeat in full

Questions to check understanding:

"What order do you do the shapes in?" [answer: dish-arch-dish-arch]

"Show me a dish? Show me an arch?" *children perform shapes*

"Do you start on your front or back?" [back]

Return to iPad

Activity	Actions	Scripts
Wobble Spot	Run to wobble spot. Pick up bean bag. Get set. Completes 5 bean bag	"This is called wobble spot. You need to balance on 1 foot, after picking up the bean bag." "Get yourself set, what do I mean by set?" [answer: balanced before starting]

bounce).

Return to iPad

Questions to check understanding:

"What type of throw do you use?" [answer: underarm]

"How close can you go?" [as close as you like]

"What do you do if you drop the ball or miss the catch?"

[return to iPad]

T-agility

Moves at half speed through all points of T facing forwards (must enter both right & left court tramlines).

"T-run is marked on the [insert tape colour] line. Show me the shape of a "T"." *performs T-shape with arms*

"You start moving forwards and then side-step into the tramline on the left then the tramline on the right."

"You will always face forward and you need to move and change direction as fast as you can."

pear to understand the task, one additional demonstration can be given. No coaching tips or technical guidance should be given during practice opportunities.

Step 5 - During the Assessment

While children do not have the opportunity to practice the full Dragon Challenge from start to finish, they should be provided with two practice trials for each individual task prior to assessment to assure that the child understands what to do. Following the demonstrations, children can be split into small groups, rotating around the activity stations to provide an opportunity for practice. When the child does not appear

10. As soon as they have attempted the arch	Gym mat	"Dish"	*gesture to turn*
11. As soon as they have attempted the dish	Gym mat	"Back to an arch"	
12. After they complete the arch	Gym mat	"Back to the iPad"	*point towards the iPad*

13. As soon as they touch the iPad	iPad	"Wobble spot"	*point towards the spot*
14. As they approach the wobble spot	Wobble spot	"Pick up the bean bag and get yourself set"	
15. As soon as they are set on the wobble spot	Wobble spot	"Go – 1, 2, 3, 4, 5"	

33. As they approach the cone gate	Sprint	"As fast as you can"	
34. Once they cross over the finish line	Sprint	"Well done, great effort!"	*clap hands, high five child*

Table 6 Additional directions for the administrator

Task	Additional Directions
iPad	Prior to starting each trial, ensure that the iPad is sufficiently charged and that the
	
Patterns	assessors by running alongside the jumping pattern

How to Record and Assess a Child's Dragon Challenge Performance

This section provides information in relation to how to record and assess a child's performance at the Dragon Challenge. As noted on page 13, all assessors of Dragon Challenge must have received training in assessment and be confident and competent in assessing children.

Child Performance Record



Assessment Criteria

Child performance at Dragon Challenge is assessed through:

- Time to completion
- Skill performance criteria (technique and outcome)

Table 7 Dragon Challenge assessment performance criteria

DC Task	Technical Criterion	Technical Criterion	Outcome Criterion
1. Balance Bench	1.1 Moves without hesitation up to turn	1.2 Body posture stable (head & trunk stable, minimal arm flailing)	1.3 Walks length of beam, completes full turn at 3/4 mark without falling off, dismounts at end zone
8. Jumping Patterns	8.1 Arms drive over first hurdle (elbows bent & arms swing to produce force)	8.2 Rhythmical pattern throughout	8.3 Completes jumping pattern sequence correctly. No contact with hurdles
9. Sprint	9.1 Drives off balls of feet, leaning forwards	9.2 Arms bent, driving forward & backwards (arms bent at approx. right angles)	9.3 Runs through start gate & then through to finish (must be running not walking)

Calculating the Dragon Challenge Score

The Dragon Challenge composite score is calculated from the same trial as follows:

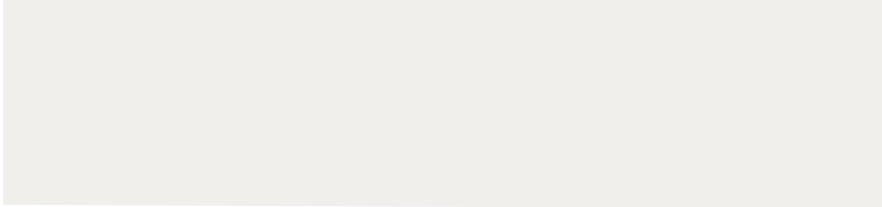
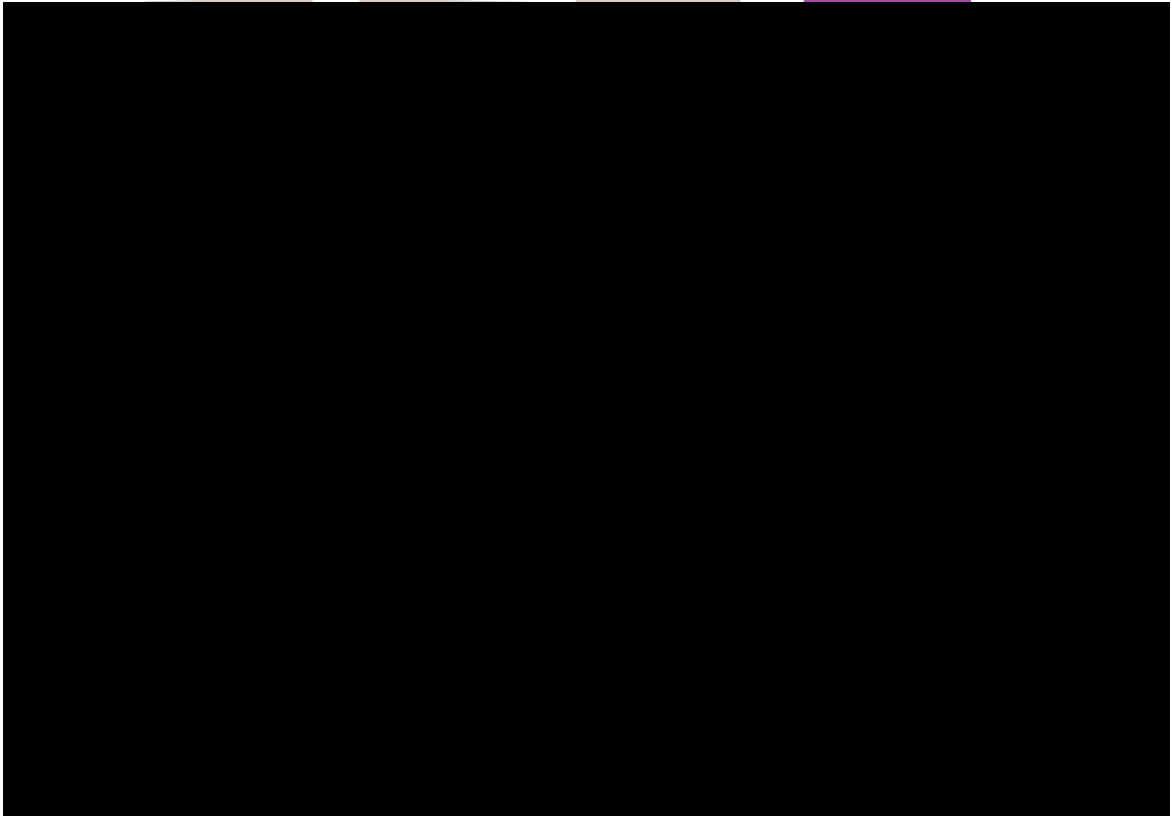
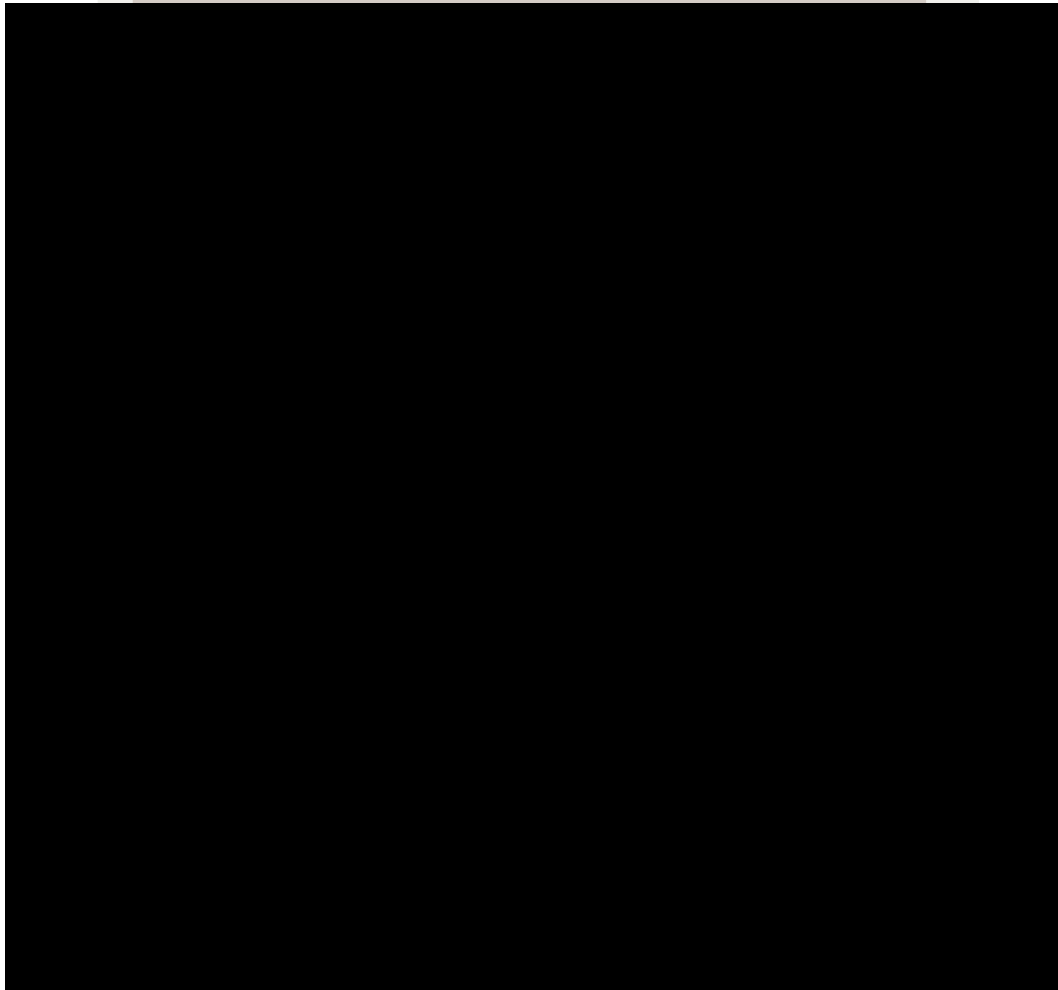


Table 8 Scoring the Technique and Outcome Skill Performance Criteria

Skill	Technique (Process)			Outcome (Product)		
	DC Criteria #	Points per criteria	Scoring range	DC Criteria #	Points per Criteria	Scoring
Balance Bench	1.1, 1.2	1	0-2	1.3	2	0, 2



3:49 to 3:58

229 to 237

1^d

>3:59

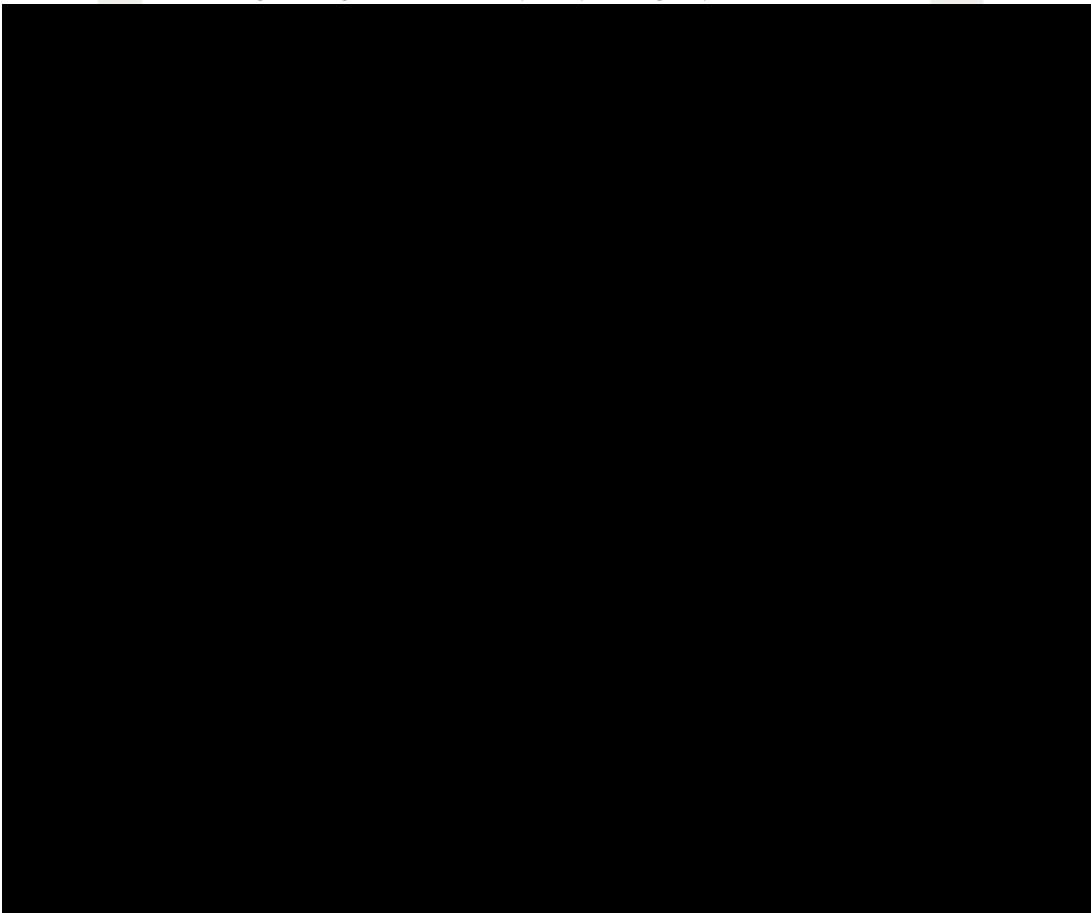
>238

0^d

Interpreting the Dragon Challenge Results

Interpreting the Dragon Challenge Total

A child's Dragon Challenge total score can be interpreted by examining their performance in relation to



different sports and activities to advance and maintain their physical skills.

encouraged to keep up the fantastic work!

*based on pilot data (n=584) collected across Wales in Spring/Summer 2015

Interpreting Time Scores

Judgements surrounding the speed in which a child completes the Dragon Challenge can be made by drawing comparisons to other children. As shown in Table 10, each time score is assigned a bronze, silver, gold or platinum ranking. The classification boundaries are at the 33rd, 66th and 95th percentile, consistent with those used for interpreting the overall score.

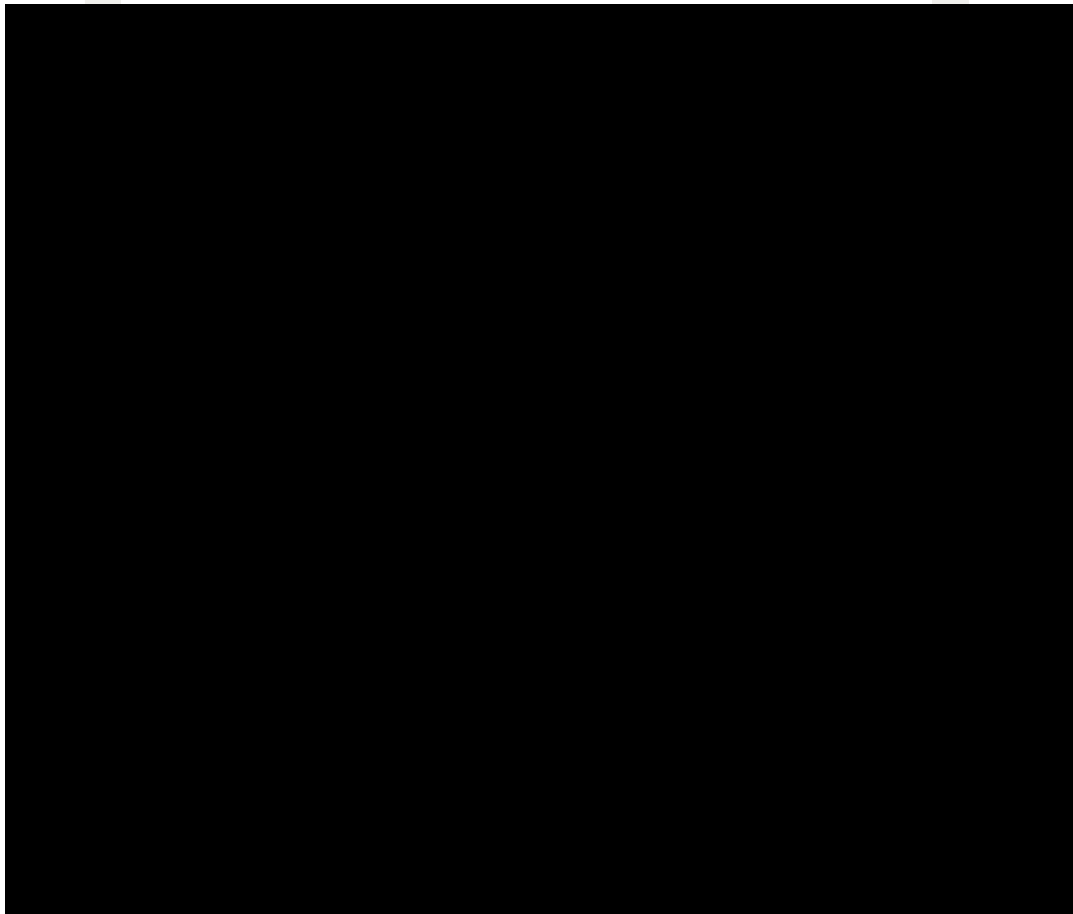
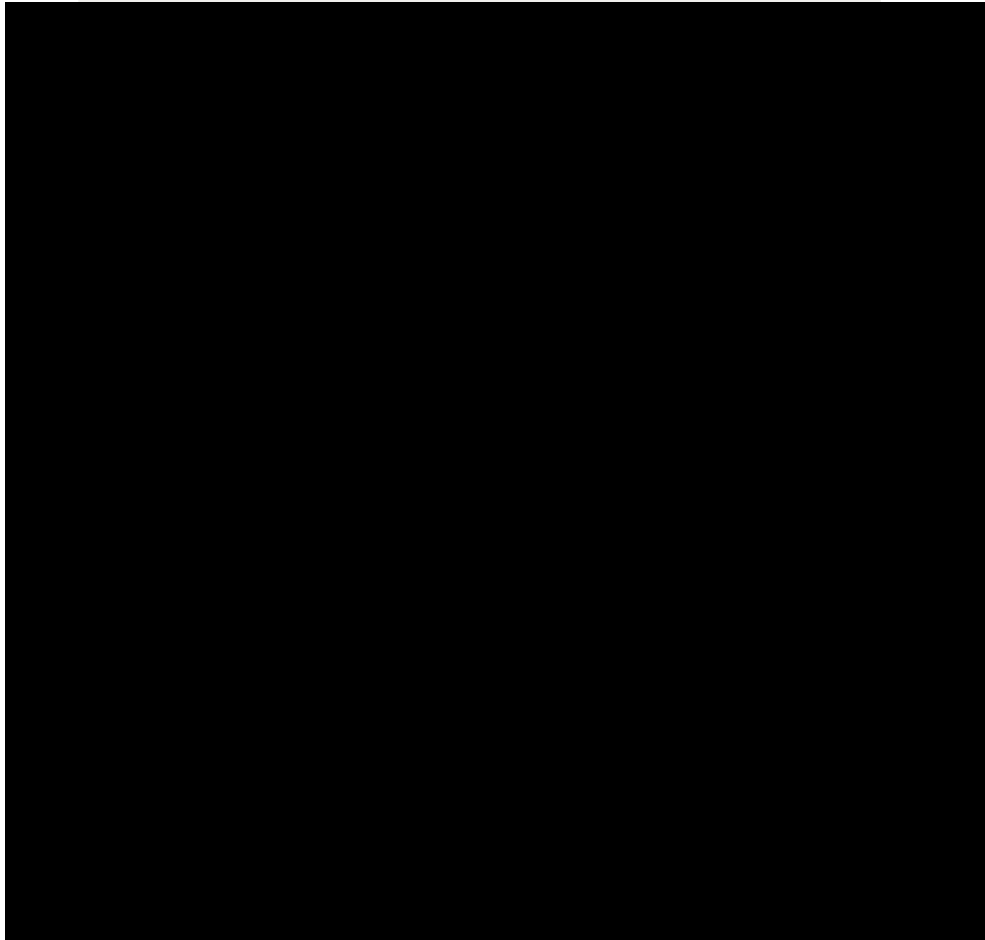


Table 11 Main data sheet: Explanation of variables and coding

Variable	Input	Missing data
Student No.	A 7-character unique child identifier number (page x)	n/a
School	Type school name in full	99999
School year*	"YEAR 6" or "YEAR 7"	99999
[REDACTED]		
3.3	"1" or "0"	99999
Overarm throw 4.1	"1" [if criteria was present] or "0" [if criteria was absent]	99999
4.2	"1" or "0"	99999
4.3	"1" or "0"	99999

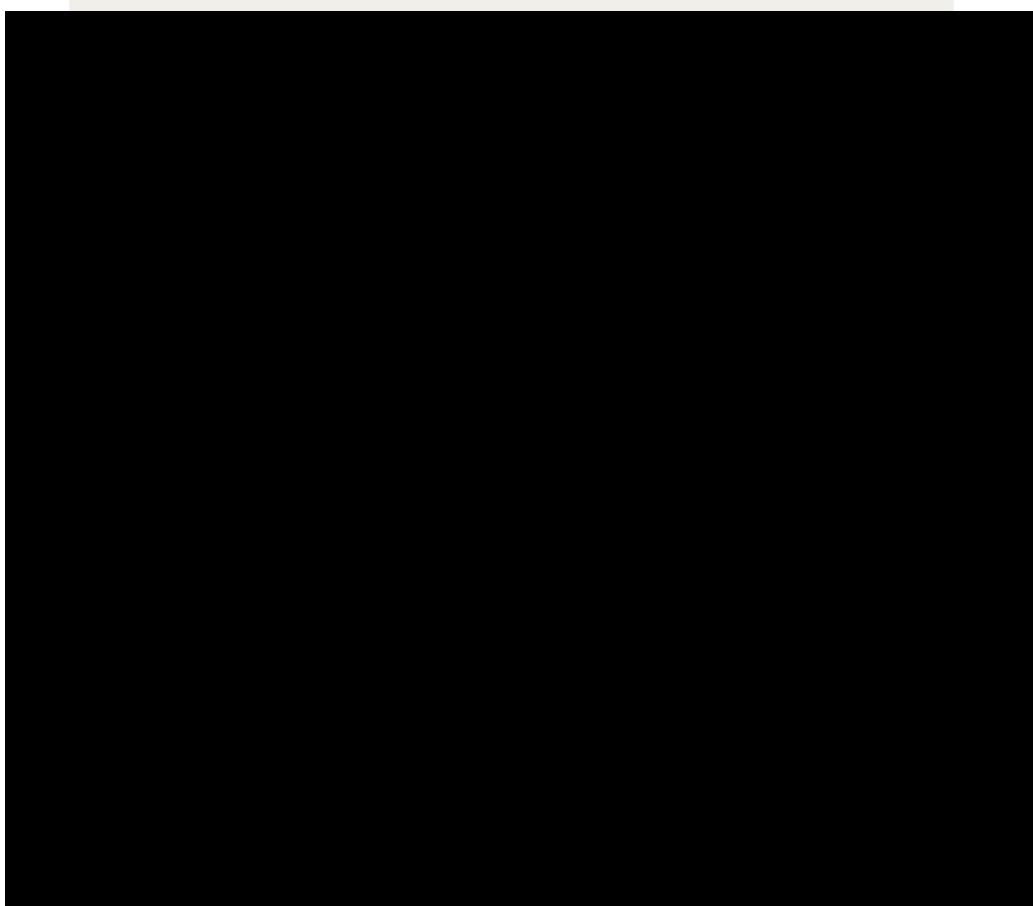
Basketball dribble 5.1	"1" [if criteria was present] or "0" [if criteria was absent]	99999
5.2	"1" or "0"	99999
5.3	"1" or "0"	99999
Catch 6.1	"1" [if criteria was present] or "0" [if criteria was absent]	99999
6.2	"1" or "0"	99999



WE00060	M H School	YEAR 7
WE00061	D T School	YEAR 7
WE00062	D T School	YEAR 7
WE00063	D T School	YEAR 7

Unique Identifier Number: Assessors

After successfully completing training, each assessor is given a unique identifier number by the regional lead Gold Standard Assessor. This number is validated against a regional database of assessors to avoid duplication. The coding helps identify the assessor's region, gender and professional role. The method for generating a unique identifier number for assessors is shown in Table 13 below:



One out of every 10 children should have a repeat assessment. This can occur through sharing video data of a child performance with a gold assessor (after obtaining the necessary permissions) or through paired observations with a gold assessor during in situ live assessments. All quality assurance checks should be documented by the lead regional gold assessor and appropriate re-training given if required.

REFERENCES

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Booth, J.N., Leary, S.D., Joinson, C., Ness, A.R., Tomporowski, P.D., Boyle, J.M., & Reilly, J.J. (2014). Associations between objectively measured physical activity and academic attainment in adolescents from a UK cohort. *British Journal of Sports Medicine*, 48(3): 265-70

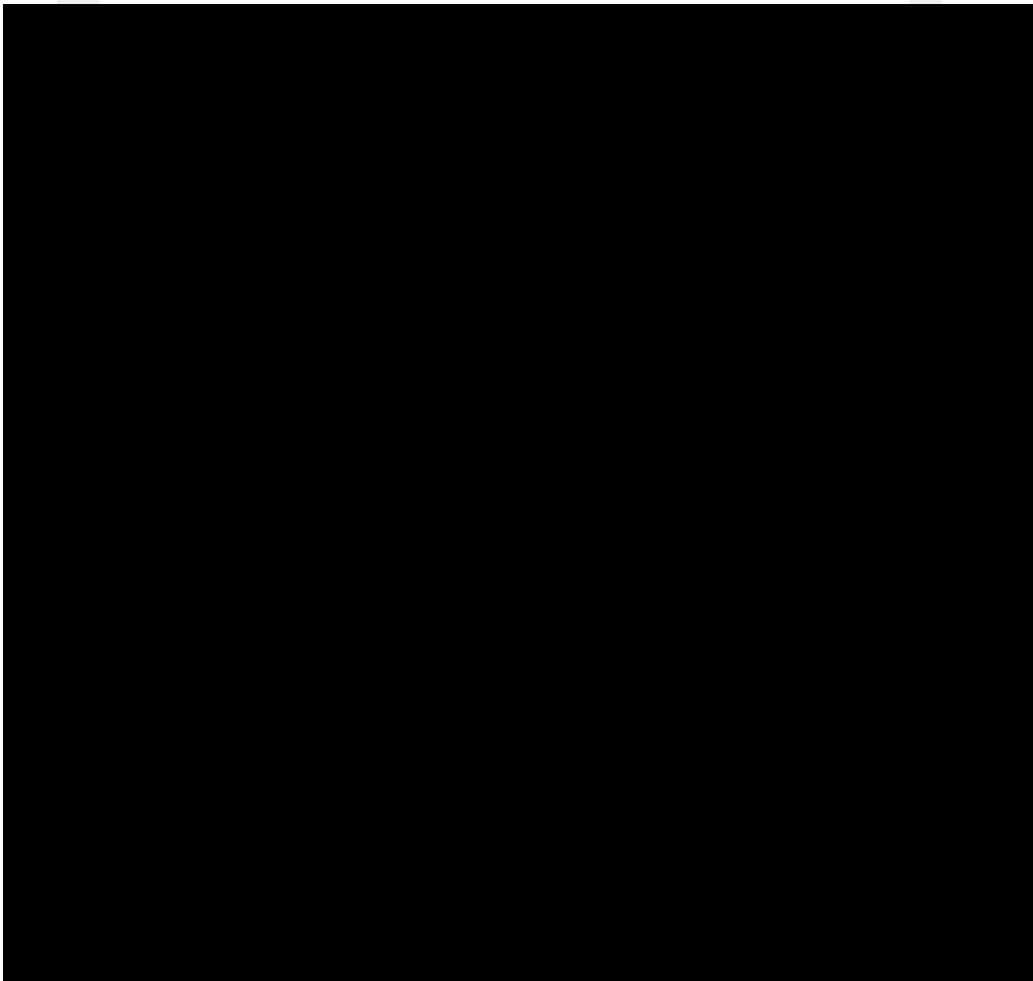
Vlahov, E., Baghurst, T. M., & Mwavita, M. (2014). Preschool motor development predicting high school health-related physical fitness: a prospective study. *Perceptual and Motor Skills*, 119(1), 279-291. doi: 10.2466/10.25.PMS.119c16z8

Whitehead, M. (2001). The concept of physical literacy. *European Journal of Physical Education*, 6(2): 127-138.

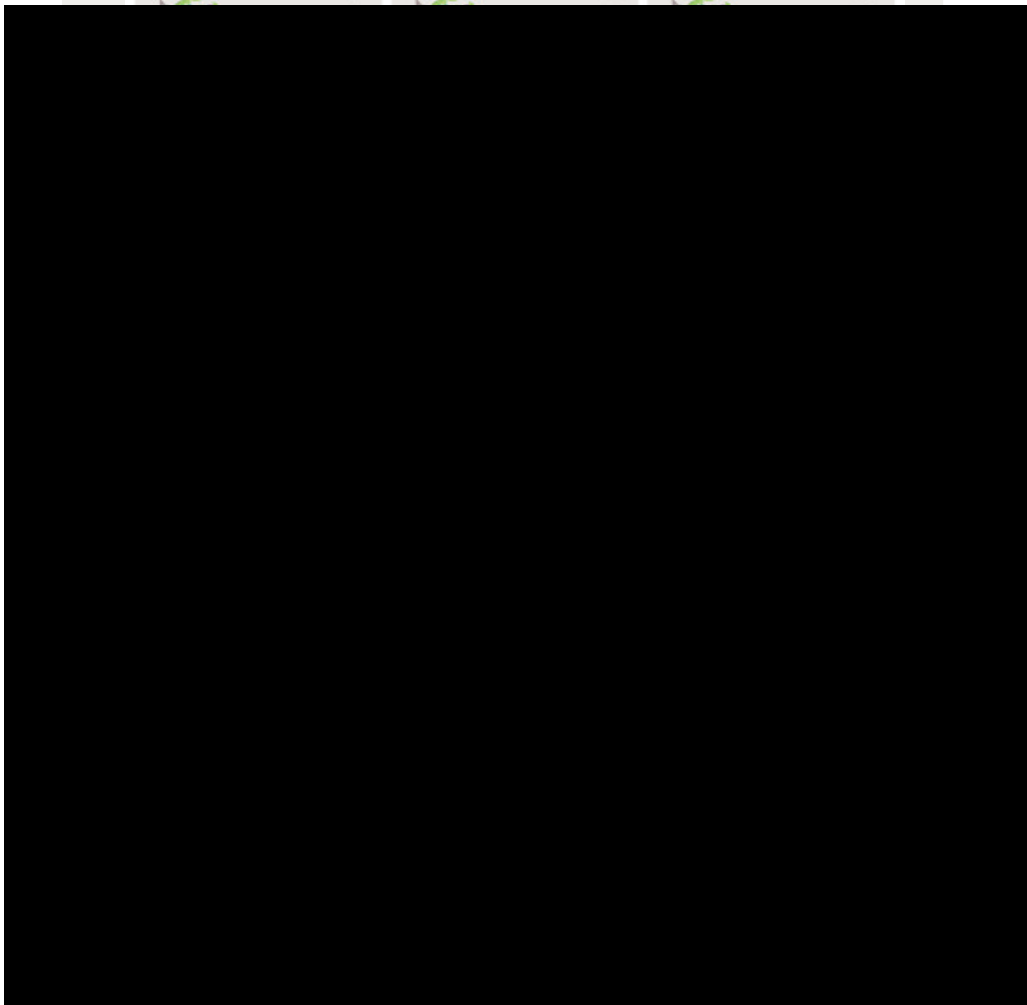
APPENDICES

APPENDIX A – LIST OF VIDEO RESOURCES

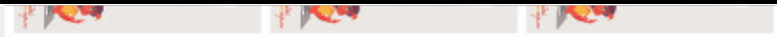
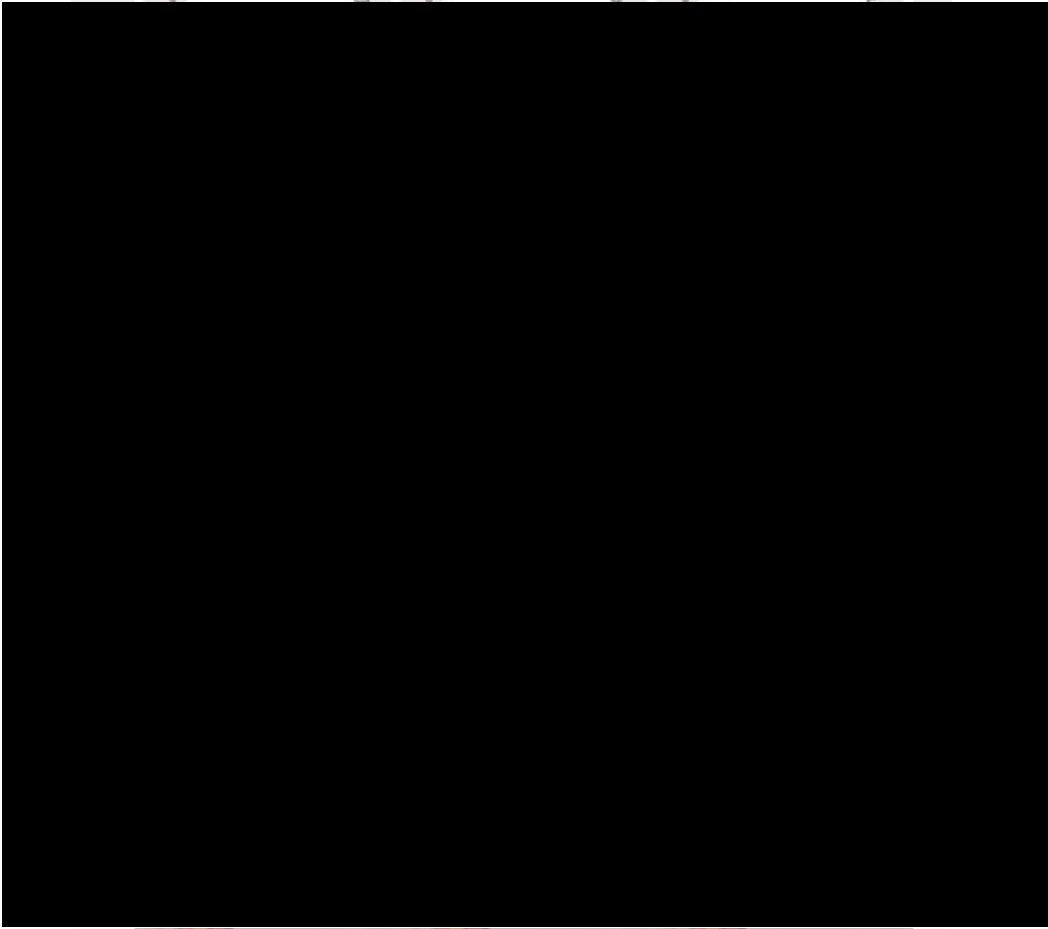
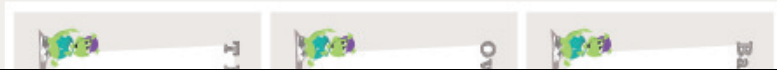
Video Material to Support Delivery of Dragon Challenge V1.0



APPENDIX B – DRAGON CHALLENGE 'ACTUAL' PRESENTATION



APPENDIX C – DRAGON CHALLENGE 'RANDOM' PRESENTATION

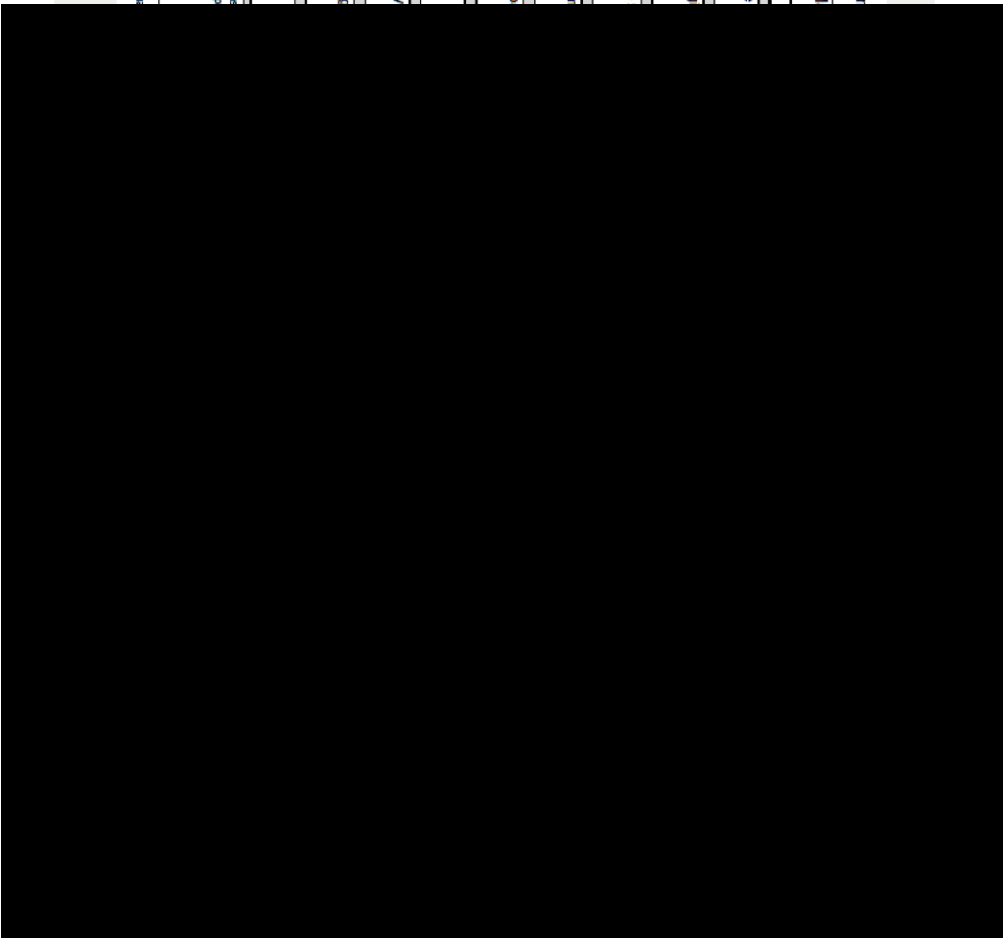


APPENDIX D – CHILD PERFORMANCE RECORD OUTLINE

Child Name: _____
 School: _____
 Sex: M

Activity	Score
1. Balance	3.0
2. Core Ag	3.0
3. Wobble	3.0
4. Overarm	3.0
5. Basketball	3.0
6. Catch	3.0
7. T Agility	3.0
8. Jumping	3.0
9. Sprint	3.0

Notes: Please provide equipment, sp...
 Score each ques...



Score: _____

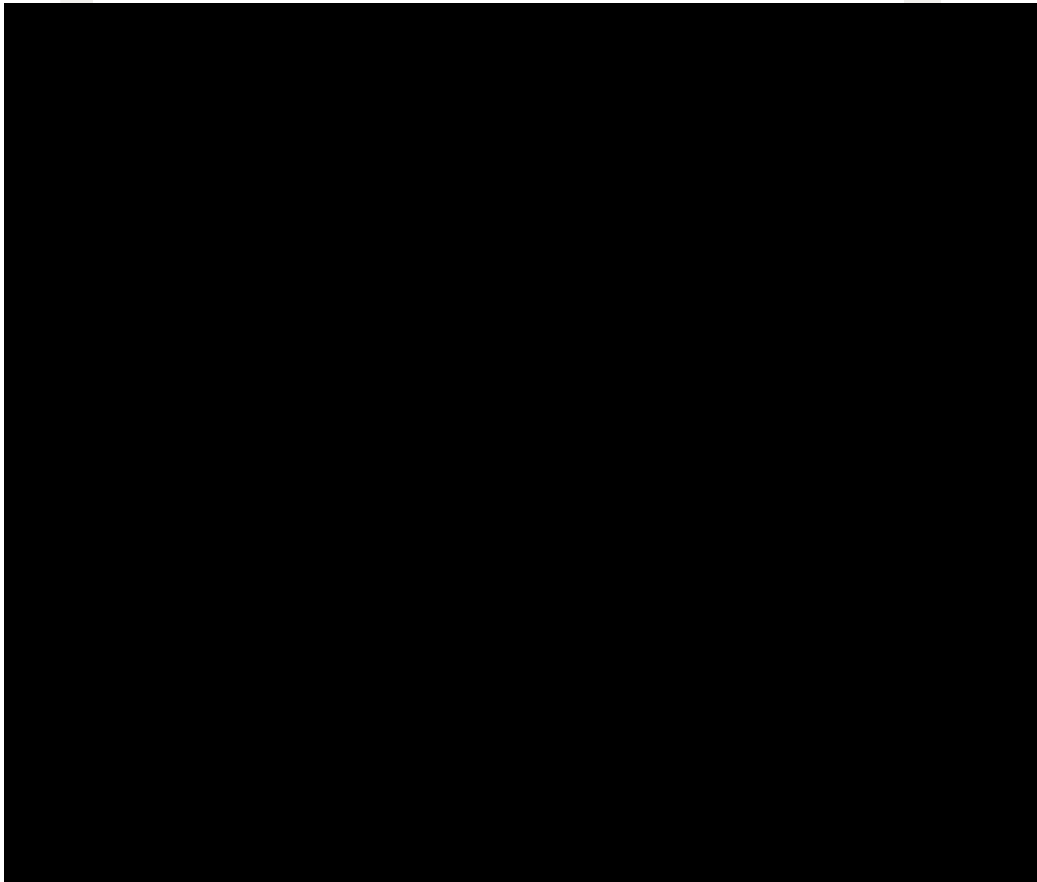
ft: _____

Activity	Score
1. Balance	3.0
2. Core Ag	3.0
3. Wobble	3.0
4. Overarm	3.0
5. Basketball	3.0
6. Catch	3.0
7. T Agility	3.0
8. Jumping	3.0
9. Sprint	3.0

Notes: Please provide equipment, sp...
 Score each ques...

APPENDIX E – INFORMATION FOR PROFESSIONALS AND PARENTS/CARERS

Information for professionals (teachers/teaching assistants, Sports Development, Sport Ambassadors, coaches, dance teachers, etc.)



Appendix VI: Dragon Challenge Video Resources

Video material to support delivery of the Dragon Challenge:

Video 1.

Title: Dragon Challenge Circuit

Hyperlink: <https://www.youtube.com/watch?v=ISPLtwDrgRM>

Video 2.

Title: Dragon Challenge Setup & Equipment

Hyperlink: <https://www.youtube.com/watch?v=bg8QUxs78qo>

Video 3.

Title: Dragon Challenge Introduction and Demonstration

Hyperlink: https://www.youtube.com/watch?v=3Pg_IHyAGxE

Video 4.

Title: Dragon Challenge Promotional video for Kids English

Hyperlink: <https://www.youtube.com/watch?v=Ddr17NbqV5I>

Video 5.

Title: Dragon Challenge Promotional video for Kids Welsh

Hyperlink: <https://www.youtube.com/watch?v=DEs2kyLiaok>

Video 6.

Title: What is the Dragon Challenge?

Hyperlink: <https://www.youtube.com/watch?v=9XD-ejbfaE8>

Video 7.

Title: Dragon Challenge Promotional video for Administrators & Assessors

Hyperlink: <https://www.youtube.com/watch?v=POq5cu0PWGQ>

Video 8.

Title: Children's Guide to the Dragon Challenge

Hyperlink: <https://www.youtube.com/watch?v=ebLNCS7DTv0>

Appendix VII: Children's Perceived Benefits/Barriers to Exercise Questionnaire



Applied Sports Technology Exercise and Medicine Research Centre (A-STEM)

Sport and Health Portfolio, College of Engineering



Children's Perceived Benefits/Barriers to Exercise Questionnaire

(Garcia et al., 1995)

ID Number: (Fitness Fun Day Number) _____

Are you a: (please circle one) **Boy** **Girl**

How old are you: _____ years old

In this programme, when we talk about physical activity, we mean any movement that requires your body to work harder than it does whilst sitting, or resting. Physical activity is any activity that makes your heart beat faster or makes you get out of breath some of the time.

Why are we asking you to do this questionnaire? We want to know what YOU think about physical activity, sports and exercise.

Please Remember:

- There are no right or wrong answers. We only want to know what you think, so please answer truthfully.
- If you do not know an answer, please write your best guess.
- There is no time limit, so please take time reading each question carefully.

1. **Children say there are many different reasons that they like to be active or play sports or dance. Being active is anything that you do when you are moving, exercising or not sitting still. Below are some reasons that other children have told us why they like to be active.** For each reason, tell us what you think. If you think it is a good reason then you would “Agree a little” or “Agree a lot”. If you do not think it’s a good reason, then you would “Disagree a little” or “Disagree a lot”. If you are not sure or you don’t think the reason is good or bad then you are “in between”.

(Please circle one number for each reason)

A reason that I might be active is because when I am active	Disagree a lot	Disagree a little	In between	Agree a little	Agree a lot
...I look better	1	2	3	4	5
...I have more energy	1	2	3	4	5
...I feel happier	1	2	3	4	5
...I have fun	1	2	3	4	5
...I make more friends	1	2	3	4	5
...I get stronger	1	2	3	4	5
...I like myself more	1	2	3	4	5
...I get in better shape	1	2	3	4	5
...I feel healthier	1	2	3	4	5

- 2. Children say there are also reasons that make it hard for them to be active.** For each reason, tell us what you think. If you think it is a good reason then you would “Agree a little” or “Agree a lot”. If you do not think it’s a good reason, then you would “Disagree a little” or “Disagree a lot”. If you are not sure or you don’t think the reason is good or bad then you are “in between”.

(Please circle one number for each reason)

I might <u>not</u> be active if...	Disagree a lot	Disagree a little	In between	Agree a little	Agree a lot
...I didn't have enough time to be active	1	2	3	4	5
...I have too many chores to do	1	2	3	4	5
...I didn't have a good place to be active	1	2	3	4	5
...If the weather was too bad	1	2	3	4	5
... I didn't have the right clothes/shoes	1	2	3	4	5
... I didn't know how to do the activity	1	2	3	4	5
... I didn't have the right equipment	1	2	3	4	5
...I had too much homework	1	2	3	4	5
... I didn't have anyone to be active with	1	2	3	4	5
...I didn't like to be active	1	2	3	4	5

THANKS FOR YOUR HELP!

DIOLCH YN FAWR!!

Appendix VIII: Children's Self-perceptions of Adequacy in and Predilection for Physical Activity Questionnaire



Applied Sports Technology Exercise and Medicine Research Centre (A-STEM)

Sport and Health Portfolio, College of Engineering



What's Most Like Me? Questionnaire

(Hay, 1992)

ID Number: (Fitness Fun Day Number) _____

Are you a: (please circle one) **Boy** **Girl**

How old are you: _____ years old

In this programme, when we talk about physical activity, we mean any movement that requires your body to work harder than it does whilst sitting, or resting. Physical activity is any activity that makes your heart beat faster or makes you get out of breath some of the time.

Why are we asking you to do this questionnaire? We want to know what YOU think about physical activity, sports and exercise.

Please Remember:

- There are no right or wrong answers. We only want to know what you think, so please answer truthfully.
- If you do not know an answer, please write your best guess.
- There is no time limit, so please take time reading each question carefully.

For the questions below you have to read 2 sentences and the circle the sentence you think is **MORE LIKE YOU**.

For example try the following question:

Some kids have one nose on their face!	BUT	Other kids have three noses on their face!
--	------------	--

That shouldn't be too hard for you to decide! Once you have circled the sentence that is more like you, then you have to decide if it is **REALLY TRUE** for you or **SORT OF TRUE** for you.

Here is another sample question for you to try. Remember, **first circle the sentence** that is more like you and then **put a check (✓) in the correct box** if it is really true or only sort of true for you.

REMEMBER THERE ARE NO RIGHT OR WRONG ANSWERS, JUST WHAT IS **MOST LIKE YOU**.

Some kids like to play with computers	BUT	Other kids don't like playing with computers
<input type="checkbox"/> REALLY TRUE for me <input type="checkbox"/> SORT OF TRUE for me		<input type="checkbox"/> REALLY TRUE for me <input type="checkbox"/> SORT OF TRUE for me

Now you are ready to start filling in this form. Take your time and do the whole form carefully.

If you have any questions, just ask!

If you think you are ready you can start now.

BE SURE TO FILL IN EACH PAGE!

Some kids can't wait to play active games after school	<input type="checkbox"/> REALLY TRUE for me	<input type="checkbox"/> SORT OF TRUE for me	BUT	Other kids would rather do something else after school	<input type="checkbox"/> REALLY TRUE for me	<input type="checkbox"/> SORT OF TRUE for me
Some kids don't like playing active games	<input type="checkbox"/> REALLY TRUE for me	<input type="checkbox"/> SORT OF TRUE for me	BUT	Other kids really like playing active games	<input type="checkbox"/> REALLY TRUE for me	<input type="checkbox"/> SORT OF TRUE for me
Some kids don't have much fun playing sports	<input type="checkbox"/> REALLY TRUE for me	<input type="checkbox"/> SORT OF TRUE for me	BUT	Other kids have a good time playing sports	<input type="checkbox"/> REALLY TRUE for me	<input type="checkbox"/> SORT OF TRUE for me
Some kids are good at active games	<input type="checkbox"/> REALLY TRUE for me	<input type="checkbox"/> SORT OF TRUE for me	BUT	Other kids find active games hard to play	<input type="checkbox"/> REALLY TRUE for me	<input type="checkbox"/> SORT OF TRUE for me
Some kids don't like playing sports	<input type="checkbox"/> REALLY TRUE for me	<input type="checkbox"/> SORT OF TRUE for me	BUT	Other kids really enjoy playing sports	<input type="checkbox"/> REALLY TRUE for me	<input type="checkbox"/> SORT OF TRUE for me
Some kids always hurt themselves when they play sports	<input type="checkbox"/> REALLY TRUE for me	<input type="checkbox"/> SORT OF TRUE for me	BUT	Other kids never hurt themselves playing sports	<input type="checkbox"/> REALLY TRUE for me	<input type="checkbox"/> SORT OF TRUE for me
Some kids like to play active games outside	<input type="checkbox"/> REALLY TRUE for me	<input type="checkbox"/> SORT OF TRUE for me	BUT	Other kids would rather read or play video games	<input type="checkbox"/> REALLY TRUE for me	<input type="checkbox"/> SORT OF TRUE for me
Some kids are among the last to be chosen for active games.	<input type="checkbox"/> REALLY TRUE for me	<input type="checkbox"/> SORT OF TRUE for me	BUT	Other kids are usually picked to play first.	<input type="checkbox"/> REALLY TRUE for me	<input type="checkbox"/> SORT OF TRUE for me
Some kids do well in most sports	<input type="checkbox"/> REALLY TRUE for me	<input type="checkbox"/> SORT OF TRUE for me	BUT	Other kids feel they aren't good at sports	<input type="checkbox"/> REALLY TRUE for me	<input type="checkbox"/> SORT OF TRUE for me
Some kids learn to play active games easily	<input type="checkbox"/> REALLY TRUE for me	<input type="checkbox"/> SORT OF TRUE for me	BUT	Other kids find it hard learning to play active games	<input type="checkbox"/> REALLY TRUE for me	<input type="checkbox"/> SORT OF TRUE for me

Some kids think they are the best at sports	BUT	Other kids think they aren't good at sports
<input type="checkbox"/> REALLY TRUE for me		<input type="checkbox"/> REALLY TRUE for me
<input type="checkbox"/> SORT OF TRUE for me		<input type="checkbox"/> SORT OF TRUE for me

Some kids find games in physical education hard to play	BUT	Other kids are good at games in physical education
<input type="checkbox"/> REALLY TRUE for me		<input type="checkbox"/> REALLY TRUE for me
<input type="checkbox"/> SORT OF TRUE for me		<input type="checkbox"/> SORT OF TRUE for me

Some kids like to watch games being played outside	BUT	Other kids would rather play active games outside
<input type="checkbox"/> REALLY TRUE for me		<input type="checkbox"/> REALLY TRUE for me
<input type="checkbox"/> SORT OF TRUE for me		<input type="checkbox"/> SORT OF TRUE for me

Some kids like to take it easy during recess	BUT	Other kids would rather play active games at recess
<input type="checkbox"/> REALLY TRUE for me		<input type="checkbox"/> REALLY TRUE for me
<input type="checkbox"/> SORT OF TRUE for me		<input type="checkbox"/> SORT OF TRUE for me

Some kids aren't good enough for sports teams	BUT	Other kids do well on sports teams
<input type="checkbox"/> REALLY TRUE for me		<input type="checkbox"/> REALLY TRUE for me
<input type="checkbox"/> SORT OF TRUE for me		<input type="checkbox"/> SORT OF TRUE for me

Some kids like to read or play quiet games	BUT	Other kids like to play active games
<input type="checkbox"/> REALLY TRUE for me		<input type="checkbox"/> REALLY TRUE for me
<input type="checkbox"/> SORT OF TRUE for me		<input type="checkbox"/> SORT OF TRUE for me

Some kids like to play active games outside on weekends	BUT	Other kids like to relax and watch TV on weekends
<input type="checkbox"/> REALLY TRUE for me		<input type="checkbox"/> REALLY TRUE for me
<input type="checkbox"/> SORT OF TRUE for me		<input type="checkbox"/> SORT OF TRUE for me

THANKS FOR YOUR HELP!

DIOLCH YN FAWR!!

Appendix IX: Additional Publications

Todd, C., Christian, D., **Tyler, R.**, Stratton, G., & Brophy, S. (2016). Developing HAPPEN (Health and Attainment of Pupils involved in a Primary Education Network): Working in partnership to improve child health and education. *Perspectives in Public Health*, 136(3), 115–116.
<https://doi.org/10.1177/1757913916638231> (assisted in writing and revision of the manuscript)

Marchant, E., Todd, C., Christian, D., **Tyler, R.**, Stratton, G., & Brophy, S. (2016). 100 Ways of Using Data to Make Lives Better. HAPPEN : Health & Attainment of Pupils in a Primary Education Network. Farr Institute of Health Informatics Research. Available from: <http://www.farrinstitute.org/public-engagement-involvement/100-ways-of-using-data-to-make-lives-better/case-study/improving-the-health-wellbeing-and-educational-outcomes-of-primary-school-children> (assisted in writing and revision of the manuscript)

Sheldrick, M., **Tyler, R.**, Mackintosh, K., & Stratton, G. (2018). Relationship between Sedentary Time, Physical Activity and Multiple Lifestyle Factors in Children. *Journal of Functional Morphology and Kinesiology*, 3(1), 15.
<https://doi.org/10.3390/jfmk3010015> (collected study data, assisted in writing, analyses and revision of the manuscript)

Appendix X: ISPAH 2016 Poster Presentation

ACTIVE HEALTHY KIDS WALES REPORT CARD 2016

IS WALES TURNING THE TIDE ON CHILDREN'S PHYSICAL INACTIVITY?

3. Since 2014, community and the built environment grades have dropped from B to C.

4. These results indicate that a concerted effort is required to increase physical activity and decrease sedentary time in children and young people in Wales.



Appendix XI: BASES Presentation Abstract

TITLE: The odds of being physically competent according to fitness and weight status in 9-11 year old girls and boys

Authors: R Tyler, K Mackintosh, M McNarry, L Fowweather, M Rosenberg, G Stratton.

Background: The development of physical competence (PC) across childhood plays an important role in providing the foundation skills for sustained physical activity/sporting behaviours throughout the life-course (Stodden *et al.* [2008]. *Quest*, 60, 290-306). Children with poor fitness levels have been reported to have low PC, higher body mass index (BMI) and increased risk of developing future health-related diseases. Few studies have examined these variables together.

Aim: This study aims to determine the odds ratios of BMI category (Underweight, Overweight, Obese), fitness level, and gender on physical competence category.

Methods: Following ethical approval, 95 children (56 boys; 39 girls) mean age 11.00 ± 0.53 years took part in the study. Stature and body mass were measured from which BMI was derived. Children completed a series of 9 motor tasks [Dragon Challenge v1.0 (DC)] in a timed circuit that included locomotion, stability and object control skills. Activities were scored on technique and completion of each task, as well as the time taken to complete the circuit. The overall score was used to calculate DC category. The children also completed the 20mMSFT (Leger and Lambert [1982]. *European Journal of Applied Physiology*, 49(1), 1-12), where laps completed were used to classify children at a 'Healthy' or 'Unhealthy' fitness level, using cut-off points (25 laps for girls; 33 laps for boys; Boddy *et al.* ([2012]. *PLoS ONE*, 7(9), e45755)). A cumulative odds ordinal logistic regression with proportional odds was run to determine the effect of BMI category, fitness level, and gender on the DC category achieved.

Results: The ordinal logistic regression significantly predicted the DC category over and above the intercept-only model, $\chi^2_{(5)} = 17.256$, $P = 0.004$. The odds of children who have an unhealthy level of fitness level achieving a higher DC category was 0.326 (95%CI, 0.128 to 0.833) times that of children whose scores were categorised as at a healthy fitness level, Wald $\chi^2_{(1)} = 5.486$, $P = 0.019$. The odds of Girls achieving a higher DC category was 0.288 (95%CI, 0.121 to 0.688) times that of Boys, Wald $\chi^2_{(1)} = 7.862$, $P = 0.005$. BMI category did not significantly affect DC category achieved, Wald $\chi^2_{(3)} = 4.048$, $P = 0.256$.

Discussion/Conclusion: These findings show that a healthy fitness level improved the odds of achieving a higher DC category; however, BMI category did not. Moreover, the odds of girls achieving a higher category were less than a third of that of boys. Further investigation and interventions are needed on children (especially girls and those with low fitness) who have low PC, and are at risk of future diseases.

Appendix XII: Active Healthy Kids Wales 2016 Report Card Press Release



ACTIVE HEALTHY KIDS WALES

PRESS RELEASE EMBARGOED TIL 12 Noon Monday July 25th 2016

Website release: www.activehealthykidswales.com

Twitter: #AHK_Wales.

AHK-WALES 2016

Report Card Launch

Great Hall,

Baycampus

Fabian Way

Swansea SA1 8EN

9.30-12.00;

25th July 2016

Rationale

AHK-Wales aims to monitor the lifestyles and behaviours of children. We know for example that Wales has the highest prevalence of child overweight in the UK and sedentary behavior and physical activity and fitness are amongst the worst globally. On the other hand we are pioneers in children's play, we have an active travel act and see physical literacy as a key part of a child's entitlement in the school curriculum. Further the number of children "hooked on Sport has increased. The AHK-Wales 2016 report card reports our current progress and position on children's health related physical activity.

Outline and Introduction to the AHK-Wales 2016 Report Card Launch

This is the second Active Healthy Kids Report Card for Wales following on from the inaugural report card published in 2014. Active Healthy Kids Canada published the first report card in 2004 and celebrated the 10th anniversary in 2014 at an international global summit. Forty-two countries are currently working on their 2016 report cards that will form an “Active Healthy Kids Global Matrix “ for 2016. Wales will join this matrix for the first time and will present its findings to an international audience in Bangkok in November.

Common to any report card are the grades. The AHK-Wales 2016 Report Card assigns letter grades to 10 different indicators that are grouped into two categories:

- 1. Strategies & Investments;** *Policy, Settings & Sources of Influence (School & Childcare Settings, Family & Peers, Community & the Built Environment).*
- 2. Behaviours that Contribute to Overall Physical Activity Levels** *(Active Play & Leisure, Physical Education and Physical Activity Participation at School & in Childcare Settings, Sedentary Behaviour, Organized Sport & Physical Activity Participation, Active Transportation).*

Letter grades (A-E) are based on an examination of current data for each indicator against a benchmark along with an assessment of changes from 2014, international comparisons and the presence of disparities (e.g., age, gender, disability, ethnicity, socioeconomic status).

Together, the indicators provide a complete and robust assessment of how Wales is doing as a country in promoting and facilitating physical activity opportunities among children and young people.

AHK-Wales Report Card Results

	Global Matrix	AHK Grades	
Indicator	Benchmark/s	2014	2016
Sedentary Behaviour	% of children and youth who meet sedentary behavior or screen-time guidelines	D	D-
Physical Activity	% of children and youth who meet physical activity guidelines	D-	D-
Active Transportation	% of children and youth who use active transportation to get to and from places (school, park, mall, friend's place)	C	C
Active and Outdoor Play	% of children and youth who engage in unstructured/ unorganized active play for several hours a day	C	C
Organised Sport Participation	% of children and youth who participate in organized sport and/or physical activity programs	C-	C
Physical Literacy (Physical Competency)	N/A	NA	INC
Family and Peer Influence	- % of parents who facilitate PA and sport opportunities - % of parents who meet the PA guidelines - % of parents who are PA with their kids - % of children with friends and peers who encourage and support them to be PA - % of children who encourage and support their friends to be PA	D	D+
Community and the Built Environment	- % of children/parents who perceive their community is good at promoting PA - % of communities that report they have policies promoting PA - % of communities that report infrastructure specifically geared toward promoting PA - % of children/parents with facilities, programs, parks, and playgrounds available - % of children/parents living in a safe neighbourhood where they can be PA - % of children or parents reporting well-maintained facilities, parks/playgrounds - % of children who report being outdoors for several hours a day	B	C

<p>National Policy, Strategy and Investment</p>	<p>Evidence of leadership and commitment in providing physical activity opportunities for all children and youth Allocated funds and resources for the implementation of physical activity promotion strategies and initiatives for all children and youth Demonstrated progress through the key stages of public policy making (ie, policy agenda, policy formation, policy implementation, policy evaluation, and decisions about the future)</p>	<p>B-</p>	<p>B-</p>
<p>School</p>	<ul style="list-style-type: none"> • % of schools with active school policies • % of schools where the majority (≥ 80%) of students are taught by a PE specialist • % of schools where the majority (≥ 80%) of students are offered at least 150 minutes of PE • % of schools that offer PA opportunities (excluding PE) to the majority of their students • % of parents with children who have access to PA opportunities at school in addition to PE • % of schools with students who have regular access to facilities /equipment that support PA 	<p>NA</p>	<p>B</p>



ACTIVE HEALTHY KIDS WALES

Launch and schedule

In the AHK-Wales 2016 launch we will release the report card grades and describe how we arrived at them. We aim to then engage in discussion and debate about how we use the report card as an advocacy tool with and for children and young people and those that support them in Wales. the programme for the launch is outlined below and we warmly invite you to attend and contribute and join us for lunch to celebrate the AHK-Wales 2016 report card launch.

Schedule

Time	Indicator	Presentations
9.30	Welcome Introduction <i>Getting Wales Moving AHK-Wales</i>	Jonathon Davies <i>Welsh Government</i> Professor Gareth Stratton <i>Swansea University</i>
9.45	Physical activity levels	Gareth Stratton/Richard Tyler <i>Swansea University</i>
9.50	Organized sport participation	Rebecca Mattingley <i>Sport Wales</i>
9.55	Outdoor and Active Play	Marianne Mannello <i>Play Wales</i>
10.00	Active Transportation	Rob Sage <i>Public Health Wales</i>
10.05	Sedentary Behaviour	Rebecca Cox <i>Welsh Government HBSC</i>
10.10	Physical Literacy	Richard Tyler <i>Swansea University</i>
Coffee 10.30	DISCUSSION + break	Interactive discussion in pods Includes coffee break Children's Activity

11.00	Family and Peer Influences	Simon Williams <i>University of South Wales</i>
11.05	School	Gareth Stratton <i>Swansea University</i>
11.10	Community and built environment	Suzan Taylor <i>Glyndwr University</i>
11.15	National Government Policy and Investment	Malcolm Ward <i>Public Health Wales</i>
11.25	Web site- Media Content	Owain Stratton Angelica Hart Lindh <i>Geoshepherds</i>
11.25	Summary	GS-Panel
12.00	Lunch	Networking Market Place Media Launch

Market Place

The market place will take place around the great hall walkways and hall space. These will include promotion by stakeholders and research projects related to physical activity and health. The market place will be a joint event between AHK-Wales 2016 and ABMU Physical Activity Alliance. Market place stallholders will have access to a table and space for pull up banners and other materials.

Appendix XIII: Ethical Approvals

Swan-Linx application for ethical approval



**Applied Sports Technology Exercise and Medicine
Research Centre (A-STEM)**
Sport and Health Portfolio, College of Engineering

APPLICATION FOR ETHICAL COMMITTEE APPROVAL OF A RESEARCH PROJECT

In accordance with A-STEM and College of Engineering Safety Policy, all research undertaken by staff or students linked with A-STEM must be approved by the A-STEM Ethical Advisory Committee prior to starting data collection.

Applications for approval should be submitted on this form. The researcher(s) should complete the form in consultation with the project supervisor. Where appropriate, the application must include the following appendices: (i) Participant Information Sheet, (ii) Participant Consent Form, (iii) Participant Health Screening Questionnaire.

After completing and signing the form students should ask their supervisor to complete and sign the declaration section. Staff members should submit the form directly to the Chair of the A-STEM Ethical Advisory Committee.

Applicants will be informed of the decision of the Committee via email to the project leader/supervisor.

TITLE OF PROJECT

What is the state of motor fitness and lifestyle in school children aged 9-11 years in Swansea.

NAMES AND STATUS OF RESEARCH TEAM

Sam Tuvey – Postgraduate Lead Researcher
Professor Gareth Stratton - Project Director
Dr Anwen Rees - Secondary Supervisor
Dr Kelly Mackintosh - Secondary Supervisor
Mr Cain Clark – PhD candidate
Mr Nils Swindell – PhD candidate
Ms Bethan Everson - MSc by Research candidate
Mr Richard Tyler - MSc by Research candidate
Dr Melitta McNarry – Senior lecturer
Professor Sinead Brophy Project Director DeCIPHer
Ms Charlotte Todd Research Assistant DeCIPHer
Ms Danielle Christian Research Assistant DeCIPHer

RATIONALE

Childhood obesity and physical inactivity is a problem within the United Kingdom with one-quarter of UK children obese by the time they leave primary school (Reilly, 2006), and fitness levels decreasing (23% decrease from 1998-2004; Stratton et al. 2007) which is resulting in poor health and an increased risk of premature death for children in the UK. There is evidence that a high body mass index (BMI) negatively affects motor performance (Okley *et al.* 2010) and that taking part in physical activity can increase ability to perform motor skills (Okley *et al.* 2001). Although childhood obesity and physical inactivity is a national concern many parents do not recognise that their children are obese (Parry *et al.* 2008) which presents a problem because although the parents know how to have a healthy lifestyle they are not enforcing it (Onnerfalt et al. 2012). This research suggests that there needs to be an intervention within schools to identify overweight, inactive and obese children and to provide them with the opportunity to become physically active and learn to adopt a healthy lifestyle. The study will attempt to assess levels of motor fitness and lifestyle of school children in Swansea and provide information that could potentially allow positive changes to be made. Further, this study will seek to test the SlamTracker accelerometer (as in ethics approval code PG/2014/009). With permission, the data generated by this program may be used to develop support programs for children based on their individual needs.

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AIMS and OBJECTIVES

The aim of the project is to assess levels of motor fitness and lifestyle of children aged 9-11 years who attend 12 primary schools in Swansea. This will be done using a series of tests from the eurofit test (Council of Europe, 1983) to quantify the association with BMI. The study will also examine the gender difference and differences between the schools' BMI

and motor fitness. Sedentary behaviours and diet will be assessed using a questionnaire. The objectives of the project are to determine whether motor fitness in school children aged 9-11 years is related to their BMI in Swansea, to determine whether there is a difference between motor fitness in boys and girls of age 9-11 years in Swansea. The study will also look at whether motor fitness is related to lifestyle behaviour in children aged 9-11 years in Swansea. Further, this study will seek to test the SlamTracker accelerometer (as in ethics approval code PG/2014/009).

METHODOLOGY

Study Design

This study is cross-sectional and will involve male and female children aged 9-11 years who attend 12 different primary schools in Swansea. There will be approximately 700-800 children taking part, equally balanced between genders. The head teacher, parents and children are all provided information sheets and the study will be clearly explained to them, they will also be reminded that they do not have to take part in the study and can withdraw at any time without question. A written approval will be obtained from the head teacher of each school. The parents will be given a consent form that they will return if they do not wish their child to take part in the study. The children will each sign an assent form. All the subjects need to be healthy and free from disease to be able to take part in the study. The whole study will take approximately one school day in total.

The children will be asked to complete two parts for the study. The first part will be to complete an online questionnaire which will take about 30-45 minutes; this will be administered in schools by the research team. The questionnaire focuses on and asks questions regarding diet, physical activity, lifestyle, sporting interest and mental wellbeing. The last part of the study will involve a fitness fun day which will take half a day to complete. The fun day will involve a variety of motor fitness activities from the Council of Europe European Physical Fitness Test battery (Eurofit), as well as the measurement of height, sitting height and weight to determine BMI. These tests will involve a small level of exertion but this will not be more than the children would face during normal physical education lessons in school.

Experimental Procedures

The study involves completing a 30 minute questionnaire which will take part at the schools. The fitness fun day will take half a day to complete and will take part at Swansea University Sports Centre. The subject will be given an assent form and therefore have the option of not being involved in the study it will also be made clear to them that they can drop out at any time if they decide they do not want to take part. Active consent will be gained from the head teacher of each school, consent will be gained from the parents and assent will be gained from the children.

The online questionnaire, which has been developed by members of Swansea University, based on the Sportslix questionnaire has 29 questions is available in Welsh and English and can be completed on computers and iPads. The questionnaire asks questions about their diet, what sports they take part in (in and out of school), what sports they would like to try, their physical activity and sedentary behaviour, their parents' physical activity. They will also provide information on their sleeping habits, what they do at school during breaktime/lunchtime, how they travel to and from school, how they feel about their fitness, health, school, friends and family.

The fitness fun day will take place in Swansea University sports centre and will take a half a school day to complete all of the activities. The students will complete a small warm up to increase heart rate and the activities the students will be taking part in are from the eurofit test battery, which is a series of 9 motor tests covering flexibility, endurance, speed and strength. The test was devised by the Council of Europe, for children of school age and has been used in many European schools since 1988 (Council of Europe, 1983). The tests include the sit and reach test to measure flexibility, speed bounce to measure agility, standing broad jump to measure explosive leg power, the handgrip test to measure static arm strength, and two running tests, the 10 x 5 meter shuttle run to measure speed and agility and then 20m endurance shuttle run to measure cardio respiratory endurance. During the 20m shuttle run ~50 volunteers, overall, will be asked to wear the SlamTracker (Fig. 1) accelerometer (as in ethics approval code PG/2014/009). The student's height, sitting height and weight will also be measured so that BMI can be worked out. For the standing broad jump, speed bounce, 10 x 5m shuttle run and 20m endurance shuttle run children will be asked to give their rating of exertion (RPE) using the Omni Scale of Perceived Exertion scale (Robertson et al. 2000).



Figure. 1. SlamTracker accelerometer

Data Analysis Techniques

A Pearson's product moment correlation will be used to analyse BMI and performance in motor fitness tests. The data from the questionnaires will be entered into Excel and analysed using an analysis of variance (ANOVA). An independent T-test will be used to look for differences between motor fitness scores of male and female students. Raw acceleration data from the SlamTrackers (as in ethics approval code PG/2014/009) will be analysed using an algorithm developed from a previous study (PG/2014/009). The trace from the accelerometer, which gives acceleration in terms of 'g' over the time period on the treadmill, is split into sections for clarity and ease of analysis. The data is then converted into the frequency domain by the Fast Fourier transform. The Fast Fourier transform involves taking a continuous function and representing it as a number of sine and cosine waves. It provides information about the harmonic content of a signal so that conclusions about the activity being performed can be made.

Let x_0, \dots, x_{N-1} be a sequence of N complex numbers. The Fast Fourier transform computes the Discrete Fourier transform

$$X_k = \sum_{n=0}^{N-1} x_n \cdot e^{-i2\pi kn/N}, K \in Z$$

Once the FFT has been completed on the signal and the Fourier coefficients are converted into a frequency spectrum, we are able to draw conclusions about the activity being performed based on the dominant frequency of the spectrum along with the harmonics present. Much research has been conducted characterising movements in terms of dominant frequencies (Zijlstra and Aminian, 2007), and our training data has certainly been in agreement with these findings with the most dominant frequencies during the walking section being between 1 and 3 Hz. We then examine spectral purity of the frequency spectra and, therefore, are able to quantify how energy is distributed across the

spectrum. We have begun to investigate links between spectral purity and walking styles. We are also able to use the spectrum to determine how much background noise is present in our signals. Results from the analysis of the spectrum are then used to inform the second part of our algorithm.

The second part of our algorithm involves using the frequency domain as a tool to correct for noise and 'idealise' the data to some extent, making use of a filter centred on the dominant frequency and prominent harmonics. Such a task would be much more difficult in the time domain. We chose those harmonics that are $\geq 10\%$ of the height of the dominant peak, however, this is something that we will seek to optimise and tailor to an individual. The idealised data is then converted back into the time domain via the inverse Fast Fourier transform, resulting in an idealised time signal. Using double integration, we can convert our acceleration data into displacement information and effectively trace out the path of a subject walking on a treadmill or performing other tasks whilst wearing an accelerometer on their body.

Storage and Disposal of Data and Samples

The completed questionnaires and fitness fun day data will be kept private and confidential, hard copies of information will be kept in a secure office and any personal information will be changed into a number rather than a name. All files on a computer will be password protected and files with personal details will only be accessible by only accessible by Sam Tuvey, Professor Gareth Stratton and Dr Anwen Rees and Mr Cain Clark, Mr Nils Swindell, Ms Bethan Everson and Mr Richard Tyler. The schools will have access to the anonymous data for educational and curriculum use. The data is part of a longitudinal study and will not be disposed of. Data may be also used, with consent, in further data linkage projects.

LOCATION OF THE PREMISES WHERE THE RESEARCH WILL BE CONDUCTED.

The fitness fun day will take place on the premises of Swansea University – the running track facility, and the administering of the questionnaire will take place at the respective schools' premises. The research team, Sport Wales Sport Ambassadors and a member(s) of City and County of Swansea sport and recreation team will all be present. The session will be overseen by school teachers

PARTICIPANT RISKS AND DISCOMFORTS

The students will not be put under any greater risk than what they would face when in a PE class in school. However, there is a possibility that whilst taking part in the fitness fun day they will get an injury, feel sick or faint. A first aid trained researcher (Mr Cain Clark, Mr Nils Swindell) and/or member of the sports centre running track staff will always be present during any activity. There will also be an automatic defibrillator stored on site (on the wall upon entrance) in case any cases of sudden death syndrome. All sports centre staff are defibrillator trained and will be responsible for the defibrillators safe operation. All anthropometric measures will be taken sensitively. All lead researchers will have a DBS check and no researcher will be on their own with any individual child.

INFORMATION SHEET AND INFORMED CONSENT

The submission should be specific about the type of consent that will be sought, which should be indicated below:

- Have you included a Participant Information Sheet for the participants of the study?
YES/~~NO~~
- Have you included a Participant Consent Form for the participants of the study?
YES/~~NO~~

COMPUTERS

- Are computers to be used to store data?
YES/~~NO~~
- If so, is the data registered under the Data Protection Act?
YES/~~NO~~

STUDENT DECLARATION

Please read the following declarations carefully and provide details below of any ways in which your project deviates from these. Having done this, each student listed in section 2 is required to sign where indicated.

- ***"I have ensured that there will be no active deception of participants.***
- ***I have ensured that no data will be personally identifiable.***
- ***I have ensured that no participant should suffer any undue physical or psychological discomfort***
- ***I certify that there will be no administration of potentially harmful drugs, medicines or foodstuffs.***
- ***I will obtain written permission from an appropriate authority before recruiting members of any outside institution as participants.***
- ***I certify that the participants will not experience any potentially unpleasant stimulation or deprivation.***
- ***I certify that any ethical considerations raised by this proposal have been discussed in detail with my supervisor.***
- ***I certify that the above statements are true with the following exception(s):"***

Student/Researcher signature: (include a signature for each student in research team)

Date:

SUPERVISOR'S DECLARATION

In the supervisor's opinion, this project (delete those that do not apply):

- ***"Does not raise any significant issues.***
- ***Raises some ethical issues, but I consider that appropriate steps and precautions have been taken and I have approved the proposal.***
- ***Raises ethical issues that need to be considered by the Departmental Ethics Committee.***
- ***Raises ethical issues such that it should not be allowed to proceed in its current form."***

Supervisor's signature:

Date:

ETHICS COMMITTEE DECISION (COMMITTEE USE ONLY)
ETHICAL APPROVAL: REC PG/2014/007; PG/2014/020

GRANTED/~~REJECTED~~

The ethical issues raised by this project have been considered by the A-STEM Ethical Advisory Committee.

Please refer to the summary comments noted in the decision email sent to the project lead/supervisor. Please ensure that you take account of these comments.

Where necessary, please prepare a revised submission that should be shown to your supervisor (for student applications) and then resubmitted to the A-STEM Ethical Advisory Committee for reconsideration.

Application number _____

Date:

Signed:

(Chair, A-STEM Ethical Advisory Committee)

written above.

4. What will happen to the children if they take part?

If you decide to allow your pupils to take part in the study they will come to a fitness fun day at the university with the rest of their class. This will involve a half day of fun physical activities which will measure the children's strength, speed, agility, endurance and flexibility. These activities include; 20m Multi Stage shuttle runs, 10x5m shuttle runs, grip strength, sit and reach, standing broad jump, and speed bounce (*for more information about these activities, please contact anyone from the research team listed*). During these activities, some of the children may be asked to wear the SlamTracker accelerometer (Fig. 1). This device will measure how fast the child moves forwards and backwards, side to side and up and down, and will only be worn during the fitness fun day activities. The children will also be asked



Fig. 1: SlamTracker Accelerometer to rate on a scale how much effort they exerted in the speed bounce, standing broad jump, 10x5m shuttle run and 20m Multi Stage shuttle run. The activities will be no harder than what a child would do during school PE lessons. The children will also have other measurements taken including; weight, height and sitting height. All measures of body size are taken privately and no results are shared with the rest of the class. Children can choose not to have their anthropometric measurements taken if they do not want to be measured. We have followed this approach with around 70000 children in Liverpool since 1996.

On a separate day the children will also be asked complete a questionnaire at your school, which will take about 30 minutes. There will be members of the research team and teachers present to assist the children in filling them in.

5. What are the possible disadvantages of taking part?

Taking part in the fitness fun day poses no greater risk than a child would face during PE lessons in school. However, in the unlikely event that a child feels unwell, sick, tired, faint or sustains an injury, there will be people monitoring the children during all parts of the fitness fun day, and the children's teachers will remain present at all times. A qualified first aider will always be present at the sports centre during the fitness fun day.

6. What are the possible benefits of taking part?

The fun day will be an active and very enjoyable day for the children and they will get to take part in a variety of different activities that they might not have taken part in before. They will be able to find out about their skills, fitness, and flexibility related to health and well-being. The final data will be made available to the school for educational and curriculum use.

7. Will my taking part in the study be kept confidential?

All the data we collect from the children will be kept private and confidential; the children's names will be changed to numbers. Any hard copies of the questionnaires and fun day data will be kept in a secure office and computer files with any personal information will be password protected. The data obtained will only be looked at by responsible individuals of the research team from Swansea University and the City & County of Swansea or from regulatory authorities where it is relevant to your child's participation in the research. The data we collect will be used to assess the health, motor fitness and lifestyle of children in Swansea.

8. What if I have any questions?

If you have any questions about what I have written above or anything to do with the

study please don't hesitate to contact me or anyone from the research team as detailed above. If after the study you are concerned about how any aspect of the research was conducted please contact the Chair of the College Ethics Committee, Professor Mike McNamee ([REDACTED])

HEADTEACHER CONSENT FORM
(Version 2.1, Date: __/__/20__)

Project Title:

Health, motor skills, fitness and lifestyle of Swansea School Children aged 9-11 years old

Contact Details:



Please initial box

1. I confirm that I have read and understood the information sheet dated __/__/20__ (Version number 2.1) for the above study and have had the opportunity to ask questions.
2. I understand that the children's participation is voluntary and that I am free to withdraw my pupils at any time, without giving any reason, without their medical care or legal rights being affected.
3. I understand that sections of the data obtained may be looked at by responsible individuals from the Swansea University or from regulatory authorities where it is relevant to the children's taking part in research. I give permission for these individuals to have access to these records.
4. I am happy for any data collected in this study to be used in future health related studies where data collected will be linked to health outcomes.

I agree to allow the pupils in my school to take part in the above study.

_____	_____	_____
Name of School	Date	Signature
_____	_____	_____
Name of Headteacher	Date	Signature
_____	_____	_____
Researcher	Date	Signature



PARENT INFORMATION SHEET

(Version 2.1, Date: __/__/20__)

Project Title:

Health, motor skills, fitness and lifestyle of Swansea School Children aged 9-11 years old

Contact Details:



Please read the information below carefully before deciding whether to consent for your child's participation.

1. Invitation Paragraph

The children in your child's school who are aged 9-11 years have been invited to take part in a study led by Swansea University and City and County of Swansea called Swan-Linx. Many other schools in the Swansea area are also taking part. Your child will be asked to take part in a fitness fun day and to complete a questionnaire. The data we collect from your child will help us assess different physical and psychological aspects of children in Swansea.

2. What is the purpose of the study?

The purpose of the study is to investigate the health, motor skills (physical competency), fitness and lifestyle of children aged 9-11 years in Swansea schools and also to test the SlamTracker accelerometer. The data collected will be used in a postgraduate student's thesis and will assist the City & County of Swansea in tracking children's health and physical activity, to decide how best to help children become healthier and more involved in sport and physical activity in the future.

3. Why have I been chosen?

Your child has been invited to take part in both the fitness fun day and questionnaire, because they attend a primary school in Swansea and are aged 9 to 11 years. During the

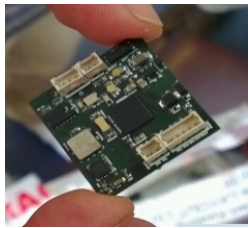
study if your child does not feel happy about anything that they are asked to do they can stop at anytime, without fear of penalty. If you need any more information about the study then please contact any member of the team on the details above.

4. What will happen to your child if they take part?

Your child will attend a fitness fun day at the University with the rest of their class. This will involve a half day of fun physical activities which will measure children's strength, speed, agility, endurance and flexibility. These activities include; 20m Multi Stage shuttle runs, 10x5m shuttle run, handgrip strength, sit and reach, standing broad jump, and speed bounce (*for more information about any of these activities, please contact anyone from the research team listed*).

During the activities, some of the children may be asked to wear the SlamTracker accelerometer (Fig. 1).

This device will measure how fast your child moves forwards and backwards, side to side and up and down, and will only be worn during the fitness fun day activities.



The children will also be asked to rate on a scale (1 = extremely easy → 10 = extremely hard) how difficult they found the speed bounce, standing broad jump, 10x5m shuttle run and 20m Multi Stage shuttle run.



Your child will also have some other measurements taken including;

weight, height and sitting height. All measures of body size are taken privately and no results are shared with the rest of the class, however, your child will not have to have them taken if they do not want to. All activities will be no harder than your child would do during school PE lessons. On a separate day your child will also be asked complete a questionnaire at their school about their health, physical activity and lifestyle, which will take about 30 minutes. There will be members of the research team and teachers present to assist your child in filling them in.

5. What are the possible disadvantages of taking part?

Taking part in the fitness fun day poses no greater risk than a child would face during PE lessons in school. However, in the unlikely event that a child feels unwell, sick, tired, faint, or sustains an injury there will be people monitoring the children during all parts of the fitness fun day, and the children's teachers will remain present at all times. A qualified first aider will always be present at the sports centre during the fitness fun day.

6. What are the possible benefits of taking part?

The fun day will be an active and very enjoyable day for the children and they will get to take part in a variety of different activities that they might not have taken part in before. They will be able to find out about their skills, fitness, and flexibility related to health and well-being. The final data will be made available to the school for educational and curriculum use.

7. Will my taking part in the study be kept confidential?

All the data we collect from your child will be kept private and confidential; the children's names will be changed to numbers. Any hard copies of the questionnaires and fun day data will be kept in a secure office and computer files with any personal information will be password protected. The data obtained will only be looked at by responsible individuals of the research team from Swansea University and the City & County of Swansea or from regulatory authorities where it is relevant to your child's participation in the research. The

data we collect will be used to assess the health, motor skills, fitness and lifestyle of children in Swansea.

8. What if I have any questions?

If you have any questions about what is written above or anything to do with the study please don't hesitate to contact me or anyone from the research team (see contact details above). If after the study you are concerned about how any aspect of the research was conducted please contact the Chair of the College Ethics Committee, Professor Mike McNamee [REDACTED].

PARENT CONSENT FORM
(Version 2.1, Date: __/__/20__)

Project Title:

Health, motor skills, fitness and lifestyle of Swansea School Children aged 9-11 years old

PLEASE RETURN THIS FORM TO SCHOOL TO CONSENT FOR YOUR CHILD TO TAKE PART IN THE PROJECT.

Contact Details:



Please INITIAL each box below

1. I confirm that I have read and understood the information sheet dated __/__/20__ (Version number 2.1) for the above study and have had the opportunity to ask questions.
2. I am happy for my child to participate in the Fitness Fun Day, and wear the SlamTracker accelerometer
3. I understand that my child's participation is voluntary and that I am free To withdraw my child at any time, without giving any reason, without their medical care or legal rights being affected.
4. I understand that sections of the data obtained may be looked at by responsible individuals from the Swansea University or from regulatory authorities where it is relevant to the children's taking part in research. I give permission for these individuals to have access to these records.
5. I am happy for any data collected in this study to be used in future health related studies where data collected will be linked to health outcomes. I agree to allow my child to take part in the above study.

Name of Child (participant)	Date	Signature
Name of Parent/Guardian	Date	Signature
Researcher	Date	Signature



PARTICIPANT INFORMATION SHEET

(Version 2.1, Date: __/__/20__)

Project Title:

Health, motor skills, fitness and lifestyle of Swansea School Children aged 9-11 years old

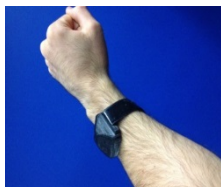
Contact Details:



You have been selected to take part in a Swansea University study. You have been chosen because you are between the ages of 9-11 years old and go to a primary school in Swansea.

In this study you have the chance to take part in a fitness fun day at the University and on another day the research team will come into your school and ask you to complete a questionnaire about your health and lifestyle and about how physically active you are. Physical activity is any movement that requires your body to work harder than it does whilst sitting, or resting.

The fitness fun day will involve lots of fun physical activities that you may not have tried before which should be really enjoyable. These include running, jumping and strength tests.



You may also get asked to wear our BRAND NEW devices, and use the NEWEST technology to measure how fast you move forwards and backwards, side to side and up and down.



You will not be forced to do any of the activities and can stop at any time without fear of penalty or having to worry about being

in trouble.

If you have any questions please ask any of the research team.

THANK YOU.



PARTICIPANT ASSENT FORM

(Version 2.1, Date: __/__/20__)

Project Title:

Health, motor skills, fitness and lifestyle of Swansea School Children aged 9-11 years old

Contact Details:



I agree to take part in this study.

Name of Participant

Date

Signature

Researcher

Date

Signature

Swan-Linx and Dragon Challenge application for ethical approval



Applied Sports Technology Exercise and Medicine Research Centre (A-STEM) Sport and Health Portfolio, College of Engineering

APPLICATION FOR ETHICAL COMMITTEE APPROVAL OF A RESEARCH PROJECT

In accordance with A-STEM and College of Engineering Safety Policy, all research undertaken by staff or students linked with A-STEM must be approved by the A-STEM Ethical Advisory Committee prior to starting data collection.

Applications for approval should be submitted on this form. The researcher(s) should complete the form in consultation with the project supervisor. Where appropriate, the application must include the following appendices: (i) Participant Information Sheet, (ii) Participant Consent Form, (iii) Participant Health Screening Questionnaire.

After completing and signing the form students should ask their supervisor to complete and sign the declaration section. Staff members should submit the form directly to the Chair of the A-STEM Ethical Advisory Committee.

Applicants will be informed of the decision of the Committee via email to the project leader/supervisor.

TITLE OF PROJECT

What is the state of motor skills (physical competency), fitness and lifestyle in children aged 8-13 years in Wales?

NAMES AND STATUS OF RESEARCH TEAM

Professor Gareth Stratton - Project Director
Dr Kelly Mackintosh - Secondary Supervisor
Mr Richard Tyler – PhD candidate
Mr Cain Clark – PhD candidate
Ms Claire Barnes – PhD candidate
Mr Nils Swindell – PhD candidate
Dr Melitta McNarry – Senior lecturer
Professor Sinead Brophy - Project Director DeCIPHer
Ms Charlotte Todd - Research Assistant DeCIPHer
Ms Danielle Christian - Research Assistant DeCIPHer
Mr Luke Martin – MSc by research candidate
Mr Michael Sheldrick – MSc by research candidate
Ms Tabatha Pace – BSc dissertation student
Mr Andrew Beveridge – BSc dissertation student

RATIONALE

Childhood obesity and physical inactivity is a problem within the United Kingdom with one-quarter of UK children being classed as obese by the time they leave primary school (Reilly, 2006). Fitness levels are decreasing (23% decrease from 1998-2004; Stratton *et al.* 2007) which is resulting in poor health and an increased risk of premature death for children in the UK. There is evidence that a high body mass index (BMI) negatively affects motor performance (Okley *et al.* 2010) and that taking part in physical activity can increase ability to perform motor skills (Okley *et al.* 2001). Although childhood obesity and physical inactivity is a national concern many parents do not recognise that their children are obese (Parry *et al.* 2008) which presents a problem because although the parents know how to have a healthy lifestyle they are not promoting it (Onnerfalt *et al.* 2012). In 2008, Stodden *et al.* created a conceptual model that identifies fundamental movement skills as being a key underlying factor that can influence participation in physical activity and, consequently, health status. These are the foundation skills that, if mastered, form the platform for motor skill competence (physical competency). The authors explain that higher physical competency levels will cause a positive trajectory toward perceived competence, health-related fitness and, sequentially, physical activity levels. This in turn, will promote the child to maintain a healthy weight. More recently, authors have reviewed the growing literature around the conceptual model (Robinson *et al.* 2015). This review confirmed that evidence shows motor skill competence (physical competency) is positively associated with perceived competence and multiple aspects of health such as, physical activity, cardio-respiratory fitness, muscular strength and endurance, and a healthy weight status. Therefore, understanding the relationships between factors that influence children's health and well-being could aid in addressing the current declining levels of fitness and high levels of obesity.

This research project seeks to quantify motor fitness, physical competency, physical activity, and health related behaviours, and seek to establish interrelationships between them. Further, this study will use an accelerometer (REC PG/2014/009) to generate raw, unfiltered data to analyse the movements of children in this context. The data generated by this programme will be used to develop support programmes for children based on their individual needs.

REFERENCES

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AIMS and OBJECTIVES

The aim of the project is to establish levels of motor fitness, physical competency and lifestyle behaviours of children who attend schools in Wales. This will be done using a series of tasks from the Eurofit test battery (Council of Europe, 1983) and the Dragon Challenge V1.0 activities. Sedentary behaviours, diet and wellbeing will be assessed using an online questionnaire (the CHAT tool). The study will also examine correlates of motor skills, physical competency, physical activity, lifestyle and fitness. There are many objectives, for example: To determine the relationship between motor fitness and BMI. To quantify the differences between motor skills and fitness in boys and girls. To establish whether motor skills and fitness, are related to lifestyle behaviours. To determine the general level of motor fitness, physical competency, health, wellbeing and lifestyle of children in Wales. Further, this study will seek to use the SlamTracker accelerometer to determine specific signals related to physical activity, fitness and motor performance (as in ethics approval code PG/2014/009).

METHODOLOGY

Study Design

This study will involve boys and girls aged 8-13 years schools in Wales. The children will be asked to complete three parts for the study.

1. The first part will be to complete an online questionnaire (CHAT) which will take about 30-45 minutes; this will be administered on schools premises' by the research team. The questionnaire focuses on and asks questions regarding diet, physical activity, lifestyle, sporting interest and mental wellbeing.
2. The second part of the study will involve a fitness fun day that will take half a day to complete. The fun day will involve a variety of motor fitness activities from the Council of Europe European Physical Fitness Test battery (Eurofit), as well as the measurement of height, sitting height and weight to determine BMI.
3. The children will complete further motor performance assessments in "dragon challenge" (third part). The dragon challenge includes 9 motor skill assessments completed serially. These further quantify motor fitness/fundamental movement tasks, including; running, jogging, balancing on a bench, balancing on the spot, basketball dribbling, jumping, catching and throwing. Dragon challenge is completed in 3 minutes. These tasks involve exertion commensurate with physical education lesson demands.

Experimental Procedures

(1) Completion of the CHAT tool (online questionnaire); (2) Fitness Fun Day tasks; (3) Dragon Challenge Tasks. The study involves completing a 30-45 minute questionnaire which will take part at the school. The fitness fun day will take half a day to complete and will take part at respective schools premises (sports halls) e.g. Pentrehafod school sports hall, and Swansea University indoor training centre. The participant will be given an assent form and therefore the choice of opting out of all or part of the project. Active consent will be gained from the head teacher of each school, consent will be gained from the parents and assent will be gained from the children. The online questionnaire, which has been developed by members of Swansea University, based on the Sportslinx questionnaire has 29 questions is available in both Welsh and English and can be completed on computers, iPads and tablets. The questionnaire includes items on diet, sport participation, physical activity and sedentary behaviour, parents' physical activity and lifestyle behaviours including sleep times, mode of travel to and from school, and perceptions about their fitness, health, school, friends and family. The fitness fun day will take place in the sports hall of the respective schools or Swansea University's indoor training centre and will take a half a school day to complete all of the activities. The students will complete a small warm up to increase heart rate and the activities the students will be taking part in are from the Eurofit test battery and Dragon Challenge activities. The Eurofit test was devised by the Council of Europe, for children of school age and has been used in many European schools since 1988 (Council of Europe, 1983). The Dragon Challenge activities were developed by Swansea and Edgehill Universities and Sport Wales. In sum the tasks include the sit and reach test to measure flexibility, speed bounce to measure agility, standing broad jump to measure explosive leg power, the handgrip test to measure static arm strength, and running tests, the 10 x 5 meter shuttle run to measure speed and agility and then 20m endurance shuttle run to measure cardio respiratory endurance, all of these activities are commensurate with physical education lessons within a school. Additionally participants will take part in "Dragon Challenge" activities, which include; running, jumping over hurdles, balancing, core agility/flexibility, ball throwing, ball catching and ball bouncing. Throughout, participants will be asked to wear the SlamTracker accelerometer (as in ethics approval code PG/2014/009 & PG14/2014/007). The student's height, sitting height and weight will also be measured, by a member of the listed research team, so that BMI and maturation offset can be calculated. For some activities the participants may be asked to give their rating of exertion (RPE) using the Omni Scale of Perceived Exertion Scale (Robertson et al. 2000). During the activities, after attaining consent from parent/guardian, school, and participant, a video recording device will be used to assess movements during the motor fitness activities, post-hoc. Four cameras will be placed along the anteroposterior and mediolateral planes to capture the movements in detail. The cameras will be placed to capture the activities, but will not impede the participants' movements during the motor fitness activities. These video recordings will be used to further analyse the motor fitness/fundamental movement skills of the participants.

Data Analysis Techniques

A Pearson's product moment correlation will be used to analyse BMI and performance in motor fitness tests. The data from the questionnaires will be entered into Excel and analysed using an analysis of variance (ANOVA). An independent T-test will be used to look for differences between motor fitness scores of male and female students. Postal code data will be used to portray a 'map' of areas/districts, enabling analysis of how socioeconomic status and WIMD scores relate to levels of health and motor fitness in children. Raw acceleration data from the SlamTrackers (as in ethics approval code

PG/2014/009) will be analysed using an algorithm developed from a previous study (PG/2014/009 & PG14/2014/007). The trace from the accelerometer, which gives acceleration in terms of 'g' over the time period, is split into sections for clarity and ease of analysis. The data is then converted into the frequency domain by the Fast Fourier transform. The Fast Fourier transform involves taking a continuous function and representing it as a number of sine and cosine waves. It provides information about the harmonic content of a signal so that conclusions about the activity being performed can be made. Data will be analysed using MatLab, with time and frequency features from the raw acceleration trace extracted. Video recordings will be used to analyse and compare the motor fitness activities and also to compare/confirm assessor ratings.

Storage and Disposal of Data and Samples

The completed questionnaires and fitness fun day (including Dragon Challenge) data will be kept private and confidential, hard copies of information will be kept in a secure office and any personal information will be changed into a number rather than a name. All files on a computer will be password protected and files with personal details will only be accessible by only accessible by Professor Gareth Stratton, Dr Kelly Mackintosh, Dr Melitta McNarry, Mr Cain Clark, Ms Claire Barnes, Mr Nils Swindell, Mr Richard Tyler, Mr Luke Martin, Mr Michael Sheldrick, Ms Tabatha Pace and Mr Andrew Beveridge. The schools will have access to the anonymous data for educational and curriculum use. The data is part of a longitudinal study and will not be disposed of. Data may be also used, with consent, in further data linkage projects. This involves linking the collected data to health and education outcomes using Secure Anonymised Information Linkage (SAIL) through the Information Governance Review Panel (IGRP). Any and all video recorded data will be kept separate from any identifying documents and will be managed under the Data Protection Act 1998, concluding each day of testing, video recordings will be transferred to a password encrypted device. The video recorded data will be kept for educational purposes, such as for training, and demonstrating the motor fitness activities to future participants. Alternatively, any video recorded data not used for academic or educational purposes will be destroyed by the lead investigator, Richard Tyler, overseen by project director Gareth Stratton, after no longer than 7 years.

LOCATION OF THE PREMISES WHERE THE RESEARCH WILL BE CONDUCTED.

The fitness fun day will take place on the premises of Swansea University's indoor training centre, or at the respective schools' premises/sports hall (for example, Pentrehafod School sports hall). The research team, Sport Wales Sport Ambassadors, volunteers, and a member(s) of City and County of Swansea sport and recreation team will all be present. The session will also be overseen by school teachers, and a qualified first aider (either Swansea indoor training centre staff, or school sports hall attendant)

PARTICIPANT RISKS AND DISCOMFORTS

The students will not be put under any greater risk than what they would face when in a PE class in school. However, there is a possibility that whilst taking part in the fitness fun day they will get an injury, feel sick or faint. A first aid trained staff will always be present during any activity. All anthropometric measures will be taken sensitively. All lead researchers will have a DBS check and no researcher will be on their own with any individual child.

INFORMATION SHEET AND INFORMED CONSENT

The submission should be specific about the type of consent that will be sought, which should be indicated below:

- Have you included a Participant Information Sheet for the participants of the study? YES/NO
- Have you included a Participant Consent Form for the participants of the study? YES/NO

COMPUTERS

- Are computers to be used to store data? YES/NO
- If so, is the data registered under the Data Protection Act? YES/NO

STUDENT DECLARATION

Please read the following declarations carefully and provide details below of any ways in which your project deviates from these. Having done this, each student listed in section 2 is required to sign where indicated.

- ***"I have ensured that there will be no active deception of participants.***
- ***I have ensured that no data will be personally identifiable.***
- ***I have ensured that no participant should suffer any undue physical or psychological discomfort***
- ***I certify that there will be no administration of potentially harmful drugs, medicines or foodstuffs.***
- ***I will obtain written permission from an appropriate authority before recruiting members of any outside institution as participants.***
- ***I certify that the participants will not experience any potentially unpleasant stimulation or deprivation.***
- ***I certify that any ethical considerations raised by this proposal have been discussed in detail with my supervisor.***
- ***I certify that the above statements are true with the following exception(s):"***

Student/Researcher signature: (include a signature for each student in research team)
Date:

SUPERVISOR'S DECLARATION

In the supervisor's opinion, this project (delete those that do not apply):

- ***"Does not raise any significant issues.***
- ***Raises some ethical issues, but I consider that appropriate steps and precautions have been taken and I have approved the proposal.***
- ***Raises ethical issues that need to be considered by the Departmental Ethics Committee.***
- ***Raises ethical issues such that it should not be allowed to proceed in its current form."***

Supervisor's signature:
Date:

ETHICS COMMITTEE DECISION (COMMITTEE USE ONLY)

ETHICAL APPROVAL: REC PG/2014/37

GRANTED/~~REJECTED~~

The ethical issues raised by this project have been considered by the A-STEM Ethical Advisory Committee.

Please refer to the summary comments noted in the decision email sent to the project lead/supervisor. Please ensure that you take account of these comments.

Where necessary, please prepare a revised submission that should be shown to your supervisor (for student applications) and then resubmitted to the A-STEM Ethical Advisory Committee for reconsideration.

Application number _____

Date:

Signed:

(Chair, A-STEM Ethical Advisory Committee)



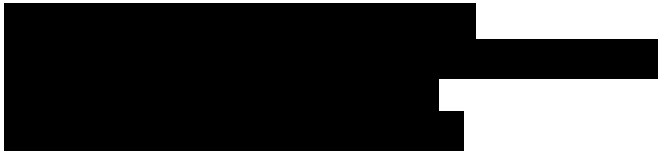
PARENT INFORMATION SHEET

(Version 1.0, Date: __/__/20__)

Project Title:

Health, motor skills (physical competency), fitness and lifestyle of School Children in Wales

Contact Details:



Please read the information below carefully before deciding whether to consent for your child's participation.

1. Invitation Paragraph

The children in your child's class have been invited to take part in a new study that will look at the relationships between lifestyle behaviours, such as, sitting time, computer game play, fitness, sleep time, type of foods eaten and so forth. The data we collect from all of the children taking part in the study will help us assess different aspects of children's motor skills (physical competency), fitness and lifestyle.

2. What is the purpose of the study?

The purpose of this study is to investigate motor skills (physical competency), fitness and lifestyle in children. The study will also test an accelerometer which measures body movement. The data collected will be used in a postgraduate student's thesis and will assist in tracking children's health, physical activity and physical competency, to decide how best to help children become healthier and more involved in sport and physical activity in the future. The data collected will also be used to map results across Wales. This will help us to further analyse levels of health and fitness in children in terms of demographics.

3. Why has my child been chosen?

All of the children in your child's class, including your child, have been invited to take part in the Fitness Fun Day. During the day, if your child does not feel happy about anything that they are asked to do, they can stop at any time, without fear of penalty. If you need

any more information about the study then please contact any member of the team on the details above.

4. What will happen to your child if they take part?

Your child will attend a Fitness Fun Day with the rest of their class. This will involve a half day of fun physical activities which will measure children's strength, speed, agility, endurance and flexibility. These activities include; 20m shuttle run (measures endurance), 10x5m sprint (measures speed and agility), handgrip (measures strength), sit and reach (measures flexibility), standing long jump (measures leg explosive power), and speed bounce (measures leg speed, agility and endurance). They will also take part in the Dragon Challenge V1.0; this Challenge assesses many fundamental movement skills. During the Dragon Challenge, your child and their class will perform 9 discrete tasks in a circuit that require single or combinations of motor skills in order to achieve a goal. These tasks involve running, jumping over hurdles, balancing, core agility/flexibility, ball throwing, ball catching and ball bouncing.

During the physical activities, some of the children may be asked to wear the SlamTracker accelerometer. This device will measure how fast your child moves forwards and backwards, side to side and up and down.

Your child will also have weight, height and sitting height measurements recorded, taken by a member of the research team listed. Measures of body weight are taken privately in a separate room or behind a screen, there will always be other children in the room or next to the screen but they will not be party to the results or be able to view the measures and no results are shared with the rest of the class, however, your child will not have to have them taken if they do not want to. All activities will be no harder than your child would do during school PE lessons. Finally, during the Fitness Fun Day session or at your child's school, your child will also be asked complete a questionnaire, about their health, physical activity and lifestyle, which will take about 30 minutes. There will be members of the research team and teachers present to assist your child in filling them in. All the activities during the Fitness Fun Day are aimed for the children's enjoyment and not as a competition. With your permission, a video camera will also be used to capture some of the activities the children are performing.

5. What are the possible disadvantages of taking part?

Taking part in the Fitness Fun Day and Dragon Challenge activities poses no greater risk than a child participating in school physical education lessons. However, in the unlikely event that a child feels unwell, there will be people monitoring the children during all parts of the fitness fun day and dragon challenge activities, and the children's teachers will remain present at all times. A qualified first aider will always be present during the Fitness Fun Day (including Dragon Challenge).

6. What are the possible benefits of taking part?

The Fitness Fun Day will be an active and very enjoyable day for the children and they will get to take part in a variety of different activities that they might not have taken part in before. They will be able to find out about their skills and fitness in relation to health and well-being. Further we want children to engage with their results. Therefore school data will be anonymised and made available to the school for educational purposes.

7. Will my child taking part in the study be kept confidential?

All the data we collect from your child will be kept private and confidential; the children's

names will be changed to numbers. Any hard copies of the questionnaires and fitness fun day data will be kept in a secure office and computer files with any personal information will be password protected. The data obtained will only be looked at by responsible individuals of the research team from Swansea University, City & County of Swansea, and the PLPS team (Sport Wales), or from regulatory authorities where it is relevant to your child's participation in the research. To enable us to track changes in health over time we will also keep the secure data available for future linkage with other sets of data collected in the future such as GP visits or educational results for example.

8. What if I have any questions?

If you have any questions about what is written above or anything to do with the study please don't hesitate to contact me or anyone from the research team (see contact details above). If after the study you are concerned about how any aspect of the research was conducted please contact the Chair of the College Ethics Committee, Professor Mike McNamee ([REDACTED]).

PARENT CONSENT FORM
(Version 1.0, Date: __/__/20__)

Project Title:

Health, motor skills (physical competency), fitness and lifestyle of School Children in Wales

PLEASE RETURN THIS FORM TO SCHOOL TO CONSENT FOR YOUR CHILD TO TAKE PART IN THE PROJECT.

Contact Details:



Please INITIAL each box below

1. I confirm that I have read and understood the information sheet dated __/__/20__ (Version number 1.0) for the above study and have had the opportunity to ask questions.
 2. I am happy for my child to participate in the Fitness Fun Day, and wear the SlamTracker accelerometer.
 3. I understand that my child's participation is voluntary and that I am free to withdraw my child at any time, without giving any reason, without their medical care or legal rights being affected.
 4. I understand that sections of the data obtained may be looked at by responsible individuals from the Swansea University or from regulatory authorities where it is relevant to the children's taking part in research
 5. I am happy for any data collected in this study to be used in future health related studies where data collected will be linked to health outcomes and educational records.
- I am happy for the activities to be video recorded for academic use ONLY.
- I agree to allow my child to take part in the above study.

Name of Participant (child)	Date	Signature
Name of Parent/Guardian	Date	Signature
Researcher	Date	Signature



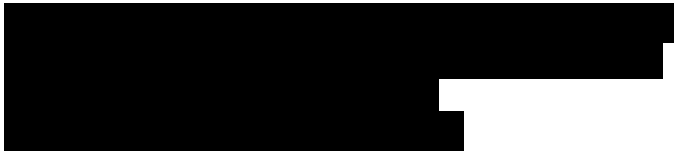
HEADTEACHER INFORMATION SHEET

(Version 1.0, Date: __/__/20__)

Project Title:

Health, motor skills (physical competency), fitness and lifestyle of Swansea School Children

Contact Details:



1. Invitation Paragraph

The children in your school have been invited to take part in a new study that will look at the relationships between lifestyle behaviours, such as, sitting time, computer game play, fitness, sleep time, type of foods eaten and so forth. Other schools are also taking part in the study. They will be asked to take part in a Fitness Fun Day, where they will complete the Dragon Challenge, and a series of physical activities and a questionnaire. The data we collect will help us assess different aspects of children's motor skills (physical competency), fitness and lifestyle. Please consider whether you are able to commit to the requirements stated below before signing the consent form.

2. What is the purpose of the study?

The purpose of this study is to investigate the health, motor skills (physical competence), fitness, lifestyle of children from selected schools. The study will also test an accelerometer which measures body movement. The data collected will be used in a postgraduate student's thesis and will assist in tracking children's health, physical activity and physical competency, to decide how best to help children become healthier and more involved in sport and physical activity in the future. The data collected will also be used to map results across Wales. This will help us to further analyse levels of health and fitness in children in terms of demographics.

3. Why have I been chosen?

The children in your school have been invited take part in the Fitness Fun Day as they

attend school in Wales. During the day if any of the children do not feel happy about anything they are asked to do, they can stop at any time, without fear of penalty. If you need any more information about the study then please contact any member of the team on the details above.

4. What will happen to the children if they take part?

Your pupils will attend a Fitness Fun Day; this will involve a half day of fun physical activities which will measure the children's strength, speed, agility, endurance and flexibility. These activities include; 20m Multi Stage shuttle runs (measures endurance), 10x5m sprint (measures speed and agility), handgrip (measures strength), sit and reach (measures flexibility), standing long jump (measures leg explosive power), and speed bounce (measures leg speed, agility and endurance). They will also take part in the Dragon Challenge V1.0; this Challenge assesses many fundamental movement skills. During the Dragon Challenge, the children will perform 9 discrete tasks in a circuit that require single or combinations of motor skills in order to achieve a goal. These tasks involve running, jumping over hurdles, balancing, core agility/flexibility, ball throwing, ball catching and ball bouncing.

During these physical activities, some of the children may be asked to wear a sensor called a SlamTracker accelerometer. This device will measure how fast the child moves forwards and backwards, side to side and up and down, and will only be worn during some activities. The activities will be no harder than what a child would do during school PE lessons. The children will also have weight, height and sitting height measurements recorded, take by a member of the research team listed. Measures of body weight are taken privately in a separate room or behind a screen, there will always be other children in the room or next to the screen but they will not be party to the results or be able to view the measures and no results are shared with the rest of the class. Children can choose not to have their anthropometric measurements taken if they do not want to be measured. We have followed this approach with around 70000 children in Liverpool since 1996. Finally, during the Fitness Fun Day session, the children will also be asked complete a questionnaire, about their health, physical activity and lifestyle, which will take about 30 minutes. There will be members of the research team and teachers present to assist the children in filling them in. All the activities during the Fitness Fun Day are aimed for the children's enjoyment and not as a competition. With your permission, a video camera will also be used to capture some of the activities the children are performing.

5. What are the possible disadvantages of taking part?

Taking part in the Fitness Fun Day and Dragon Challenge activities poses no greater risk than a child would face during physical education lessons in school. However, in the unlikely event that a child feels unwell, there will be people monitoring the children during all parts of the fitness fun day and dragon challenge activities, and the children's teachers will remain present at all times. A qualified first aider will always be present during the fitness fun day (including Dragon Challenge).

6. What are the possible benefits of taking part?

The Fitness Fun Day will be an active and very enjoyable day for the children and they will get to take part in a variety of different activities that they might not have taken part in before. They will be able to find out about their skills and fitness in relation to health and well-being. Further we want children to engage with their results. Therefore school data

will be anonymised and made available to the school for educational purposes.

7. Will my taking part in the study be kept confidential?

All the data we collect from the children will be kept private and confidential; the children's names will be changed to numbers. Any hard copies of the questionnaires and fun day data will be kept in a secure office and computer files with any personal information will be password protected. The data obtained will only be looked at by responsible individuals of the research team from Swansea University and the City & County of Swansea, and the PLPS team (Sport Wales), or from regulatory authorities where it is relevant to the children's participation in the research. To enable us to track changes in health over time we will also keep the secure data available for future linkage with other sets of data collected in the future such as GP visits or educational results for example.

8. What if I have any questions?

If you have any questions about what I have written above or anything to do with the study please don't hesitate to contact me or anyone from the research team as detailed above. If after the study you are concerned about how any aspect of the research was conducted please contact the Chair of the College Ethics Committee, Professor Mike McNamee [REDACTED]

HEADTEACHER CONSENT FORM
(Version 1.0, Date: __/__/20__)

Project Title:

Health, motor skills (physical competency), fitness and lifestyle of School Children in Wales

Contact Details:



Please INITIAL each box below

1. I confirm that I have read and understood the information sheet dated __/__/20__ (Version number 1.0) for the above study and have had the opportunity to ask questions.
2. I understand that the children’s participation is voluntary and that I am free to withdraw my pupils at any time, without giving any reason, without their medical care or legal rights being affected.
3. I understand that sections of the data obtained may be looked at by responsible individuals from the Swansea University or from regulatory authorities where it is relevant to the children’s taking part in research.
4. I am happy for any data collected in this study to be used in future health related studies where data collected will be linked to health outcomes and educational records.
5. I am happy for the activities to be video recorded for academic use ONLY.

I agree to allow the pupils in my school to take part in the above study.

Name of School	Date	Signature

Name of Headteacher	Date	Signature

Researcher	Date	Signature



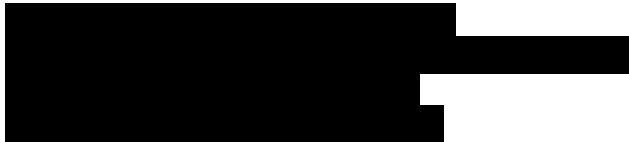
PARTICIPANT INFORMATION SHEET

(Version 1.0, Date: __/__/20__)

Project Title:

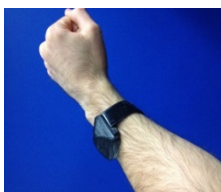
Health, motor skills (physical competency), fitness and lifestyle of School Children in Wales

Contact Details:



You have been invited to take part in a Swansea University study. You have been chosen because you are between the ages of 8-13 years old and go to a school in Wales.

In this study you have the chance to take part in a fitness fun day, the Dragon Challenge, and complete a questionnaire about your health and lifestyle and about how physically active you are. Physical activity is any movement that requires your body to work harder than it does whilst sitting, or resting. The fitness fun day will involve lots of fun physical activities that you may not have tried before which should be really enjoyable. These activities will include a 20m shuttle run to see how long you can run for, a shuttle sprint to see how quick you can run back and forth, gripping with your hands to find out your strength, sit and reach to find out how flexible you are, standing long jump to see how far you can jump, and speed bounce to see how many times you can jump in 30 seconds. The Dragon Challenge involves running, jumping over hurdles, balancing, core agility/flexibility, ball throwing, ball catching and ball bouncing. These are done in a circuit and should be really fun.



You may also get asked to wear our BRAND NEW devices, and use the NEWEST technology to measure how fast you move forwards and backwards, side to side and up and down. This will be worn on your wrist and ankle during some of the physical activities. You may also be video recorded during some of the physical activities. This will help us see how well you have done.

You will not be forced to do any of the activities and can stop at any time without fear of penalty or having to worry about being in trouble.

If you have any questions please ask.

THANK YOU.

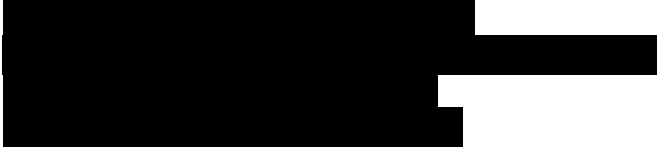










PARTICIPANT ASSENT FORM
 (Version 1.0, Date: __/__/20__)

Project Title:

Health, motor skills (physical competency), fitness and lifestyle of School Children in Wales

Contact Details:



	<i>Please look at the following statements and put your initials if you agree. Example Sarah Jones: SJ</i>		
	I have read the Participant Information Sheet		
	I understand what I will be doing if I take part		
	I have had a chance to think about taking part		
	I have had a chance to ask any questions		
	I agree that my data can be used in a research report and that I will not be named so no-one will know it was my information		
	I understand that all of the information will be kept private and only shared with the research team		
	I am happy to try to do the activities that the Swan-Linx Team wants me to do during the fitness fun day, and complete the questionnaire.		
	I am happy to take part in this study		

Name of Participant

Date

Signature

Researcher

Date

Signature

Validating the Dragon Challenge application for ethical approval



Applied Sports Technology Exercise and Medicine Research Centre (A-STEM) Sport and Health Portfolio, College of Engineering

APPLICATION FOR ETHICAL COMMITTEE APPROVAL OF A RESEARCH PROJECT

In accordance with A-STEM and College of Engineering Safety Policy, all research undertaken by staff or students linked with A-STEM must be approved by the A-STEM Ethical Advisory Committee prior to starting data collection.

Applications for approval should be submitted on this form. The researcher(s) should complete the form in consultation with the project supervisor. Where appropriate, the application must include the following appendices: (i) Participant Information Sheet, (ii) Participant Consent Form, (iii) Participant Health Screening Questionnaire.

After completing and signing the form students should ask their supervisor to complete and sign the declaration section. Staff members should submit the form directly to the Chair of the A-STEM Ethical Advisory Committee.

Applicants will be informed of the decision of the Committee via email to the project leader/supervisor.

TITLE OF PROJECT

The validity and reliability of the Dragon Challenge V1.0 in measuring physical competency in children aged 8-14 years.

NAMES AND STATUS OF RESEARCH TEAM

Professor Gareth Stratton - Project Director
Dr Kelly Mackintosh - Secondary Supervisor
Mr Richard Tyler – PhD candidate
Mr Cain Clark – PhD candidate
Ms Claire Barnes – PhD candidate
Mr Nils Swindell – PhD candidate
Dr Melitta McNarry – Senior lecturer
Mr Luke Martin – MSc by research candidate
Mr Michael Sheldrick – MSc by research candidate
Ms Tabatha Pace – BSc dissertation student
Mr Andrew Beveridge – BSc dissertation student
Professor Sinead Brophy
Ms Charlotte Todd
Ms Danielle Christian

RATIONALE

A physically active lifestyle is extremely important to a child's health (Janssen and LeBlanc, 2010). Physical literacy is the motivation, confidence, physical competence, knowledge and understanding to value and take responsibility for engagement in physical activities for life (Whitehead, 2010). The ability to monitor children's progression throughout their physical literacy journey across the life-course requires a broad spectrum of valid and reliable methods. Notably, the physical competence domain of physical literacy includes not only fitness, but also physical movement competence.

Stodden et al. (2008) created a conceptual model that identifies fundamental movement skills as being a key underlying factor that can influence participation in physical activity and, consequently, health status. These are the foundation skills that, if mastered, form the platform for motor skill competence. The authors explain that higher physical competency levels will cause a positive trajectory toward perceived competence, health-related fitness and, sequentially, physical activity levels.

Among older children and adolescents, the strength of physical movement competency and physical activity relationship becomes increasingly more important. Children, who are not proficient in locomotor, object control and stability skills, are less likely to adopt an active lifestyle (Lubans et al, 2013; Lloyd et al, 2014, Robinson *et al.* 2015). Thus, movement competence is an increasingly important determinant of physical literacy in children.

Current assessments of movement skill require children to perform each skill in isolation (Henderson et al 2010; Folio & Fewell 2000, Ulrich 2000), making them time and resource intensive to administer (Wiat & Darah, 2001). Over the past 2 years Swansea University have worked with Sport Wales to design an assessment of physical competence in a continuous circuit of 9 tasks.

Task		Description
1.	Balance bench	Walk the length of the narrow side of a bench beam, completing a 360 degree turn at mark before dismounting at the end of the bench.
2.	Core agility	Complete 4 body shape positions (dish - arch - dish - arch), rotating the body in both directions.
3.	Wobble spot	Complete 5 bean bag 'passes' around the body whilst balancing on the wobble spot on one leg.
4.	Overarm throw	Throw a tennis ball, using an overarm throw, at a target approximately 9 metres away.
5.	Basketball dribble	Using either hand, dribble a basketball around 4 coloured spots positioned in a 'z' formation.
6.	Catch	Catch a tennis ball thrown underarm at a rebound net from any distance.
7.	Jumping patterns	Complete a jumping pattern sequence that includes a series of hops and jumps (2 footed jump over hurdle → 2 footed landing → 2 left hops → 2 right hops → 2 foot jump over hurdle → 2 footed landing).
8.	T-agility	Complete t-agility run, facing forwards throughout.
9.	Accelerate-sprint	10m acceleration to a sprint over finish line.

The Dragon Challenge Version 1.0 (DC V1.0) has been implemented in schools across Wales. DC V1.0 was designed for use in the field by professionals (sport coaches, PE teachers) and has content and face validity. DCV1.0 does not have criterion validity or reliability data. Empirical work is required to achieve this.

Previous Validation Work that has been completed on DC V1.0:

Content and face validity - A group of paediatric exercise specialists from Swansea, Glyndwr and Edge Hill University with expertise in physical education, physical competency and physical literacy research were involved in evaluating the content validity of the Dragon Challenge. Content and face validity of the 9 constituent tasks were qualitatively reviewed by a trained researcher. This researcher had > 10 years' experience of physical competence and movement skill assessment. Internationally recognised experts (n=5) in childhood movement skill, fitness and physical literacy assessment provided guidance for the review process.

Construct validity - Construct validity needs to be gathered on the 9 tasks constituent to the Dragon Challenge in 8-14 years old children.

This research project seeks to investigate the validity and reliability of the Dragon Challenge V1.0 in children aged 8-14 years old using video and accelerometer data. These data will be used to develop and refine the Dragon Challenge V1.0 and create the Dragon Challenge V2.0.

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AIMS and OBJECTIVES

The aim of the project is to establish the reliability and validity of the Dragon Challenge V1.0. This will be done using a series of tasks from the Eurofit test battery (Council of Europe, 1983), the Dragon Challenge V1.0, and other motor skill activities from the Test of Gross Movement Development-2 (Ulrich, 2000). There are many objectives, for example: Additionally, this study will seek to use the SlamTracker accelerometer to determine specific signals related to motor performance (as in ethics approval code PG/2014/009), in order to support/further investigate criterion validity.

METHODOLOGY

Study Design

Participants and settings

Instruments and procedures

Design and analysis

One hundred girls and boys from school Years 4, 5, 6, 7, 8 and 9 will be invited to take part in this study. Children will be invited primarily from one primary school and one comprehensive school, with use of past links/communications made with the schools and teachers. Children will complete each of the 9 tasks from the DCV1.0 whilst being video recorded from the frontal, transverse and sagittal planes. These assessments quantify children's motor fitness and fundamental movement skills, including; running, jumping over hurdles, core agility/flexibility, ball throwing, ball catching, ball bouncing, balancing on a bench and balancing on the spot. The Dragon Challenge activities were developed by Swansea and Edgehill Universities and Sport Wales. Observation criteria from Haywood and Getchell (2014) will be used to assess fundamental movement skills in participating children. These data will be compared to DCV1.0 and agreement statistics calculated. This will be repeated twice over 2 weeks to estimate reliability of measures.

The children will also take part in a variety of further motor fitness activities from the Council of Europe European Physical Fitness Test battery (Eurofit) (PG/2014/37) and the Test of Gross Movement Development-2 (Ulrich, 2000). These will provide further measures of object control, locomotor and stability skills which will be used to generate validity data. The Eurofit test was devised by the Council of Europe, for children of school age and has been used in many European schools since 1988 (Council of Europe, 1983). Activities such as the flamingo test (stability skill) and 10x5m shuttle run (locomotor skill) from this Test battery will be completed. The Test of Gross Movement Development-2 is a standardized test that measures gross motor abilities in children (Ulrich, 2000). This test includes locomotor skills: run, gallop, jump, slide, hop, and leap, as well as object control skills: striking a stationary ball, stationary dribble, catch, kick, overhand throw, and underhand roll. Other gold standard activities (tests), similar to the activities mentioned above (e.g. Lower Quarter Y Balance Test (YBT-LQ) & Movement Assessment Battery for Children), may also be used to provide further validity data to investigate criterion validity.

The student's height, sitting height and weight will also be measured so that BMI and maturation offset can be calculated (PG/2014/37). Teachers (Physical education specialist or whoever provides PE lessons) of the participants will provide their perception of the

child's physical competence (Scale from 1 (very low) to 10 (very high)) as a proxy to investigate predictive validity.

Throughout all activities, participants will be asked to wear the SlamTracker accelerometer (as in ethics approval code PG/2014/009 & PG14/2014/007). Currently work with SPEC engineers has been completed to develop algorithms to quantify children's movement skills. This study will use the algorithms developed and match them to the video analysis and DCV1.0 data. This will enable the research team to quantify the degree to which movement skills can be assessed using sensors. The pragmatics of children wearing sensors was carried out in (PG/2014/009 & PG14/2014/007).

At the end of this process construct validity and reliability of the DCV1.0 will be determined. As a result DCV2.0 will be produced.

Experimental Procedures

Validating the Dragon Challenge

- Year groups: Years 4, 5, 6, 7, 8 and 9
- Duration: 1hr 30 mins for 5 pupils

The study will consist of sessions lasting 1hr 30 mins, with 5 pupils attending each session at a time. The study will take place in the school's sports hall, and/or Swansea University. Active consent will be gained from the head teacher of each school that the children attend, consent will be gained from the parents and assent will be gained from the participant. The participants will self-report their names, date of birth, and home postcode (to calculate WIMD & SES). Data will be stored on computer and password protected. Teachers (Physical education specialist or whoever provides PE lessons) of the participants will provide their perception of the child's physical competence.

The participants will complete a standardised warm up to increase heart rate, after which they will complete each Dragon Challenge task individually rather than serially. The participants will also take part in further object control, locomotor and stability skills selected from the Eurofit test battery and/or the Test of Gross Movement Development-2. Participants will take part in each activity twice for familiarisation and to ensure quality of video recording. Anthropometric measures will also be taken.

Throughout all activities, participants will be asked to wear the SlamTracker accelerometer (as in ethics approval code PG/2014/009 & PG14/2014/007). Additionally, during all activities, a video recording device will be used to assess children's movement during the motor fitness activities. Four cameras will be placed along the anteroposterior and mediolateral planes to capture the movements in detail. The cameras will be placed to capture the activities, but will not impede the participants' movements during the motor fitness activities. These video recordings will be used to further analyse the motor fitness/fundamental movement skills of the participants.

Data Analysis Techniques

- A Pearson's product moment correlation will be used to analyse concurrent validity.
- Limit's of agreement will be used to assess agreement between measures
- Factor analysis or Principal Component analysis (PCA)
- Confirmatory Factor Analysis (CFA)

- To further assess construct validity, age and gender differences will be explored using independent t-tests and chi square, for DC Score, Time, Technique (process) and Outcome (product) variables, as well as in the individual criterion.

- Raw acceleration data from the SlamTrackers (as in ethics approval code PG/2014/009) will be analysed using an algorithm developed from a previous study (PG/2014/009 & PG14/2014/007). The trace from the accelerometer, which gives acceleration in terms of 'g' over the time period, is split into sections for clarity and ease of analysis. The data is then converted into the frequency domain by the Fast Fourier transform. The Fast Fourier transform involves taking a continuous function and representing it as a number of sine and cosine waves. It provides information about the harmonic content of a signal so that conclusions about the activity being performed can be made. Data will be analysed using MatLab, with time and frequency features from the raw acceleration trace extracted.

- Video recordings will be used to analyse and compare the motor fitness activities and also to compare/confirm assessor (rater) scores.

Storage and Disposal of Data and Samples

All data will be kept private and confidential, hard copies of information will be kept in a locked cabinet in a secure office and any personal information will be changed into a number rather than a name. All files on a computer will be password protected and files with personal details will only be accessible by the research team. Any and all video recorded data will be kept separate from any identifying documents and will be managed under the Data Protection Act 1998. The video recorded data will be kept on an external memory drive which will be password protected at all times. After analysis, the video recorded data will be deleted, and alternatively, any video recorded data not used for analysis will be destroyed. Teachers will not have access to any individual data or non-anonymised data, but anonymised group data will be provided to teachers on their request. Lead professional for City and County of Swansea and from Mid & West Wales PLPS who are part of the research team (Wendy Anderson, Sarah McCoubrey, Helen John & Kirsty Edwards) will have access to the data.

LOCATION OF THE PREMISES WHERE THE RESEARCH WILL BE CONDUCTED.

The project will take place in School sports hall or in the University Sportshall. The research team, member(s) of PLPS group, and a member(s) of City and County of Swansea sport and recreation team will all be present. School teachers and/or teaching assistants will also be present, and a qualified first aider (Swansea University sport hall staff, or school sports hall attendant, or member of PLPS group/AYP team, or qualified member of the research team).

PARTICIPANT RISKS AND DISCOMFORTS

The students will not be put under any greater risk than what they would face when during physical activity during sport dance or play. However, there is a possibility that whilst taking part children may get injured, feel sick or faint. First aid trained staff will be available during any activity. Weight will be measured privately and sensitively. All lead researchers will have a DBS check and no researcher will be on their own with any individual child.

DBS Certificate Number for Lead Researcher (Richard Tyler) – 001464235079

Other evidence for DBS certificates can be obtained from the Project Director.

INFORMATION SHEET AND INFORMED CONSENT

The submission should be specific about the type of consent that will be sought, which should be indicated below:

- Have you included a Participant Information Sheet for the participants of the study? YES/~~NO~~
- Have you included a Participant Consent Form for the participants of the study? YES/~~NO~~

COMPUTERS

- Are computers to be used to store data? YES/~~NO~~
- If so, is the data registered under the Data Protection Act? YES/~~NO~~

STUDENT DECLARATION

Please read the following declarations carefully and provide details below of any ways in which your project deviates from these. Having done this, each student listed in section 2 is required to sign where indicated.

- ***“I have ensured that there will be no active deception of participants.***
- ***I have ensured that no data will be personally identifiable.***
- ***I have ensured that no participant should suffer any undue physical or psychological discomfort***
- ***I certify that there will be no administration of potentially harmful drugs, medicines or foodstuffs.***
- ***I will obtain written permission from an appropriate authority before recruiting members of any outside institution as participants.***
- ***I certify that the participants will not experience any potentially unpleasant stimulation or deprivation.***
- ***I certify that any ethical considerations raised by this proposal have been discussed in detail with my supervisor.***
- ***I certify that the above statements are true with the following exception(s):”***

Student/Researcher signature: (include a signature for each student in research team)

Date:

SUPERVISOR'S DECLARATION

In the supervisor's opinion, this project (delete those that do not apply):

- ***“Does not raise any significant issues.***
- ***Raises some ethical issues, but I consider that appropriate steps and precautions have been taken and I have approved the proposal.***
- ***Raises ethical issues that need to be considered by the Departmental Ethics Committee.***
- ***Raises ethical issues such that it should not be allowed to proceed in its current form.”***

Supervisor's signature:

Date:

ETHICS COMMITTEE DECISION (COMMITTEE USE ONLY)

ETHICAL APPROVAL: REC PG/2014/39

GRANTED/REJECTED

The ethical issues raised by this project have been considered by the A-STEM Ethical Advisory Committee.

Please refer to the summary comments noted in the decision email sent to the project lead/supervisor. Please ensure that you take account of these comments.

Where necessary, please prepare a revised submission that should be shown to your supervisor (for student applications) and then resubmitted to the A-STEM Ethical Advisory Committee for reconsideration.

Application number _____

Date:

Signed:

(Chair, A-STEM Ethical Advisory Committee)

PARENT INFORMATION SHEET

(Version 1.0, Date: __/__/20__)

Project Title:

The validity and reliability of the Dragon Challenge V1.0 in measuring physical competency in children aged 8-14 years.

Contact Details:



Please read the information below carefully before deciding whether to consent for your child's participation.

1. Invitation Paragraph

Children in your child's class/year at school have been invited to take part in a new study that will look at how good the Dragon Challenge is at measuring physical competency (how well the children can perform the fundamental movement skills needed in all sports, dance and physical activities). Our aim is to assess the validity and reliability of the Dragon Challenge V1.0 at measuring physical competency.

2. What is the purpose of the study?

The purpose of the study is to investigate the validity and reliability of the Dragon Challenge V1.0 in measuring physical competency in children aged 8-14 years. The study will also use the SlamTracker accelerometer, which is a small sensor in a device similar to a watch that measures your child's movement.

3. Why has my child been chosen?

Children in your child's class have been invited to take part in the study. During the study, if your child does not feel happy about anything that they are asked to do, they can stop at any time, without fear of penalty. If you need any more information about the study then please contact any member of the team on the details above.

4. What will happen to your child if they take part?

Your child will participate in a number of fun physical activities which will measure movement skills. These involve moving the body in any direction from one point to another, balancing the body in one place or while in motion, and handling or controlling objects with the hand or foot. Sport Wales, in partnership with Swansea University, Glyndwr University and Edge Hill University, have carefully constructed a single practical assessment "Dragon Challenge V1.0" that aims to assess many of these movement skills. During the Dragon Challenge, your child and the other children invited from their class will perform 9 discrete tasks that require single

or combinations of skills in order to achieve a goal. These tasks involve running, jumping over hurdles, balancing, core agility/flexibility, ball throwing, ball catching and ball bouncing. These will all be completed separately as well as in a timed circuit. Your child will also be asked to take part in similar activities to those in the Dragon Challenge V1.0; this is to see if they perform these activities as well as they perform in the Dragon Challenge activities.

During all of the physical activities, all of the children will be asked to wear a small sensor (called a SlamTracker accelerometer) on their wrist and ankle, the device is small and is similar to a watch. This device will measure how fast your child moves forwards and backwards, side to side and up and down. Your child will also have weight, height and sitting height measurements. Measures of body weight are taken privately behind a screen, there will always be other children in the room or next to the screen but they will not be party to the results or be able to view the measures and no results are shared with the rest of the class.

All the activities during the study are educational for the children's enjoyment and not as a competition. With your permission, a video camera will also be used to capture the activities the children are performing; this will allow us to further investigate the reliability and validity of the activities and results.

5. What are the possible disadvantages of taking part?

Taking part in the Dragon Challenge and other measures of movement performance poses no greater risk than a child participating in physical activity in sport, dance or play. However, in the unlikely event that a child feels unwell a qualified first aider will always be available during the study sessions.

6. What are the possible benefits of taking part?

The activities will be active and educational for the children and they will get to take part in a variety of different activities. They will be able to find out a lot about their physical skills.

7. Will my child taking part in the study be kept confidential?

All the data we collect from your child will be kept private and confidential; the children's names will be changed to numbers. Any hard copies of data will be kept in a secure office and computer files with any personal information will be password protected. The data obtained will only be looked at by responsible individuals of the research team. All of the recorded videos will be securely stored and will not be shared publicly. These will be deleted once analysed.

8. What if I have any questions?

If you have any questions about what is written above or anything to do with the study please don't hesitate to contact me or anyone from the research team (see contact details above). If after the study you are concerned about how any aspect of the research was conducted please contact the Chair of the College Ethics Committee, Professor Mike McNamee (m.j.mcnamee@swansea.ac.uk).

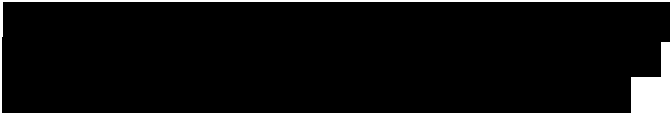
PARENT CONSENT FORM
(Version 1.0, Date: __/__/20__)

Project Title:

The validity and reliability of the Dragon Challenge V1.0 in measuring physical competency in children aged 8-14 years.

PLEASE RETURN THIS FORM TO SCHOOL TO CONSENT FOR YOUR CHILD TO TAKE PART IN THE PROJECT.

Contact Details:



Please INITIAL each box below

1. I confirm that I have read and understood the information sheet dated __/__/20__ (Version number 1.0) for the above study and have had the opportunity to ask questions.
2. I am happy for my child to participate in the Dragon Challenge and similar activities, and wear the sensor that tracks movement.
3. I understand that my child's participation is voluntary and that I am free to withdraw my child at any time, without giving any reason, without their medical care or legal rights being affected.
4. I understand that sections of the data obtained may be looked at by responsible individuals from the Swansea University or from regulatory authorities where it is relevant to the children's taking part in research
5. I am happy for the activities to be video recorded for academic use ONLY. I agree to allow my child to take part in the above study.

Name of Participant (child)	Date	Signature
Name of Parent/Guardian	Date	Signature
Researcher	Date	Signature

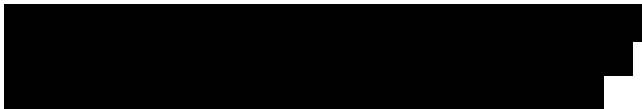
HEADTEACHER INFORMATION SHEET

(Version 1.0, Date: __/__/20__)

Project Title:

The validity and reliability of the Dragon Challenge V1.0 in measuring physical competency in children aged 8-14 years.

Contact Details:



1. Invitation Paragraph

Children from your school have been invited to take part in a new study that will look at how valid and reliable the Dragon Challenge is at measuring physical skills. The data we collect from all of the children taking part in the study will help us assess the validation and reliability of the Dragon Challenge V1.0 in measuring physical competency.

2. What is the purpose of the study?

The purpose of the study is to investigate the validity and reliability of the Dragon Challenge V1.0 in measuring physical competency in children aged 8-14 years. The study will also use a small sensor to quantify movement. We are interested to see if physical skills are related to children's health. This will further help to decide how best to help children become healthier and physically active in the future and throughout their life.

3. Why have I been chosen?

Children from your school/class have been invited to take part in the study. During the study, if the children do not feel happy about anything that they are asked to do, they can stop at any time, without fear of penalty. If you need any more information about the study then please contact any member of the team on the details above.

4. What will happen to the children if they take part?

The children will attend a session at Hafod School and/or at Swansea University. This will involve around 1hr 30min sessions (5 children per session) of fun physical activities which will measure children's aspects of physical competence (this Challenge aims to assess many fundamental movement skills: locomotion - skills that involve moving the body in any direction from one point to another, stability - skills that involve balancing the body in one place or while in motion, & object control - skills that involve handling or controlling objects with the hand, foot or an implement). During the Dragon Challenge, the children will perform 9 discrete tasks that require single or combinations of skills in order to achieve a goal. These tasks involve running, jumping over hurdles, balancing, core agility/flexibility, ball throwing, ball catching and ball bouncing. These will all be completed separately as well as in a timed circuit. The children will also be asked to take part in similar activities to those in the Dragon Challenge

V1.0; this is to see if they perform these activities as well as they perform in the Dragon Challenge activities.

During all of the physical activities, all of the children will be asked to wear the SlamTracker accelerometer (a small sensor) on their wrist and ankle. This device will measure how fast each child moves forwards and backwards, side to side and up and down. The children will also have weight, height and sitting height measurements recorded, taken by a member of the research team listed. Measures of body weight are taken privately in a separate room or behind a screen, there will always be other children in the room or next to the screen but they will not be party to the results or be able to view the measures and no results are shared with the rest of the children, however, the children will not have to have them taken if they do not want to. All activities will be no harder than the children would do during school PE lessons.

All the activities during the study are aimed to educate and for the children's enjoyment, and not as a competition. With your permission, a video camera will also be used to capture the activities the children are performing; this will allow us to further investigate the reliability and validity of the activities and results.

5. What are the possible disadvantages of taking part?

Taking part in the Dragon Challenge and other physical activities poses no greater risk than a child participating in school physical education lessons or during physical activity in sport, dance or play. However, in the unlikely event that a child feels unwell, there will be people monitoring the children during all parts of the activities, and the children's teachers will remain present at all times. A qualified first aider will always be present during the study sessions.

6. What are the possible benefits of taking part?

The activities will be active and educational for the children and they will get to take part in a variety of different activities that they might not have taken part in before. They will be able to find out a lot about their physical skills.

7. Will my taking part in the study be kept confidential?

All the data we collect from the children will be kept private and confidential; the children's names will be changed to numbers. Any hard copies of data will be kept in a secure office and computer files with any personal information will be password protected. The data obtained will only be looked at by responsible individuals of the research team, or from regulatory authorities where it is relevant to your child's participation in the research. All of the recorded videos will be securely stored and will not be shared publicly, and will be deleted once analysed. Any videos that are not used for analysis will be destroyed.

8. What if I have any questions?

If you have any questions about what is written above or anything to do with the study please don't hesitate to contact me or anyone from the research team (see contact details above). If after the study you are concerned about how any aspect of the research was conducted please contact the Chair of the College Ethics Committee, Professor Mike McNamee (m.j.mcnamee@swansea.ac.uk).



**Applied Sports Technology Exercise and Medicine
Research Centre (A-STEM)**
Sport and Health Portfolio, College of Engineering

HEADTEACHER CONSENT FORM
(Version 1.0, Date: __/__/20__)

Project Title:

The validity and reliability of the Dragon Challenge V1.0 in measuring physical competency in children aged 8-14 years.

Contact Details:



Please INITIAL each box below

1. I confirm that I have read and understood the information sheet dated __/__/20__ (Version number 1.0) for the above study and have had the opportunity to ask questions.
2. I understand that the children’s participation is voluntary and that I am free to withdraw my pupils at any time, without giving any reason, without their medical care or legal rights being affected.
3. I understand that sections of the data obtained may be looked at by responsible individuals from the Swansea University or from regulatory authorities where it is relevant to the children’s taking part in research.
4. I am happy for the activities to be video recorded for academic use ONLY.

I agree to allow the pupils in my school to take part in the above study.

_____ _____ _____
Name of School Date Signature

_____ _____ _____
Name of Headteacher Date Signature

_____ _____ _____
Researcher Date Signature

PARTICIPANT INFORMATION SHEET

(Version 1.0, Date: __/__/20__)

Project Title:

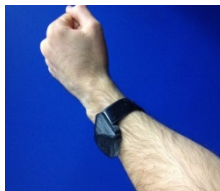
The validity and reliability of the Dragon Challenge V1.0 in measuring physical competency in children aged 8-14 years.

Contact Details:



You have been invited to take part in a Swansea University study. You have been chosen because you are between the ages of 8-14 years old and go to a school in Wales.

In this study you have the chance to take part in the Dragon Challenge, and other similar activities, that look at how well you can perform tasks that are needed in all sports, dance and physical activity. Physical activity is any movement that requires your body to work harder than it does whilst sitting, or resting. The sessions will involve lots of fun physical activities that you may not have tried before which should be really enjoyable. The Dragon Challenge involves running, jumping over hurdles, balancing, core agility/flexibility, ball throwing, ball catching and ball bouncing. These will be done separately as well as done in a circuit and should be really fun. The other activities that you will be asked to take part in will be similar to the ones in the Dragon Challenge.



You will also get asked to wear our BRAND NEW devices, and use the NEWEST technology to measure how fast you move forwards and backwards, side to side and up and down. This will be worn on your wrist and ankle. You will also be video recorded during all of the physical activities. Don't worry this is just to help us see how well you have done and help us see if the

Dragon Challenge needs changing. None of the activities are a competition.

You will not be forced to do any of the activities and can stop at any time without fear of penalty or having to worry about being in trouble.

If you have any questions please ask.

THANK YOU.

PARTICIPANT ASSENT FORM










(Version 1.0, Date: __/__/20__)

Project Title:

The validity and reliability of the Dragon Challenge V1.0 in measuring physical competency in children aged 8-14 years.

Contact Details:



	<i>Please look at the following statements and put your initials if you agree. Example Sarah Jones: SJ</i>	
	I have read the Participant Information Sheet	
	I understand what I will be doing if I take part	
	I have had a chance to think about taking part	
	I have had a chance to ask any questions	
	I agree that my data can be used in a research report and that I will not be named so no-one will know it was my information	
	I understand that all of the information will be kept private and only shared with the research team	
	I am happy to try to do the activities that the research team wants me to do during the study	
	I am happy to be video recorded during the activities in this study	
	I am happy to take part in this study	

Name of Participant

Date

Signature

Researcher

Date

Signature