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

Abstract

Purpose: 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.

Methods: Stature, body mass and grip strength data were collected for 512 participants (n= 230 boys, n= 282 girls) in 2003 during a Crucial CrewDay and for 414 participants (n= 198 boys, n= 216 girls) in 2013 during the Swan-Linx programme. BMIs were calculated from this data and used to calculate BMI standard deviation scores. A two-way ANOVA was conducted to examine if there was a statistically significant difference in BMI z-score by gender and year of testing. A two-way ANCOVA was used to investigate if there were differences on grip strength by gender and year of testing, with BMI z-score as a covariate.

Results: 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).

Conclusion: The study shows promising results in terms of BMI z-scores and prevalence of overweight and obesity. However, the prevalence of overweight and obesity recorded in 2013 is still high, therefore further decreases in prevalence should continue to be an aim. 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.

Keywords: School children; BMI; Childhood obesity; Childhood overweight; Prevalence; Grip strength

Research Article

Volume 3 Issue 5- 2015

Richard Tyler[1]*, Kelly Mackintosh[1], Anthony Palmer[2], Anwen Jones[3], Sinead Brophy[1] and Gareth Stratton[1]

[1]*Swansea University, UK*
[2]*Department of Sports Science, Gower College, UK*
[3]*Cardiff Metropolitan University, UK*

***Corresponding author:** Richard Tyler, Applied Sports Technology Exercise and Medicine (A-STEM) Research Centre, College of Engineering, Swansea University, Bay Campus, Fabian Way, Swansea, United Kingdom; Tel: +4407983629791; Email: r.p.o.tyler.837039@swansea.ac.uk

Received: October 26, 2015 | **Published:** December 29, 2015

Abbreviations: BMI: Body Mass Index; BMI z-scores: Body Mass Index Standard Deviation Scores; SD: Standard Deviation; WIMD: Welsh Index of Multiple Deprivation; ANOVA: Analysis of Variance; DEXA: Dual-Energy X-ray Absorptiometry

Introduction

In school-aged children, physical activity is associated with numerous physiological and psychosocial health benefits [1]. 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 [1].When these levels are attained, physical activity contributes to the prevention of childhood obesity [2] and low physical fitness levels [3].

Children classified as overweight or obese are at risk of developing a number of obesity-related conditions [4], including type 2 diabetes [5], metabolic and cardiovascular complications [6,7] and mental health problems [8]. Globally, the prevalence of overweight and obesity has more than doubled between 1980 and 2014 [9]. The amount 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 [10]. 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 [11-15]. It is well documented that childhood obesity continues into adolescence and adulthood [16]; 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 [17-19]. Levels of physical fitness in children have declined globally, as well as in the United Kingdom, in recent years [20-22]. The majority of studies relating to physical fitness report on cardio respiratory fitness [20-23], 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 [18,21,24-26]. Whilst there are numerous measures of strength, grip strength has been shown to be a good

indicator for total muscular strength [27]. Specifically, studies on grip strength have revealed its direct associations with chronic diseases, multimorbidity and premature mortality [8,18,28,29]. 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 [30], 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.

Materials and 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 [31] and *Sports* Linx project [32]. The Swan-Linx programme has ongoing University ethical approval for its procedures and measures. The programme is a continuation of the *Sports* Linx project which has acceptable test/retest reliability for its field-based testing [33].

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= 230boys, n= 282 girls) in 2003 and 414 participants (n= 198 boys, n= 216 girls) in 2013 were measured.

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 [34]. Body Mass Index (BMI) was calculated using these measures (BMI = body mass (kg) / stature^2 (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.

Design and analysis

Body Mass Index was used to calculate body mass index standard deviation scores (BMI z-scores), standardised for age and gender, using the 1990 British Growth BMI reference standard [35]. 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 gender specific BMI cut-off points [36]. Descriptive statistical analysis, mean and standard deviation (mean ±*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 gender and year of testing. A two-way Analysis of Covariance (ANCOVA) was used to investigate if there were differences on grip strength by gender 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 [37]. 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 gender.

Results

Mean age for participants were 11.33 years and 10.99 years ±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 1.

BMI z-scores

Mean BMI z-scores for boys and girls in 2003 and 2013 are presented in Figure 1. The interaction effect between gender 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 gender 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.

Citation: Tyler R, Mackintosh K, Palmer A, Jones A, Brophy S, et al. (2015) Ten-Year Secular Changes in Selected Health and Fitness Parameters of 10-11 Years Old Swansea School Children – 2003-2013. Adv Obes Weight Manag Control 3(5): 00072. DOI: 10.15406/aowmc.2015.03.00072

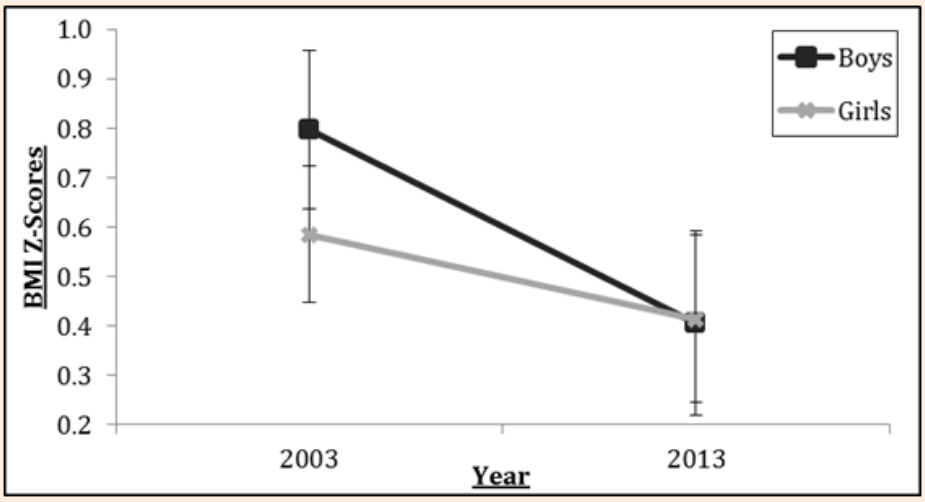

Figure 1: Displays mean BMI z-scores for boys and girls in 2003 and 2013, with 95% confidence intervals.

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 [36], are presented in Table 2. Prevalence of overweight and obesity in participants shows a decrease from 2003 to 2013 for both boys and girls.

Table 1: Mean ±SD Anthropometric measures for boys and girls in 2003 and 2013.

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

Table 2: Proportion of boys and girls in 2003 and 2013 classed as unhealthy weight and percentage difference between 2003 and 2013.

Prevalence of Unhealthy Weight	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	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

Grip strength

Mean grip strength for boys and girls in 2003 and 2013 are presented in Figure 2. 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 gender 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 ($F_{(1,886)} = 0.16$, $p = 0.69$).

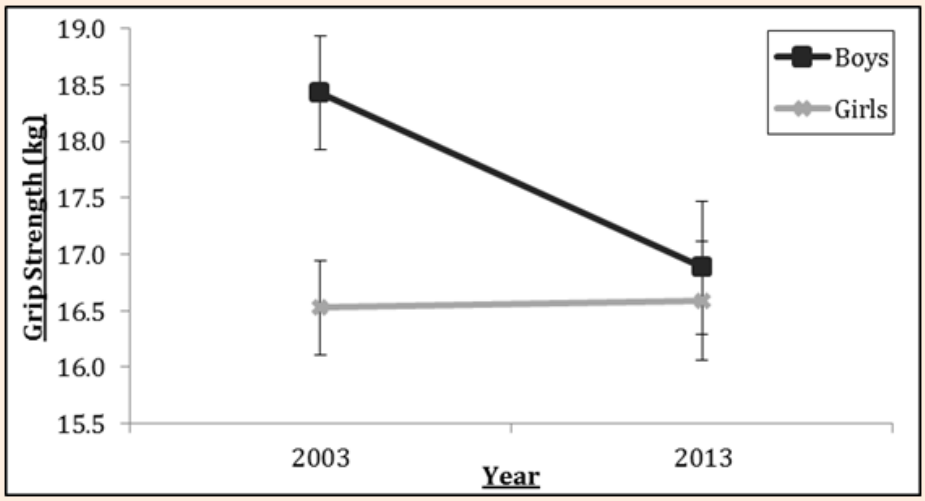

Figure 2: Displays mean Grip Strength for boys and girls in 2003 and 2013, with 95% confidence intervals.

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.

BMI & 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 [11-15]. In contrast with some reports that BMI and prevalence of overweight and obesity is still slowly rising or reaching a plateau [12,13,15], 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 [14] and also the decreases in BMI and prevalence in both boys and girls seen in other European countries [11]. These results show promise for targeting childhood obesity in Wales and may therefore show some optimism for the future. It should be noted, 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.

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 participation, which has been shown to be associated with muscular strength [38].

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 [21], comparing data on 8-10 year olds between 1981 and 2007–2009 and a study on Spanish adolescents [25], 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 [26]. 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 Sports Survey [39], may provide a possible explanation behind this inconsistency in the changes in grip strength between boys and girls. Ara et al. [40], 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 beat greater risk of future health-related illnesses [17-19].

Muscular strength and BMI

Previous studies have shown a relationship between fat-free mass (muscle mass) and grip strength in adults [41,42].

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) [43]. 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.

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 [34], or dual-energy X-ray absorptiometry (DEXA) [44], 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 [45]. 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.

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.

References

1. Davies S, Burns H, Jewell T, McBride M (2011) Start active, stay active: a report on physical activity from the four home countries. Chief Medical Officers 16306: 1-62.
2. Guinhouya BC (2012) Physical activity in the prevention of childhood obesity. Paediatr Perinat Epidemiol 26(5): 438-447.
3. Janssen I, LeBlanc AG (2010) Systematic review of the health benefits of physical activity and fitness in school-aged children and youth. Int J Behav Nutr Phys Act 7: 40.
4. Reilly JJ, Methven E, McDowell ZC, Hacking B, Alexander D, et al. (2003) Health consequences of obesity. Arch Dis Child 88(9): 748-752.
5. Haines L, Wan K, Lynn R, Barrett TG, Shield JP (2007) Rising Incidence of Type 2 Diabetes in Children in the U.K. Diabetes Care 30(5): 1097-1101.
6. L'Allemand-Jander D (2010) Clinical diagnosis of metabolic and cardiovascular risks in overweight children: early development of chronic diseases in the obese child. Int J Obes 34(Suppl 2): S32-S36.
7. Cote AT, Harris KC, Panagiotopoulos C, Sandor GG, Devlin AM (2013) Childhood Obesity and Cardiovascular Dysfunction. J Am Coll Cardiol 62(15): 1309-1319.
8. Griffiths LJ, Parsons TJ, Hill AJ (2010) Self-esteem and quality of life in obese children and adolescents: a systematic review. Int J Pediatr Obes 5(4): 282-304.
9. World Health Organisation (2015) Obesity and overweight. World Health Organization.
10. National Obesity Observatory (2015) UK prevalence: Public Health England Obesity Knowledge and Intelligence team.
11. Olds T, Maher C, ZuminS, Péneau S, Lioret S, et al. (2011) Evidence that the prevalence of childhood overweight is plateauing: data from nine countries. Int J Pediatr Obes 6(5-6): 342-360.
12. Stratton G, Canoy D, Boddy L, Taylor SR, Hackett AF, et al. (2007) Cardiorespiratory fitness and body mass index of 9-11-year-old English children: a serial cross-sectional study from 1998 to 2004. Int J Obes 31(7): 1172-1178.
13. Boddy L, Hackett A, Stratton G (2009) Changes in BMI and prevalence of obesity and overweight in children in Liverpool, 1998-2006. Perspect Public Health 129(3): 127-131.
14. Boddy L, Hackett A, Stratton G (2010) Changes in fitness, body mass index and obesity in 9-10 year olds. J Hum Nutr Diet 23(3): 254-259.
15. van Jaarsveld C, Gulliford M (2015) Childhood obesity trends from primary care electronic health records in England between 1994 and 2013: population-based cohort study. Arch Dis Child 100(3): 214-219.
16. Park M, Falconer C, Viner R, Kinra S (2012) The impact of childhood obesity on morbidity and mortality in adulthood: a systematic review. Obes Rev 13(11): 985-1000.
17. Parfitt G, Pavey T, Rowlands A (2009) Children's physical activity and psychological health: the relevance of intensity. Acta Paediatr 98(6): 1037-1043.
18. Ruiz J, Castro-Pinero J, Artero E, Ortega FB, Sjöström M, et al. (2009) Predictive validity of health-related fitness in youth: a systematic review. Br J Sports Med 43(12): 909-923.
19. McMurray RG, Anderson LB (2010) The influence of exercise on metabolic syndrome in youth: a review. Am J Lifestyle Med 4(2): 176-186.

Citation: Tyler R, Mackintosh K, Palmer A, Jones A, Brophy S, et al. (2015) Ten-Year Secular Changes in Selected Health and Fitness Parameters of 10-11 Years Old Swansea School Children – 2003-2013. Adv Obes Weight Manag Control 3(5): 00072. DOI: 10.15406/aowmc.2015.03.00072

20. Tomkinson GR, Olds TS (2007) Secular changes in pediatric aerobic fitness test performance: the global picture. Med Sport Sci 50: 46-66.

21. Tremblay MS, Shields M, Laviolette M, Craig CL, Janssen I, et al. (2010) Fitness of Canadian children and youth: results from the 2007–2009 Canadian Health Measures Survey. Health Rep 21(1): 7-20.

22. Boddy LM, Fairclough SJ, Atkinson G, Stratton G (2012) Changes in cardiorespiratory fitness in 9-to 10.9-year-old children: SportsLinx 1998-2010. Med Sci Sports Exerc 44(3): 481-486.

23. Ortega FB, Ruiz JR, Castillo MJ, Sjöström M (2008) Physical fitness in childhood and adolescence: a powerful marker of health. Int J Obes 32(1): 1-11.

24. De Miguel-Etayo P, Gracia-Marco L, Ortega F, Intemann T, Foraita R, et al. (2014) Physical fitness reference standards in European children: the IDEFICS study. Int J Obes 38(Suppl 2): S57-S66.

25. Moliner-Urdiales D, Ruiz J, Ortega F, Jiménez-Pavón D, Vicente-Rodriguez G, et al. (2010) Secular trends in health-related physical fitness in Spanish adolescents: The AVENA and HELENA Studies. J Sci Med Sport 13(6): 584-588.

26. Cohen D, Voss C, Taylor M, Delextrat A, Ogunleye AA, et al. (2011) Ten-year secular changes in muscular fitness in English children. Acta Paediatr 100(10): e175-e177.

27. Wind AE, Takken T, Helders PJ, Engelbert RH (2010) Is grip strength a predictor for total muscle strength in healthy children, adolescents, and young adults? Eur J Pediatr 169(3): 281-287.

28. Volaklis K, Halle M, Meisinger C (2015) Muscular strength as a strong predictor of mortality: A narrative review. Eur J Intern Med 26(5): 303-310.

29. Metter E, Talbot L, Schrager M, Conwit R (2002) Skeletal Muscle Strength as a Predictor of All-Cause Mortality in Healthy Men. J Gerontol A Biol Sci Med Sci 57(10): B359-B365.

30. Welsh Government (2014) Welsh Health Survey 2014– Health of Children.

31. Adam C, Klissouras V, Ravazzolo M, Renson R, Tuxworth W (1988) EUROFIT: European test of physical fitness. Council of Europe, Committee for the Development of Sport, Rome, Italy.

32. Taylor S, Hackett A, Stratton G, Lamb L (2004) SportsLinx: Improving the health and fitness of Liverpool's youth. Education and Health 22(1): 11-15.

33. Boddy LM, Stratton G, Hackett AF (2010) The test/re-test reliability of a field-based fitness test battery in 9-10 year old schoolchildren. In: Baquet G & Berthoin S (Eds.), Children and Exercise XXV: The proceedings of the 25th Pediatric Work Physiology Meeting. Routledge, UK, pp. 213-218.

34. Eston R, Reilly T (2009) Kinanthropometry and Exercise Physiology Laboratory Manual: Anthropometry. Vol. 1, (3rd edn), Routledge, Taylor & Francis Group, UK, pp. 5-353.

35. Cole TJ, Freeman JV, Preece MA (1995) Body mass index reference curves for the UK, 1990. Arch Dis Child 73(1): 25-29.

36. Cole TJ, Bellizzi MC, Flegal KM, Dietz WH (2000) Establishing a standard definition for child overweight and obesity worldwide: international survey. BMJ 320(7244): 1240-1243.

37. Milliken LA, Faigenbaum AD, Loud RL, Westcott WL (2008) Correlates of upper and lower body muscular strength in children. J Strength Cond Res 22(4): 1339-1346.

38. Paalanne NP, Korpelainen RI, Taimela SP, Auvinen JP, Tammelin TH, et al. (2009) Muscular fitness in relation to physical activity and television viewing among young adults. Med Sci Sports Exerc 41(11): 1997-2002.

39. Sport Wales–ChwaraeonCymru (2014) School Sports Survey. Research & Policy–Statistics.

40. Ara I, Moreno LA, Leiva MT, Gutin B, Casajús JA (2007) Adiposity, physical activity, and physical fitness among children from Aragon, Spain. Obesity 15(8): 1918-1924.

41. Lebrun CE, van der Schouw Y, de Jong F, Grobbee D, Lamberts S (2006) Fat mass rather than muscle strength is the major determinant of physical function and disability in postmenopausal women younger than 75 years of age. Menopause 13(3): 474-481.

42. Yoon BK, Kim CH, Lim HJ, Kim YS, Im JA, et al. (2009) Association of physical performance and health-related factors among elderly Korean subjects: original research article. ISMJ 10(4): 205-215.

43. Field A, Laird N, Steinberg E, Fallon E, Semega-Janneh M, et al. (2003) Which Metric of Relative Weight Best Captures Body Fatness in Children? Obes Res 11(11): 1345-1352.

44. Lohman TG, Going SB (2006) Body composition assessment for development of an international growth standard for preadolescent and adolescent children. Food Nutr Bull 27(4): 314-325.

45. Dummer TJ, Gibbon MA, Hackett AF, Stratton G, Taylor SR (2005) Is overweight and obesity in 9–10-year-old children in Liverpool related to deprivation and/or electoral ward when based on school attended? Public Health Nutr 8(6): 636-641.

Citation: Tyler R, Mackintosh K, Palmer A, Jones A, Brophy S, et al. (2015) Ten-Year Secular Changes in Selected Health and Fitness Parameters of 10-11 Years Old Swansea School Children – 2003-2013. Adv Obes Weight Manag Control 3(5): 00072. DOI: 10.15406/aowmc.2015.03.00072