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Investigating relationships between body mass index, aerobic fitness, and asthma in pre-pubescent children.

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Abstract

Asthma is one of the main chronic diseases of childhood and there are over 416,000 asthma-related deaths worldwide every year (SIJU, 2016). Without controlling asthma symptoms, respiratory failure can occur and may result in mortality (Nurmagambetov et al., 2018). Asthma and obesity are often found concurrently in children, but it is yet unknown if asthma independently contributes to the increasing childhood obesity epidemic (Chen et al., 2017). The purpose of this thesis was to investigate the potential relationship between body mass index and cardiorespiratory fitness in children with and without asthma in a rural Welsh primary school and secondly, to determine the influence of parental understanding and physical activity levels on these variables.

For this study, primary school children aged 9.6 (±1.1) years were used who were of a mix of healthy, overweight, and obese BMI. The children had a mean height of 142.7cm (±9.2) and mass of 38.7kg (±10.0). Participating in the study were 38 boys and 40 girls. During the testing, variables were tested for including, height, body mass, peak flow, FVC, FEV_1, and multistage fitness test. Parental information was also gathered through a parental questionnaire. All children completed all testing, and the results were grouped according to BMI or asthma diagnosis.

Children with asthma performed worse than non-asthmatics in the multistage fitness test (3.1 ± 1.6 compared to 3.4 ± 1.2, P=0.034)), and these results were also produced with children who had high BMI who also scored low on the multistage fitness which showed low physical fitness in both overweight and obese children as well as those with asthma. Linear regression was carried out to assess whether BMI is predictive of the multistage fitness test scores. There was a statistically significant negative correlation reported between the variables (t=-2.691, P=.009, R= 0.088). Results from the parental questionnaire found parents who reported taking part in regular physical activity also reported regular physical activity for their children (N=58), whilst all parents reported to discourage physical activity participation in those that had children with asthma (N=11).

Declarations

This work has not previously been accepted in substance for any degree and is not being concurrently submitted in candidature for any degree.

Signed............H Lewis...

Date...................30/9/2022...

This thesis is the result of my own investigations, except where otherwise stated. Other sources are acknowledged by footnotes giving explicit references. A bibliography is appended.

Signed....................H Lewis ....

Date.....................30/9/2022...

I hereby give consent for my 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............................30/9/2022..

The University's ethical procedures have been followed and, where appropriate, that ethical approval has been granted.

Signed..................H Lewis..

Date....................30/9/2022..

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Abbreviations

BMI	Body Mass Index
MSFT	Multistage Fitness Test
FEV_1	Forced Expiratory Volume
FVC	Forced Vital Capacity
CHAQ	Childhood health assessment questionnaire
MVPA	Moderate-Vigorous physical activity
QoL	Quality of life
PA	Physical activity
CRF	Cardiorespiratory fitness

1. Introduction

Asthma is the most common chronic lung disease (Di Genova et al., 2018) with 5.4 million people affected by the disease in the UK (Asthma & Lung UK, 2022). It negatively effects the quality of life of many of those that have a diagnosis (Uchmanowicz et al., 2016). It is essential to control asthma symptoms to avoid symptom flare up and respiratory failure which can result in mortality (Nurmagambetov et al., 2018). Symptom flare ups can fluctuate over time, but they include coughing, wheezing and dyspnoea episodes which are caused by periods of airflow restriction (Brusasco, Crimi & Pellegrino, 1998). These symptoms are typically at their peak during early mornings and at night-time and these episodes can trigger bouts of coughing (National Institutes of Health, National Heart, Lung, and Blood Institute, 1991). To help control asthma it is important to take medication as it is prescribed, however it has been reported only 54.5% of children follow medication guidelines (Wilson et al., 2010). An asthmatic symptom flare up can reduce the ability to do normal day to day activities and lead a normal childhood (Al-Gewely et al., 2013). There are more barriers and restrictions on physical activity (PA) for severe asthma sufferers and they have been shown to miss more school days than other children that do not have asthma or those with less severe asthma due to unmanageable symptom flare ups and associated medical treatment (Ferrante & La Grutta, 2018).

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Childhood obesity is considered by the World Health Organisation to be one of the most serious health challenges in the 21st century (WHO, 2020). One in five children in the UK are overweight or obese by the time they start school, and this rises to 1 in 3 by the time they reach secondary school (age 11) (Active, 2011). In a 2018 European review by Hamilton, Dee and Perry suggest that childhood obesity will generate a considerable lifetime direct healthcare and indirect productivity costs up to €126,108 for females and €107,264 for males. The main contributors of childhood obesity have been reported to be poor dietary intake, reduced physical activity, and increased sedentary behaviour (Faienza et al., 2020). Obesity in children is of particular concern as there is an increased risk of them never being 'normal' weight and carrying obesity onto adulthood which leads them to face the somatic, mental, and social consequences of the condition (Lobstein et al., 2004). Geserick et al. (2018) reported that among obese adolescents the most rapid weight gain had happened between the ages of 2 and 6 as most children who were obese at these ages continued to be obese during adolescence and from this it can be assumed that they were likely exposed from an early age to unhealthy lifestyle choices such as large amounts of sedentary time and unhealthy foods (Pearson & Biddle, 2011).

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Asthma and obesity are often found concurrently in children (Chen et al., 2017) and it has been concluded that children with asthma may be at a higher risk of obesity in late childhood and adolescence. Chen et al. (2017) also suggested that being asthmatic along with an unhealthy diet and lack of physical activity contributes to the childhood obesity epidemic. Studies have confirmed that there is an increased risk of children developing asthma and having severe respiratory illnesses when being overweight and obese (Scholtens et al., 2009). Many studies have reported obesity as a risk factor for the increase in asthma incidence (Stenius-Aarniala et al., 2000; Ford et al., 2004). Obesity is known to have a negative impact on normal lung function, regardless of the status of asthma diagnosis (Forno, et al., 2018). These include changes in lung volumes and spirometry parameters, and this link is known to be present in both children and adults, therefore weight control should be considered as a strategy to manage respiratory weaknesses among obese individuals. Having high physical fitness levels in childhood has been found to be associated with a reduced risk of the development of asthma (Rasmussen et al., 2000) but it is unknown if having asthma during childhood decreases levels of physical fitness. It has been reported that physical training can increase cardiorespiratory fitness without changing lung function therefore it’s not clear if it has any effect on asthma and a reduction in symptoms (Ram, Robinson & Black, 2000). A recent study by De Pieri et al. (2021) demonstrated increased cardiorespiratory endurance in children with asthma following altitude training, but body mass index (BMI) was not considered. There are limited studies available showing differences in children with asthma against non-asthmatic children during any physical fitness testing when accounting for differences in BMI.

Physical activity is defined by Caspersen, Powell and Christenson (1985) as any bodily movement produced by skeletal muscles that result in energy expenditure. The energy expenditure can be measured in Kilocalories (Kcal). The same researchers have also defined physical fitness as a set of attributes that are either health or skill related. Singh (2013) also states that physical fitness is a set of attributed that people have or achieve. Being physically fit has also been defined by Singh as the ability to carry out daily tasks with vigor and alertness, without undue fatigue.

The global physical activity recommendations require children and adolescents to engage in at least 60 minutes of daily moderate-to-vigorous physical activity (MVPA) (World Health Organisation, 2020). During the early school years of a child's life (6-8 years) it is important to increase their physical activity levels as this is where their positive physical activity behaviours are established therefore it is important to emphasise this during this stage as it is important for their current and future health (Jago et al., 2005). SECTION REMOVED. Todendi et al. (2021) study shows that there is a need for children to achieve high levels of physical fitness during early childhood to avoid excess weight gain, especially for those with conditions that could result in increased weight gain in all ages. SECTION REMOVED. The full impact of the Covid-19 pandemic on childhood obesity, physical activity levels, cardiorespiratory fitness and asthma prevalence is not yet known. Post-pandemic, findings may differ to these earlier studies as early research has shown increasing incidence of children being overweight and obese, following increased sedentary time and being stuck at home during the lockdown periods. Using the physical activity report card (Marchant, 2019) to assess levels of physical activity in countries can help the countries understand the issues children are facing and what needs doing to improve the lack of physical activity. From the physical activity report card, it is evident that activity levels are low and that there is an increased amount of sedentary time with over 86% of children spending more than 2 hours a day being sedentary (Richards et al., 2022). The report gives evidence that PA decreased during the pandemic and there is great concern for children's health and well-being in Wales following the release of these figures. Whilst the report card is showing a decrease in physical activity levels across the pandemic, this shows that physical fitness levels will have dropped as children have been less active and have spent more time sedentary which could mean an increase in BMI following their new unhealthy behaviour style. SECTION REMOVED.

From the Welsh health survey (Sadler et al., 2012) it was reported that almost 10% of all children, roughly 59,000, have asthma and are being treated for it. Following a report from Iacobucci (2019) deaths from asthma were up 33% in England and Wales between 2008-2018 which raises concerns for the health of the nations. Following the physical activity report card for Wales (Richards et al., 2022) it is clear to see physical activity levels in Wales are poor as overall have been scored an 'F' and reports only 17% of young people completed the recommended 60 minutes of moderate-vigorous physical activity daily. Only 12% of children from less affluent families were reported to complete the recommended amounts of activity which shows the need for research in the more rural, less wealthy areas of Wales. Previous research has shown parents to be unsatisfied with the information they have been provided with about their children's condition (Cosper & Erickson, 1985). Research has shown parents who are uneducated on their child's asthmatic diagnosis and how to correctly manage the diagnosis with treatment, greatly contribute to the deterioration of their child's health. These parents underestimate their child's capabilities to exercise and take part in physical activity potentially reducing their quality of life as they cannot live a 'normal life' (Lal, Kumar & Malhotra, 1995). Children with asthma face several possible barriers to physical activity, these include fear of symptom flare-ups or exercise-induced asthma, having a strong negative self-perception of physical activity, and parental perceptions of negative risks associated with physical exercise and asthma (Leinaar, Alamian, & Wang, 2016). Children with severe asthma and mild asthma can be restricted during exercise as their capacity to exercise can be reduced due to their condition flaring up and causing difficulties breathing. Whilst guidelines suggest children with asthma can and should do physical activity, parents have been shown to have concerns about this. Parents of children with asthma have been found to restrict their children doing any or only allow little amounts of physical activity due to the fear of aggravating their condition (Kim & Ju, 2021).

2. Asthma

2.1 Overview of asthma

Asthma is the most common chronic lung disease of childhood; it cannot be cured and negatively affects the quality of life of many of those diagnosed (SIJU, 2016). Asthma is caused by periods of airflow restrictions which results in coughing, wheezing and dyspnoea episodes. Wheezing has been said to be the most important symptom for the identification of asthma (Douwes & Pearce, 2014). Symptoms of asthma fluctuate over time, but they can be controlled by following appropriate medical care and being properly educated about asthma, it is important to identify the triggers for each individual and subsequently avoiding or reducing exposure to those triggers (Zahran et al., 2018). Without controlling asthma symptoms, respiratory failure can occur which can result in mortality (Nurmagambetov et al., 2018). Vos et al. (2019) reported that worldwide there was 461,000 asthma related deaths in 2019 and over 262 million people were diagnosed with the condition. The predominant cause of airway restriction for those with asthma is chronic inflammation of the airway walls, which is accompanied by plasma extravasation and oedema and influx of inflammatory cells (e.g., Eosinophils, neutrophils, lymphocytes, macrophages, and mast cells) (Lambrecht, Hammad & Fahy, 2019). The combination of genes with extrinsic and intrinsic factors in the pathogenesis of asthma are crucial (Jesenak, Zelieskova & Babusikova, 2017).

2.1.1 Aetiology of asthma

Asthma symptoms are typically at their peak during early morning and at night-time where episodes of wheezing, breathlessness and chest tightness occur which frequently triggers bouts of coughing (National Institutes of Health, National Heart, Lung, and Blood Institute, 1991). Asthma is more prevalent in younger boys and older women and this change occurs during puberty which suggests that hormones released during puberty have a major impact on the aetiology of asthma. The gender differences in young boys are thought to be because of a narrower airway calibre in males at a young age (Sestini et al., 2005). This also leads to reports that asthma may be a group of heterogeneous phenotypes with different aetiologies and prognoses instead of being on single disease as originally reported (Pavord et al., 2018). Dharmage et al. (2019) reports that the epidemic of asthma is still on going and the need for further research into the environmental factors that influence the condition is hugely important in the aetiology of asthma. They report that the epidemic is continuing in low to middle income countries whilst beginning to subside in some high-income countries. There is a need for further research into the mechanisms linking environmental and genetic determinants and suggest that the focus of reducing the health burden should focus on short term and long-term symptoms and outcomes (Szefler, 2018).

To help manage asthma symptoms it is also important to take medication as prescribed to make sure symptoms are under control (Wilson et al., 2010), however, only just over half of children are reported to be following medication guidelines (54.5%). There is a large variation in asthma prevalence, severity, and mortality worldwide with asthma related mortality more likely in low- to middle- income countries (To et al., 2012).
People living in urban areas are at an increased risk of developing asthma (Aligne et al., 2000). It is shown that both indoor and outdoor environmental factors also are some of the major issues that increase the risk of asthma attacks and symptoms (Akinbami, 2012). Erbas et al. (2018) reports that one of the biggest triggers for childhood asthma exacerbations that result in emergency medical attention is ambient grass pollen. It is important to manage this trigger with appropriate medication and care to avoid the need for emergency care, although the link between adults and pollen triggers is lesser reported (Guilbert et al., 2018). Although it has been suggested that if an infant is exposed to environmental exposures (herbicide, pesticides farming environments) during their first year of life, it will play a crucial role in the aetiology of that child developing asthma (Salam et al., 2004). Salam et al. (2004) also states that there is further need for studies to be done on the role of environmental exposure on children during the important developmental phases in life. Asthma clinicians all over the world need a better understanding of the 'local' asthma so they are more equipped to treat and provide the basic asthma care to all (Szefler et al., 2020). This is down to the different asthma triggers which exist in different areas of the world such as high pollution or high pollen. The study by Salam et al. (2004) used parental report of physician diagnosis which has been found to be an accurate method (Burr, 1992). However, many of the exposures they included in the study weren't all reported as common asthma risk factors therefore there could be some bias in the study. The data collection was only completed area with one set of exposures, which doesn't allow for comparison for the asthma triggers.

Diagnosis for asthmatics following NICE (2017) guidance can be run in different ways. The main method using spirometry is offered to adults, young people and children over the age of 5 these patients are then requited to give a FEV1/FVC ration of less than 70% if they are to be diagnosed with asthma as this shows a positive result of obstructive airway disease. They then monitor the peak flow for 2-4 weeks and track the variability and up to 20% variability is used as a positive result and the asthma diagnosis is given.

2.1.2 Prevalence of asthma

There are approximately 334,000,000 people worldwide with asthma (Asher & Pearce, 2014) and it is reported to be the most common chronic disease within paediatric populations (Di Genova et al., 2018). Zahran et al. (2018) reports that the prevalence of asthma attacks decreased between 2001-2010 however there was an increase in asthma action plans being distributed to children which shows the incidence of asthma attacks occurring is being further researched and monitored closely. This may suggest more people are being educated on the matter and can therefore manage their asthma better to help prevent major attacks happening. However, more than half of the patients who had an action plan did not receive advice on environmental control which could help improve the effectiveness of the action plan and reduce the use of emergency health care (Sunshine, Song & Kreiger, 2011). Nurmagambetov et al. (2018) study reports that there is a critical need for the improvement in self-management for asthma and the inclusion of environmental factors in asthma action plans is vital in reducing the severity of asthma flare ups and consequently should reduce hospitalisations and mortality. The effect on the quality of life for asthma patients is incomparable to most other diseases, it reduces the ability to do normal day to do activities and lead a normal childhood as there is a limitation on physical activity for severe asthma sufferers and they have been shown to miss more school days than other children due to unmanageable symptom flare ups and associated medical attention (Ferrante & La Grutta, 2018). A child that is experiencing asthma exacerbations can lose 3-5 days of school per flare up (Sidney & Braman, 2006). Asthma deaths in Wales have been reported to be more common than anywhere else in the UK which is alarming for the small population compared to other nations in the UK (NHS Wales, 2022).

2.1.3 Cost of asthma- economic burden

Childhood asthma is becoming increasingly more prevalent each year with 1.1 million children living with asthma in the UK (Chacko et al., 2020) and the number of children requiring medical attention following asthma attacks is also increasing which shows the (Turner et al., 2018 & Moorman et al., 2012). The annual cost of asthma is also rising because of the emergencies as there is increased need for medication and treatments and in 2013 the cost of asthma on the United States was $81.9 billion and annually per person this equals to $3,266 (Carrier and Cunningham, 2014) and in the UK it is reported to cost £1.1 billion every year with £666 million going on prescriptions alone (Asthma & Lung, 2020). Around 300 million people have asthma across the world and this number is rising and it is predicted that another 100 million people will be affected by 2025 which means the prevalence is increasing at an alarming rate (Network GA, 2018). Almost 1000 people a day die from asthma (Abubakar, Tillmann & Banerjee, 2015) which is a concerning statistics with the alarming prevalence rates increasing rapidly. Asthma is the third leading cause for hospitalisations for children under 15 (American Lung association, 2018). In Wales the prevalence of asthma is one of the highest in the world, there are currently 314,000 people with asthma and 59,000 of them are children, the hospitalisation risk for children more than triples between August and September, this is down to the return to school following the summer break (Asthma UK, 2020) as the children pick up illnesses being back in school which triggers their asthma symptoms.

2.1.4 Quality of life in children with asthma

It has been reported that asthma has a negative effect on quality of life (QoL) in children and that this is exacerbated in those with excessive body weight (van Gent et al., 2007). It is also reported that the QoL in a family is negatively impacted regardless of the severity of the asthma diagnosis of the child (Taminskiene et al., 2019). Everyday life can be limited by the physical ability of the child which can cause emotional consequences and have an economic impact as the child may require more care and attention than other children in the family (Taminskiene et al., 2019). Children with asthma report that asthma impairs their QoL even during asymptomatic days and they then become further impaired when symptoms flare up (Merikallio et al., 2005). The reduced QoL reported in the asymptomatic days is linked to the fear of asthma triggers and not wanting to cause a flare up (Ten Thoren & Petermann, 2000). A key contributor directly affecting asthmatic children's QoL is their frequent cough which can interrupt almost all daily activities (Petsios et al., 2009). Children that face a reduced QoL are reported to have poorer control and severity of asthma (Fontan et al., 2020). The seasons have been shown to have a significant effect on the QoL of asthmatics as the change in seasons can trigger changes in asthmatic symptoms and therefore reduce their ability to go about their daily lives as normal (Garcia-Marcos et al., 2007). For maximal QoL, it is recommended that the children and caregivers have strong management of the children's asthma to avoid asthma flare ups as much as possible (Ibrahim et al., 2019).

2.1.5 Parental knowledge and understanding

Jago et al. (2017) concluded that future asthma control programmes should work closely with schools and increase parental knowledge to help provide children with practical support to help them be more physically active as part of the UK's efforts to extend provision. Maternal education results in greater health benefits for the next generation as they are more likely to understand their child's symptoms or conditions better and offer the child better support regarding physically, mentally and financially (Desai & Alva, 1998). It has been shown that mothers make bigger investments into their child's health compared to the child's father (Case & Paxson, 2001). Harknett (2009) reported that the children of unmarried parents are more likely to have poor well-being and health although an unhealthy marriage can also cause other issues for the child therefore it is essential to make sure the children's health is considered too as the children living permanently with fathers are less likely to attend regular health care appointments and this does not improve if step-mothers are also introduced (Case & Paxon, 2001)

Parent's perception of what a child with asthma can do greatly contributes to the child's health, with those underestimating their child's ability reinforcing a lack of physical activity leading to health deterioration, and a reduced ability to live a 'normal life' (Lal, Kumar & Malhotra, 1995). Cosper & Erickson, (1985) report that parents are unsatisfied with the information they get from their child's physician and therefore this could be one of the reasons for the lack of understanding, although this study was conducted in 1985 and is therefore dated. There is a need for new research in this area as the technology and research conducted around children and asthma has improved and therefore it is expected parents now receive better information and develop a clearer understanding around their child's condition. More recently, Morawska, Gregory and Burgess, (2012) reported that parents were confident in their abilities to help their child manage their asthma, but many parents reported that medication and taking it as prescribed raised challenges for them. Some parents had a perception medication increased their child's hyperactivity, disobedience, and disruptiveness and in some instances, parents reported their children refused the medication which therefore put more pressure on the parents to manage their asthma. Parents reported each day was unique and needed thorough planning to avoid triggering symptoms and they needed to ensure that the medication was always on hands. This presents a challenge particularly during school times and parents reported finding a good management regimen required lots of effort and they found it very demanding (Morawska, Gregory & Burgess, 2012). Parents reported both forgetting to administer the medication and their child refusing the medication which has also been corroborated by other studies (Burgess et al., 2008; Morawska et al., 2008) presenting a concern.

2.2 Obesity

2.2.1 Overview of obesity

Childhood obesity prevalence worldwide has increased dramatically over the last three decades but there is limited evidence of any strategies curtail this increase being successful (Lloyd et al., 2018). Childhood obesity is considered by the World Health Organisation to be one of the most serious health challenges in the 21st century (WHO, 2020). Schools play a vital role in creating a supportive environment for both social and physical determinants, but if they fail to address the consistency needed within the home for these children, they are unlikely to continue the supported and will not change their behaviours (Maggi et al., 2010). Lloyd et al. (2018) reported that the whole system approach to childhood obesity prevention is theoretically appealing but there is limited application and evidence for the effectiveness, and this could be down to the need for rigorous research into this area. Across the life course, physical activity and well-being are beneficial to health (Physical Activity Guidelines Advisory Committee, 2008). In the UK's obesity action plan in 2016 and the 'chapter 2' instalment (Finch et al., 2016) suggested that half of the recommended minutes (60 minutes of daily moderate to vigorous physical activity) were to be delivered by schools. From the recent physical activity report card, we can see that this isn't being met by over 80% of children outside of school but during school times the score was '-B' which shows schools aren't delivering the correct amount of physical activity. Physical activity and associated energy expenditure is an accepted determinant of adiposity (Pagnini et al., 2007). The World Health Organisation ranks increased body weight as the third biggest health risk in high income countries as it is the cause of 8.4% of deaths and 6.5 % of disability adjusted life years (Cole & Lobstein, 2012). In a 2018 review by Hamilton, Dee, and Perry suggest that childhood obesity will generate a considerable lifetime direct healthcare and indirect productivity costs. If a child is obese then they are more likely to become obese adults as the treatment and recovery for obesity takes too long and the treatment is often failed (Bülbül, 2020). Following Centre for disease control and prevention charts for BMI for both boys and girls, BMI was classified using age and BMI (Appendix D & E). Classification was made using age therefore different for the 5 ages used in this study (7-11). Children over the 75th percentile were classified as overweight and those over the 95th percentile were classified as obese.

2.2.2 Childhood obesity

2.2.2.1 Causes of childhood obesity

According to Davison et al. (2001) the main contributors to childhood obesity include poor dietary intake, decreased physical activity, and increased sedentary behaviour although this review was done prior to many technological developments which have led to changing lifestyles therefore there may be utility in a fresh review to find the most recent contributors to childhood obesity as it is possible they have changed (Faienza et al., 2020). If all children reached the world health organisation recommendation of 60 minutes of daily moderate-vigorous physical activity then there would be a reduction in the prevalence of children becoming overweight (72%) or obese (Pearce et al., 2019). One in five children in the UK are overweight or obese by the time they start school, rising by the age of 11 to one in three children (Active, 2011) and this is evident across the globe with similarly high rates in the majority high income countries (Timmons et al., 2012). Being sedentary for more than 5 hours day has been reported to have the highest prevalence of obesity whereas lower amounts were less obvious indicative of a dose response (Biddle, Bengoechea & Wiesner, 2017). Pearson and Biddle (2011) reported that eating in front of the TV may trigger greater snacking and consumption of unhealthy foods due to the increased advertisement the children would be exposed to from watching more TV than other children. Therefore, the less time a child is watching TV the less time they are likely to learn these unhealthy behaviours, although since 2011 there are many different forms of screentime which has taken over the TV exposure time. Childhood obesity that lasts through to adulthood is often manifested during the ages of 3 and 8 years of age as height growth begins to slow (Wang & Lobstein, 2006) so it is important to make sure behaviours learned during these years have a positive impact on the child's health. Geserick et al. (2018) reported that among obese adolescents (15-18 years old) the most rapid weight gain had happened between the ages of 2 and 6 as most children who were obese at these ages continued to be obese during adolescence and this suggests that they were likely exposed from an early age to unhealthy lifestyle choices such as large amounts of sedentary time and unhealthy foods. The early development of obesity is linked to complications such as metabolic and cardiovascular disorders which can manifest even in childhood (Körner et al., 2007)

2.2.2.2 Effects of COVID-19 on obesity

The COVID-19 pandemic has impacted on the eating habits, physical activity and other weight-related lifestyle behaviours and people with obesity have been greatly affected (Teixeira et al., 2021). Robinson et al. (2020) reported that 56% of people were snacking more frequently and were experiencing more barriers to weight management such as increased sedentary time and decreased motivation as well as having poor control around food compared to before the pandemic started and these negative behaviours were reported from those with high BMI levels. The impact that the pandemic had on weight related behaviours is not yet fully understood but it is suggested to be substantial as the levels of obesity for all adults and children has increased during the pandemic (Pearl, 2020). During the pandemic there was limited availability to fresh foods and one of the reasons for this was people 'panic buying' therefore people have had to rely on unhealthy foods with longer shelf lives to ensure they had food to last them longer (Tan, He &MacGregor, 2020) which has meant that some families relied on processed and unhealthy foods which would increase their fat intake and unhealthy eating habits. People began reporting negative effects of the lockdown just three weeks in, where they reported increased consumption of unhealthy 'junk' food and less time exercising due to the perceived increased infection risk if they exercised outside (Pietrobelli et al., 2020) and as gyms and sports clubs had to close, a lot of people didn't have access to any equipment or training so felt they didn't know what they were doing. Early pandemic-related research by Robinson et al. (2020) reported that there was a 40% decline in people exercising during lockdown although 45% of people reported to be exercising more frequently. Parents have reported to allow their children more sedentary time as it benefits them more as they have more free time to go about daily chores and working from home easier and found it easier to 'get things done' which increased greatly on children's sedentary time (Hesketh, Lakshman & van Sluijs, 2017). Another reason for the increased sedentary time during the pandemic was the 'home school' aspect which meant children were sat more during their time at home having to do schoolwork (Zhao et al., 2020). Parents have also acknowledged that the media was a major barrier to children's physical activity (Bentley, Turner & Jago, 2016) and previous research pre-pandemic has shown children should not be exposed to a lot of television and media (Christakis et al., 2004).

2.2.2.3 Risks associated with childhood obesity

Childhood obesity is a disease with high-risk consequences that are frequently compounded due to its multisystem nature (Must & Strauss, 1999). Some of the diseases that childhood obesity increases the prevalence of, include hypertension, chronic inflammation, increased blood clotting tendency, endothelial dysfunction, and hyperinsulinemia (Freedman et al., 1999). The risk of childhood obesity is related to the complex interaction between the child, family, school, and societal levels (Lloyd et al., 2018) which means everyone involved in child's life should help ensure they are leading healthy lifestyles. Higher levels of physical activity are related to better social and motor development, improved metabolic health and decreased adiposity, (Timmons et al., 2012). Developing many of these skills would help the child in many important development stages of their life. Having high sedentary levels is associated with higher adiposity and poor psychosocial health and decreased cognitive development (Barnes et al., 2012). Childhood obesity is linked to poor mental wellbeing, premature onset of chronic illness and shortened life expectancy and those children living in poorer socio-economic circumstances are at an increased risk of becoming overweight than their more advantages peers (Bornstein et al., 2011). Increased sedentary behaviour is linked to poor cognitive performance and a worse academic performance in children (Borzekowski & Robinson, 2005). Körner et al. (2007) also reported that the complications associated with early obesity are also linked to increased risk of early death in adulthood, ensuring the child has behaviour changes will help decrease the likelihood of carrying the obesity onto adulthood. Childhood obesity is associated with causal relationships with hypertension, dyslipidaemia, and high results for cardio metabolic risks. Sommer and Twig (2018) reported that subclinical atherosclerosis, type 2 diabetes, and insulin resistance are results of childhood obesity. Obesity in children is becoming more worrisome as there is an increased risk of them never becoming normal weight and carrying obesity onto adulthood and this leads them to face the somatic, mental, and social consequences of the condition (Lobstein et al., 2004). Quek et al. (2017) conducted a meta-analysis which concludes that children are more likely to suffer from depressive symptoms and depression if they are obese and girls are at an increased risk compared to boys to suffer from these conditions. Obese children have been stereotyped as unhealthy, academically unsuccessful, socially inept, unhygienic, and lazy and some healthcare providers with expertise in obesity treatment have been shown to share these negative stereotypes (Hill & Silver, 1995; Teachman & Brownell, 2001).

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2.2.2.4 Asthma and obesity in children

Asthma and obesity are often found concurrently in children, but it is yet unknown if asthma alone contributes to the increasing childhood obesity epidemic (Chen et al., 2017). The pathophysiology of both conditions suggests they could have a strong link (Delgado, Barranco & Quirce, 2008). Studies have confirmed that there is an increased risk of children developing asthma and having severe respiratory illnesses when being overweight and obese (Scholtens et al., 2009). There are many studies investigating whether children with asthma are at increased risk of obesity, but with mixed conclusions on this (Ford et al., 2004; Lang et al., 2018). Ho et al. (2013) states that excess caloric intake and lack of physical activity occur because of asthma symptoms, suggesting that asthma is a contributor to obesity, but this is not the case for all severities of asthma. Chen et al. (2017) states that if a child has access to early intervention to help improve their asthma symptoms it will help reduce the severity of the asthma and allow for increased physical activity levels and avoid worsening obesity in the future which is likely to then increase the risk for many metabolic diseases such as diabetes. A systematic review by Noal et al. (2011) reports that there is strong evidence that obesity precedes and has a link to the intensity of asthma symptoms. Children that are overweight or obese also have an increased risk and prevalence to acute respiratory tract infections than those with normal weight (Jedrychowski et al., 1998). Lang et al. (2018) concluded that obesity is a major preventable risk factor for paediatric asthma, whilst Chen et al. (2017) conclude that asthma rescue medication is linked to reduction of obesity risk even when accounting for adjustments in physical activity levels**.** Several studies have shown children with obesity are at an increased risk of having more severe respiratory symptoms and an increased risk of asthma (Gilland et al., 2003; Scholtens et al., 2009). Many studies have reported obesity as a risk factor for the increase in asthma incidence, but it remains unclear if asthma is an increased risk factor for obesity (Stenius-Aarniala et al., 2000). Chen et al. (2017) also reports that children with obesity have an increased risk of developing asthma, but this result comes from children who also had other known diagnoses which could also lead to an increased risk for obesity. Obesity is known to be detrimental to normal lung function (Forno et al., 2018), no matter the status of an asthma diagnosis, including changes in lung volumes and spirometry parameters, and this link is known to be present in all age groups, therefore weight control should be considered as a way of managing respiratory weaknesses among obese individuals. There is growing evidence of a 'obese asthma' phenotype which includes high body weight affecting and modifying asthma characteristics (Wood, 2015). SECTION REMOVED

2.3 Physical Fitness and Physical Activity

2.3.1 Recommended physical activity guidelines for children

The global physical activity recommendations require children and adolescents to engage in at least 60 minutes of daily moderate-to-vigorous physical activity (MVPA) (World Health Organisation, 2020). School aged children in both developed and developing countries are reported to not be sufficiently active for achieving the recommended levels for MVPA to gain the optimal health benefits (Khan, Burton, & Trost, 2017). It has been reported that 80% of adolescents are not achieving the guidelines (Hallal et al., 2012), and that children living in urban areas particularly have low levels of MVPA and high levels of sedentary behaviours (Zhu et al., 2017). During the early school years of a child's life (6-8 years) it is important to increase their physical activity levels as this is where their positive physical activity behaviours are established therefore it is important to emphasise this during this stage as it is important for their current and future health (Jago et al., 2005). Low participation in physical activity is known to increase the risk of many non-communicable diseases and has been recognised as a major contributor to many diagnoses of ill health around the world (Lee et al., 2012).

Physical fitness is divided into two categories: skill-related and health-related. This includes components of health-related fitness such as flexibility, muscular strength, muscular endurance, body composition, and cardiorespiratory fitness (Chen et al., 2022). Carson et al. (2017) reported that following the physical activity guidelines will overall improve physical fitness in children. Fitness level classification will be determined by Tomkinson et al. (2018) published normative values for physical activity.

2.3.2 Asthma and physical fitness

A systematic review concluded that children with asthma take part in less physical activity than children without asthma and these differences may be more likely in girls than boys (Wanrooij et al., 2014). Children who have low levels of physical activity are at a 35% increased risk of developing new-onset asthma and/or wheezing (Lochte et al., 2016). Crosbie (2012) reported from their systematic review that there is evidence that physical activity interventions can improve peak flow, reduce exercise-induced asthma, and improve physical activity and quality of life in children with asthma. The current National Institute for Health and Care Excellence (NICE, 2013) recommends children with asthma follow the same recommendations for physical activity as the public health guidelines of 60 minutes per day of MVPA but add a focus on managing their asthma well whilst being active. There is a need for a UK-specific programme to help children with asthma be more physically active as those with asthma might struggle to complete the 60 minutes recommended due to their condition. Jago et al. (2017) reported that for many children with asthma, physical activity is a challenge and there is a need for a more consistent approach to help them be active as it desirable for most children with asthma with few minor exceptions. Eijkemans et al. (2012) conducted a systematic review and meta- analysis that shows physical activity may reduce the risk of developing asthma and they also reported that in a cross-sectional study that had high levels of physical activity there was a lower asthma prevalence reported. It is reported that there is anecdotal information that suggests children with asthma are not as aerobically fit as those without asthma (Welsh, Roberts & Kemp, 2004). Physical fitness guidelines will follow those used in the WALES 2021 Active Healthy Kids (AHK) Report Card as participants in the recent and current study are from similar areas and therefore a direct comparison can be made.

2.3.3 Obesity and physical fitness

Regular physical activity is associated with a lower body mass, normal blood pressure readings, decreased body fat and improved mental well-being among children (Raitakari et al., 1997). Deforche et al. (2003) reported that combining physical activity with psychological and dietary support is an effective way of decreasing body fat and improving overall physical performance. This was reinforced by Lee et al. (2010) who suggest that short-term exercise programmes are a good way to decrease BMI, blood pressure, waist circumference and improve physical fitness. Todendi et al. (2021) showed that there is a need for children to achieve high levels of physical fitness during early childhood to avoid excess weight gain, especially for those with conditions that could result in increased weight gain in all ages. High levels of BMI are associated with declines in physical fitness no matter the age and children that are obese are reported to be the least fit out of all children (Dumith et al., 2010). It has been concluded that if children are properly encouraged with the correct motivations, then they are likely to perform well in exercise testing no matter what their BMI (Fanti-Oren et al., 2020). It has been reported that the treatment of obesity in children is difficult therefore the best way to avoid treatment is through prevention (Bülbül, 2020). One specific prevention recommendation is the 5-2-1-0 rule, where the participant eats 5 or more fruit or vegetables a day, watches tv or is sedentary for 2 hours a day, participates in physical activity for at least an hour a day and consumes 0 fizzy drinks (Whelan et al., 2020). Rogers et al. (2013) show that this rule can be effective if the program is implemented at a community level with all these linked to the children following the rule ensuring there is multi-setting support for the prevention of obesity. Even though recommendations for physical activity are the same for all children there is a difference in rural-urban children's prevalence of obesity according to Joens-Matre et al. (2008) as they are exposed to more unhealthy behaviour patterns. The WALES 2021 Active Healthy Kids (AHK) Report Card shows that <20% of 5- to 17-year-olds do not do more than two hours of recreational screen time per day. This guideline is set by the Canadian society for Exercise Physiology (2018) and this guideline will be used to determine sedentary behaviour in the current study.

Being physically active is important at all stages of life and active play during childhood is important regarding physical, mental and social aspects of development and growth (Hills, Okley & Baur, 2010), building this physical activity habit at a young age can help set a positive attitude towards sports through into adulthood (Huang, Sallis & Patrick, 2009). The normal daily environmental factors which contributed to physical activity such as active transport and changes in playground facilities (Nielson et al., 2012) have hugely contributed to the decrease in physical activity and the increase in the childhood obesity epidemic (Biddle, Gorley & Stensel, 2004). It has been concluded that physical inactivity in children is an important factor that adds to childhood obesity, to overcome this then increased self-efficacy regarding exercise, awareness of the condition and activity, access to facilities and guidance, and increase parental modelling of physical activity (Trost et al., 2001) Day length and weather conditions play a huge role in the participation barriers for physical activity, but it is unclear how to overcome this barrier as it is out of the participant controls (Harrison et al., 2017). Activity levels are generally reported to be lower in the winter when the days are short, and weather is generally wet and cold (Chan & Ryan, 2009). Children in Melbourne, Austrailia and Northern Europe are reported to have higher activity levels due to weather conditions being improved, drier and warmer, compared to those in Western Europe and USA which are wetter and colder (Rappaport, 2009).

2.3.4 Parental influences on physical activity participation

Children with mothers who are obese are at an increased risk of obesity, although the age they developed obesity was not different from those children who had mothers of normal weight (Geserick, 2018). If a mother becomes obese during pregnancy this increases the likelihood of the child being born at a heavier weight which can result in increased BMI from birth increases the chance of becoming obese during early childhood (Donkor et al., 2017). Children with asthma face several possible barriers to physical activity, these include fear of symptom flare-ups or exercise-induced asthma, having a strong negative self-perception of physical activity, and parental perceptions of negative risks associated with physical exercise and asthma (Leinaar, Alamian, & Wang, 2016). A prediction of perceived barriers that adults face includes things like level of education, self-perception of health, socioeconomic level, and marital status (Herazo-Beltran et al., 2017). Level of parental education could have an influence on the amount of physical activity their child participates in due to the understanding of health and exercise and their knowledge about different sporting activities their child could be part of, as if they weren't encouraged to participate during their childhood, they are unlikely to be participating as adults.

Physical activity is beneficial for a wide range of health-related aspects such as physical, psychological, and cognitive (Sullivan & Lachman, 2017). The adult recommendation for physical activity is 150 minutes of aerobic activity and 2 days of muscle strengthening activities each week (Centres for Disease Control and Prevention, 2014). Sigmund, Sigmundová, and Badura (2020) concluded that parental participation in PA linked with family-related PA can be a natural way of reducing the risk of obesity developing in their offspring.

3. Aims and Objectives

The primary aim of this study was to investigate the potential relationship between anthropometric parameters and cardiorespiratory fitness in primary school children with and without asthma in a rural Welsh primary school. A secondary aim was to determine the influence of parental understanding and physical activity levels on these factors. The objectives will investigate whether parental knowledge of asthma and their involvement in physical activity has a link with children's participation, BMI, or cardiorespiratory fitness.

It can be hypothesised that from this study there will be an interaction between asthma and obesity on cardiorespiratory fitness results which can be estimated using the multistage fitness test. It can also be hypothesised that parents have a negative influence on physical activity levels on children with asthma.

4. Methods

4.1 Participants

78 children and 53 of their parents or guardians volunteered for the study. All participants were children at a local primary school in a rural town in South Wales. In the school there were 29.5% of children eligible for free school meals which is above the national average and each child had one corresponding parent or guardian who completed the parental questionnaire. All parents gave informed consent for their own and their child's participation in the study and each child gave assent to the testing taking place. The headteacher was the first point of contact between the researcher and the school and gave consent for the school to participate and for parents to be invited. Ethical approval was given by the Ethics committee at the College of Engineering and Sport science, Swansea University (HL_05-01-21). None of the children were reported to have any known conditions or risk factors that would interfere with the testing which was confirmed on the childhood health assessment questionnaire (CHAQ) (appendix B) which was completed by their parents prior to any testing taking place.

TABLE MOVED

4.2 Study Design

The children's testing was conducted onsite at the school and was done over a consecutive 3-day period as data collection for each class in the school was done during different sessions to avoid any increase in the transmission of COVID-19, therefore each class was kept in their class 'bubbles'. Each class session followed the same format, height, and body mass was measured before bioelectrical impedance analysis was carried out. Spirometry was then completed before the children were instructed on how to do multistage fitness test and then completed it. Children were encouraged to ask any questions they had during the testing. One parent/guardian for each child participating was invited to complete a questionnaire. The study was a cross-sectional study design, and each participant was tested for each variable within a 1-hour time slot. On the testing days 3 groups of children were tested per day and there were 9 groups in total over the 3 testing days. All parental questionnaires were returned before the testing commenced and once all data was collected the questionnaires were analysed alongside the data collected from the children at the school.

4.3 Testing Procedures

4.3.1 Procedures for Children

4.3.1.1 Anthropometric data

Height and body mass were measured using standardised anthropometric techniques (Lohman et al., 1988). Height was measured using a stadiometer (Seca 123, Germany) and the head piece was moved to the top of the participants head whilst positioned in the Frankfort plane and a reading taken to the nearest 0.1cm. Mass was measured using scales (Seca) which each participant stood on to give measurements to the nearest 0.1kg. The age of the participant was taken prior to testing from the parental questionnaire and each parent completed a CHAQ to assess overall health of the children before testing began. Height and body mass were measured without shoes and in minimal clothing. These measures were taken by researchers and therefore only once was the data recorded.

From the height and mass values, the body mass index (BMI) of each participant was calculated using age and sex specific percentiles for each child (BMI= kg/(cm^2)) (Monasta et al., 2011). BMI was used to categorise normal and obese participants, although it is not a direct measure of body fat which can be affected by muscle mass, it is the most utilised method of categorising and reporting BMI as it uses sex and age and can be easily calculated without additional equipment.

SECTIONS REMOVED.

4.3.1.2 Respiratory lung function assessment/peak flow

Open circuit spirometry (Care Fusion Micro I, Wales) was carried out following the Miller et al. (2005) standardized procedure for the forced vital capacity (FVC) manoeuvre. The spirometry test includes tests for forced vital capacity (FVC), forced expiratory volume (FEV1) and peak flow. The participants were demonstrated the procedure by the researcher whilst wearing a nose clip. They were then required to inhale maximally and then exhale into the spirometer until no more air could be expelled whilst remaining in an upright position. These measures assess the lungs' ability to move large volumes of air quickly and can identify any airway obstructions. The procedure was firstly demonstrated to the participants by the researcher. Each participant had their own disposable tube for the spirometry. This assessment was performed 3 times and an average was taken from each participant. This was for familiarisation as majority of the group had not performed this test before.

4.3.1.3 Multistage fitness test

Approximately 15 children completed the multistage fitness test at one time and a researcher ran with the children to set the pace for them as most of the children had not completed one before and to avoid the children working too hard at the beginning (Jenny & Armstrong, 2013). The multistage fitness test was chosen as it was a method that could be used safely and time effectively during the COVID-19 period. Discussion between the school, researchers and ethics approval ensured safety and reduced risk of COVID-19 transmission. The multistage fitness test (MSFT) sometimes referred to as the beep test, is a 20m shuttle run and is often used to help predict an athlete's estimated aerobic capacity (VO_2 max). The test was conducted outside on a level grass playing field and the participants had to run back and forth to the marked out 20m parallel lines in time with the beep that gradually got faster. The participants were required to stop the test when they failed to reach the line in time with two consecutive beeps, this was monitored by spotters who gave the first warning then removed the children from the test. Level 1 of the test begins at 8.5kph and there is an increase of 0.5kph (Cooper et al., 2005) at every level increase and the children were verbally encouraged to work maximally during the test and encouraged each other once they were removed from the test. This test was only carried out once on each participant as this test worked participants to exhaustion and as we had a short testing period, we were unable to complete the test more than once. It is recognized that this testing method only shows a estimate for cardiorespiratory fitness (Armstrong and Welsman, 2019) and does not give accurate values but given the COVID-19 restrictions and guidelines, the testing method was used for safety of participants and researchers.

4.3.2 Procedures for Parental Participants

4.3.2.1 Questionnaire- See Appendix A

Parents or guardians of children participating in the study were invited to participate themselves and to give their consent for their child to participate, parents who gave consent were each sent a questionnaire to complete. The questionnaire asked the parents/guardians about their own and their child's health, including physical activity levels and asthma diagnosis and included questions about their understanding about the condition as well as their experiences including childhood and adulthood asthma influences. Parents were the sole information providers, and this was the only information provided to give information on children's health. As asthma status was reported by parents you can assume there was a formal diagnosis given using NICE (2017) guidelines. No parents reported severe asthma within the children as there was nobody impacted by the study following the questionnaire.

The questionnaire questions were written following further readings linked to the Physical activity questionnaire for older children (Kowalski et al., 2004) and questions were also added linked to information needed to be gathered from parents which was needed to help analyse against the children's data.

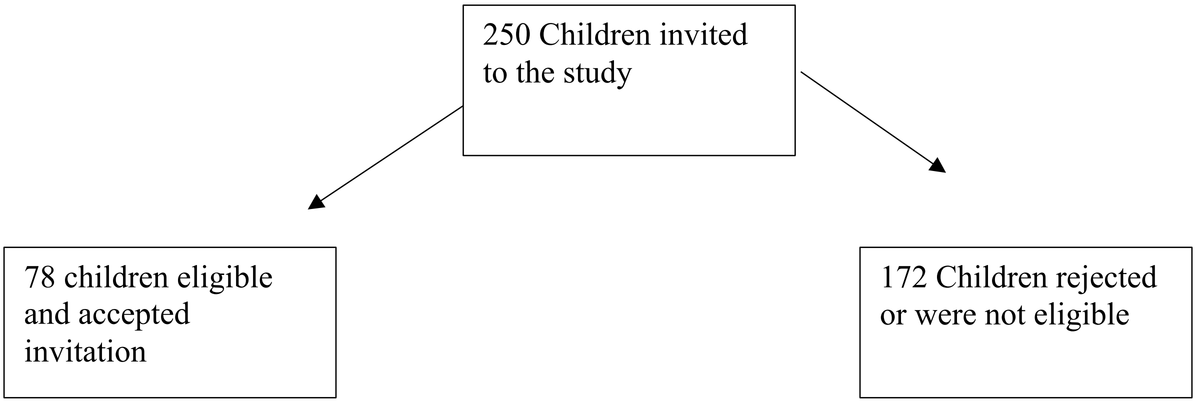

Figure 1- Flow chart of the number of children that were invited compared to those that were eligible

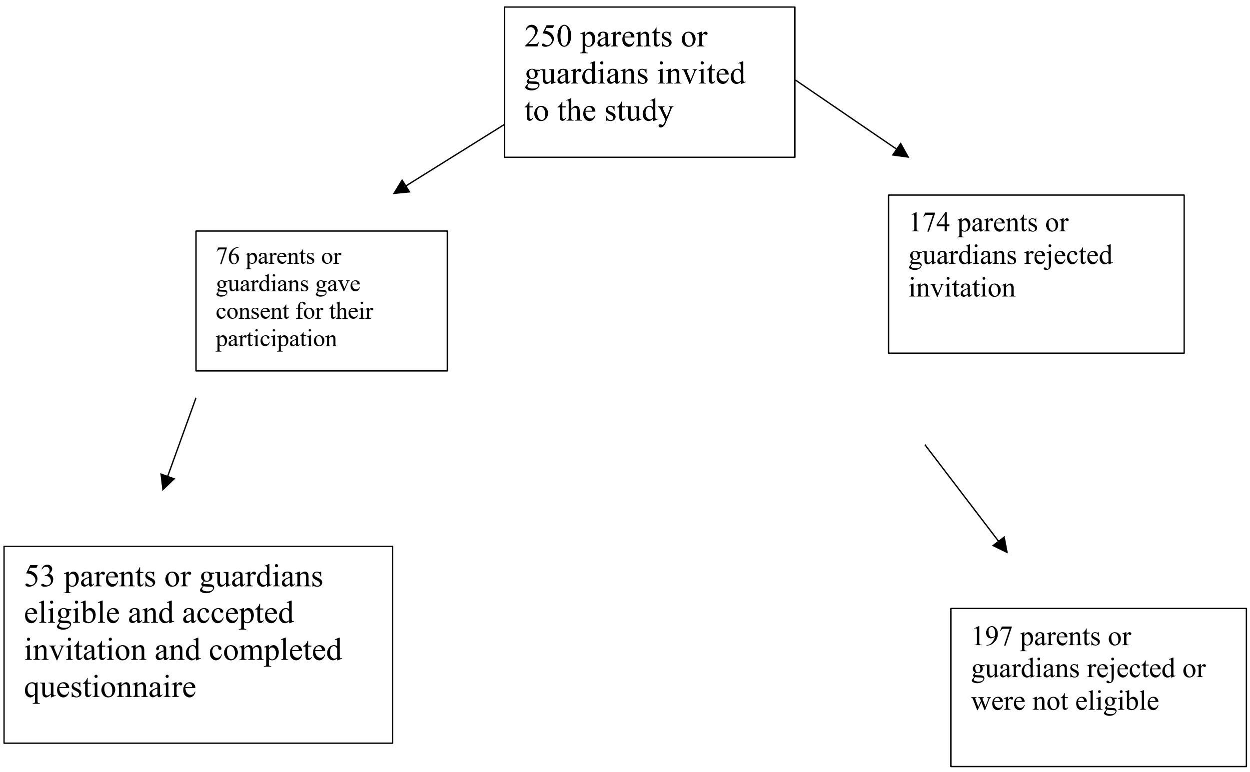

Figure 2- Flow chart of the number of parents or guardians that were invited compared to those that were eligible after the questionnaires were analysed

4.4 Data Analysis

Data was analysed using statistical package for social sciences (SPSS Inc., Chicago, IL, USA) and $P<0.05$ was used for statistical significance. Data was analysed to check for normality of the distribution within the data using the Shapiro-Wilk analysis. Linear regression was carried out to find any relationships between body mass index and, peak flow, FVC, FEV_1. Independent t-tests were carried out comparing those with asthma to non-asthmatic individuals for variables which were normally distributed (peak flow,FEV1, height). For data, which was not normally distributed, Mann-Whitney test was run on the variables (age, gender, weight, BMI, FVC, MSFT). Post-hoc analysis was run on healthy BMI children against those that were overweight and obese. Linear regression was then run again to test whether BMI was a predictive of the multistage fitness test and then run on the parental data to find out if parental BMI was predictive of the children's BMI. Independent t test was run on children that did regular physical activity t test against the variables such as peak flow, FVC, FEV_1 and multistage fitness test shuttles. Finally, a Kryskal-Wallice test was run for hours of physical activity weekly against hours sedentary daily.

5. Results

The primary aim of the study was to investigate the relationships between different variables and cardiorespiratory fitness in primary school aged children with and without asthma. The secondary aim was to get a clear understanding on the influence parents have on children's physical activity levels and their understanding on their children's health. Results show interaction between variables and appropriate analysis has been run to report interactions between groups.

5.1 Children's data

Table one shows the descriptive statistics used to perform analysis on the children's data. This data was also used to calculate BMI and then transferred into SPSS for analysis. Eight of the children who participated in the study (N = 77) were asthmatic. No differences were found in any of the test variables between the two groups (Table 2).

Table 1- Descriptive statistics for the anthropometric data (mean ± standard deviation) showing the differences between male and female children.

Children	**All**		**Female**		**Male**	
Participants	78		40		38	
	Mean	SD	Mean	SD	Mean	SD
Age (Years)	9.6	1.1	9.7	1.1	9.6	1.2
Asthmatics (N)	8		2		6	
Height (cm)	142.7	9.1	140.9	8.8	144.6	9.2
Mass (kg)	38.8	10.9	32.9	5	45.2	11.8

Table 2- Descriptive statistics for the children's variables (mean ± standard deviation) including a *t* statistic or Z value to identify any significant between asthmatics and non-asthmatics as collectives.

	Asthmatic (N=8)	**Non-asthmatic (N=69)**	**Condition Difference**	
	Mean (±SD)	Mean (±SD)	*t* statistic/ Z value**	P Value
Age (years)	9.6 ±1.3	9.6 ±1.1	<.001**	1
Height (cm)	147.6 ±11.8	142.1 ±8.7	1.610	.096
Mass (kg)	46.3 ±19.1	37.9 ±9.4	-1.523**	.243
Peak Flow (L/min)	205.3 ±49.1	193.8 ±65.0	.482	.399
FVC (L)	2.0 ±.6	1.9 ±.7	-.036**	.720
FEV_1 (L)	1.8 ±.5	1.7 ±.4	.457	.986
MSFT (Level)	3.1 ±1.6	3.4 ±1.2	-1.112**	.266
BMI (kg/m2)	20.7 ±5.8	18.6 ±3.5	-.099**	.320

*P is significant at the <0.05 level

** Z value present for analysis run on data not normally distributed- Mann-Whitney

The figures below (3-6) show the linear regression produced between BMI and different variables. These show that BMI was not predictive of peak flow, FVC, FEV1 or MSFT.

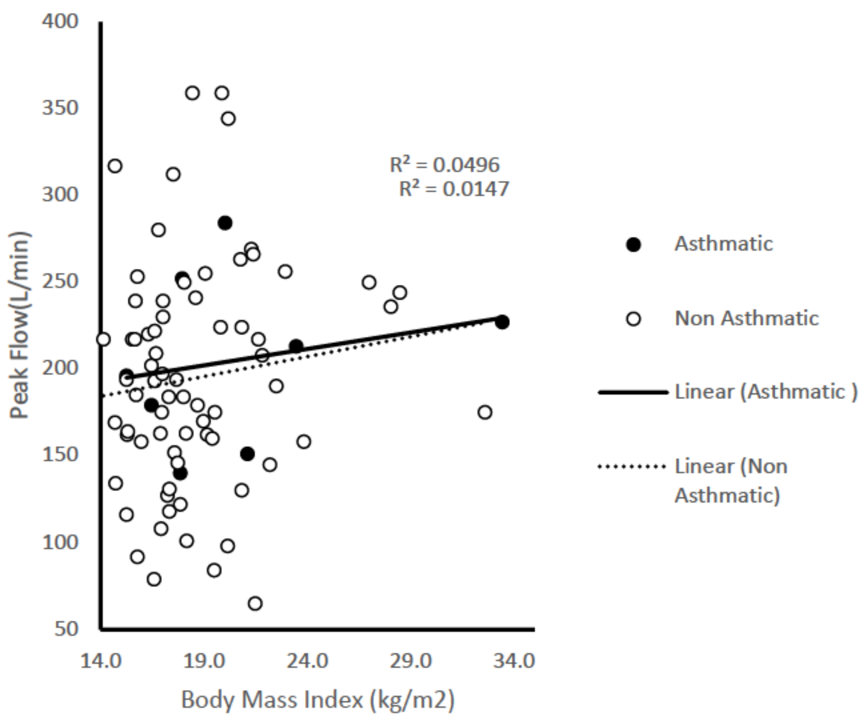

Figure 3- This shows linear regression between body mass index (kg/m2) and peak flow (L/min).

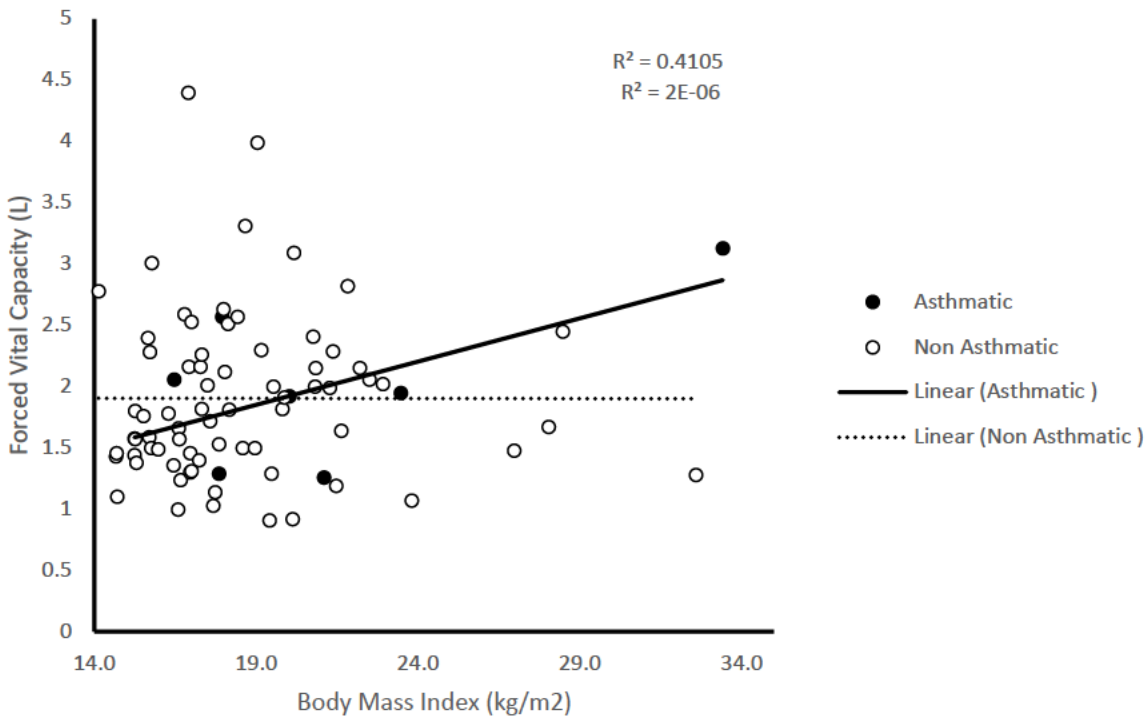

Figure 4- This shows linear regression between Body mass index (kg/m2) and forced vital capacity (L).

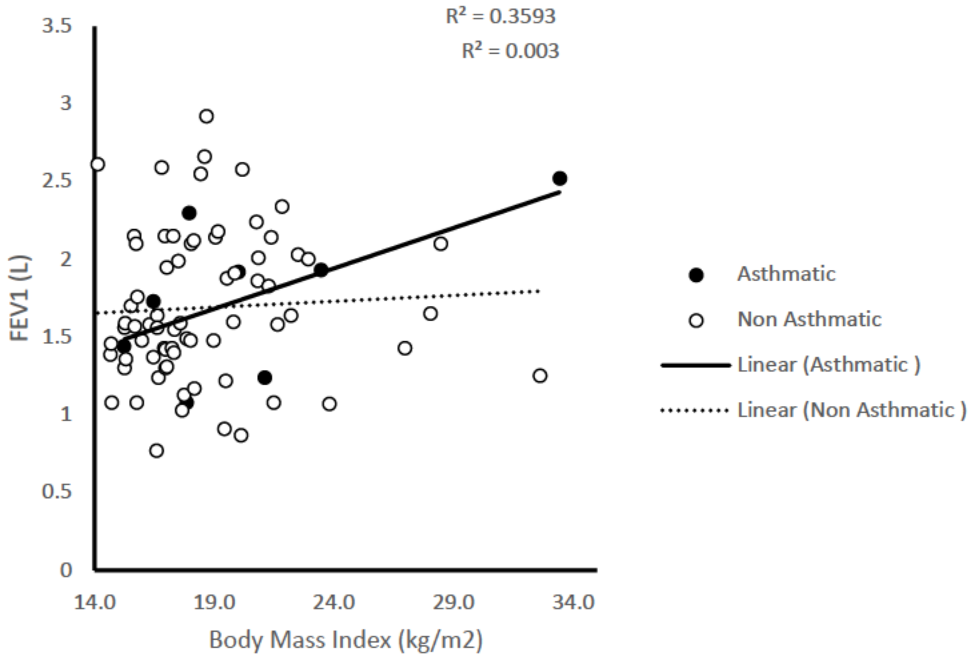

Figure 5- This shows the relationship between Body mass index (kg/m2) and FEV_1 (L)

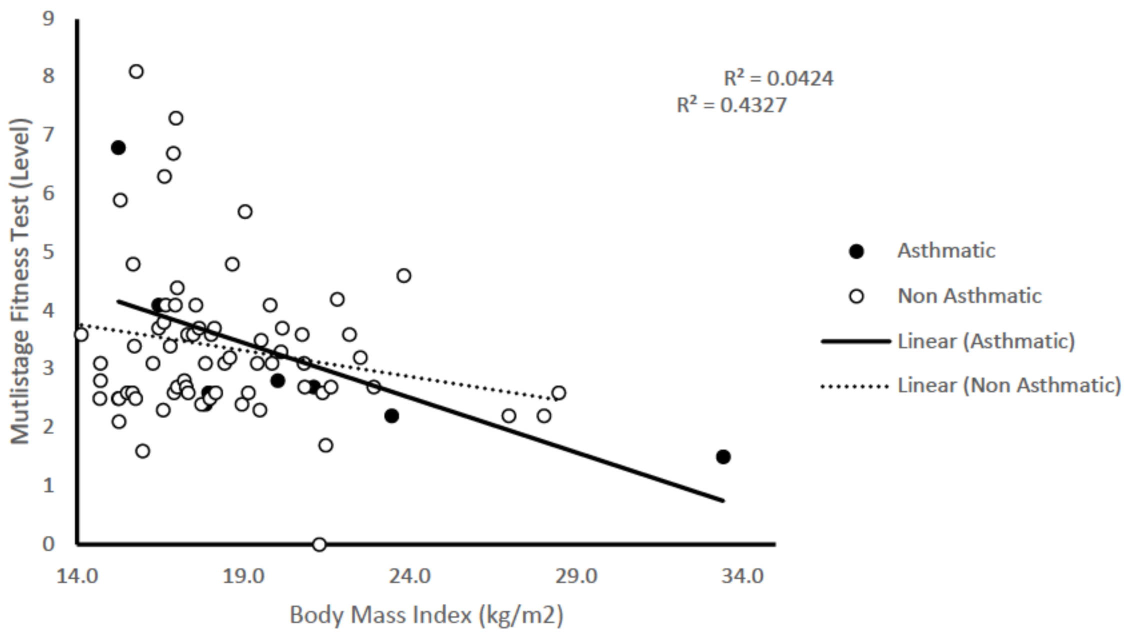

Figure 6- This shows the relationship between body mass index (kg/m2) and multistage fitness test (levels) for asthmatic and non-asthmatic individuals.

Table 3- Descriptive statistics for the children's variables (mean ± standard deviation) including the degrees of freedom and F ratio.

	All (N=77)	**Underweight & Healthy BMI (N=51)**	**Overweight BMI (N=17)**	**Obese BMI (N=9)**	**Condition Difference**	
	Mean(±SD)	Mean(±SD)	Mean (±SD)	Mean (±SD)	F (2)	P Value
Age (years)	9.6 ±1.1	9.5 ±1.1	9.9 ±1.2	9.8 ±1.1	.78	.464
Height (cm)	142.7 ±9.2	142.6 ±9.1	140.6 ±8.9	147.1 ±8.9	1.53	.224
Mass (kg)	38.7 ±10.9	34.7 ±6.3	40.7 ±7.1	58.6 ±14.9	36.01	<.001#
Peak Flow (L/min)	195.0 ±63.3	194.5 ±63.7	187.2 ±72.9	212.2 ±40.6	.46	.636
FVC (L)	1.9 ±.6	1.9 ±.7	1.8 ±.7	1.9 ±.7	.12	.882
FEV_1 (L)	1.7 ±.5	1.7 ±.5	1.7 ±.6	1.7 ±.5	.03	.963
MSFT (Level)	3.4 ±1.3	3.6 ±1.4	3.1 ±.7	2.6 ±.9	3.52	.034*
BMI (kg/m2)	18.8 ±3.8	16.9 ±1.1	20.4 ±1.4	26.8 ±4.3	104.77	<.001#

*P is significant at the <0.05 level. #P is significant at <0.001

Linear regression was carried out to assess whether BMI is predictive of the multistage fitness test scores. There was a statistically significant negative correlation reported between the variables (t=-2.691, P=.009, R= 0.088). Asthmatic and non-asthmatic children were grouped together due to low numbers of children with asthma, but the findings suggest that across both groups higher BMI is predictive of lower shuttle number on the multistage fitness test.

Nine of the children who participated in the study (N = 77) were considered obese, 17 overweight and 51 underweight or with a healthy BMI. As there was only being one child with an 'underweight' BMI, underweight and healthy BMI individuals were analysed collectively and compared to overweight and obese BMI as separate groups. Other than mass (F=36.01, P<0.001) and BMI (F = 104.77, P<0.001)) the multistage fitness test level was the only variable to report that there was a significant difference between groups (F=3.52, P=0.034). Post-hoc analysis revealed that healthy BMI children were not significantly different when compared to those in the overweight category (P=.108), but a significant difference was identified between healthy and obese BMI categories ($P=.020$) with children in the obese category completing significantly fewer shuttles than their healthy weight peers. None of the other test variables were found to have a difference between the groups (table 3).

An independent t test was carried out comparing those children reported by parents to do regular physical activity outside school ($N=58$) and those who do not ($N=18$). No variables reported to be significantly different between the two groups but with those children who are active regularly had a higher mean FVC (1.95L ± 0.6) versus those who aren't regularly active (1.78L ± 0.8), but all other variables including peak flow, FEV_1, and multistage fitness test were not significantly different ($P \geq .280$). A Kryskal-Wallice test revealed no significant differences when considering 'hours of physical activity weekly' and 'hours sedentary daily' ($P \geq .549$ & $P \geq .803$) (Appendix C).

Normality checking was completed on all variables and FEV1 ($P=.094$), peak flow ($P=.345$) and height ($P=.859$) were all variables shown to be not significant which shows normal distribution of data. All other variables were reported as $P<.001$ which shows to be highly significant and not normally distributed.

5.2 Parental data

Of the 77 children participating in the study, parental questionnaires were returned by 53 parents (68.8%), of the responding parents 22.6% were fathers and the remainder were mothers, all reported to be biological parents rather than 'guardians. Questionnaires were returned by parents for all the children with asthma (N = 8, 100%). Eleven parents reported being asthmatic themselves and from this group, 4 were parents of asthmatic children (36.4%). Independent t-tests were carried out on the parental data comparing asthmatic individuals ($N=11$) to non-asthmatic individuals ($N=42$), regular participation in physical activity was reported to be significantly different ($t(51)=3.421$, $P=.023$) between these groups but no other statistically significant differences were found ($P \geq .241$), these included BMI, height, mass hours of physical activity weekly and hours sedentary daily. Asthmatic parents reported to complete an average 3.36 ±1.08 hours of physical activity weekly compared to an average of 4.40 ±0.92 hours for non-asthmatic individuals.

Table 4- Descriptive statistics for the participant characteristics for the parents showing the male and female differences.

Parents	**All**		**Female**		**Male**
Participants	53		41		12
Asthmatics	11		11		0
Age groups	25-34	35-44		45-54	55-64
	14	28		8	3

Table 5- Descriptive statistics for the parents' variables (mean ± standard deviation) including a *t* statistic to identify any significant differences between asthmatic and non-asthmatics as collectives.

	All (N=53)	**Asthmatic (11)**	**Non-Asthmatic (42)**	**Condition Difference**	
	Mean (±SD)	Mean (±SD)	Mean (±SD)	*t* statistic	P Value
BMI (kg/m2)	26.2 ±4.7	27.2 ±4.0	26 ±4.9	.725	.901
Height (cm)	168.3 ±9.5	164.1 ±6.7	169.4 ±9.9	-1.685	.375
Mass (kg)	74.1 ±12.9	73.1 ±10.8	74.4 ±13.5	-.293	.319
Physical activity (hours)	4.19±1.12	3.36 ±1.08	4.40 ±0.92	3.421	.023

Three parents reported they had childhood asthma that did not continue to adulthood, but they reported that this was due to "weight loss" and "quitting smoking". Eleven parents reported to have asthma as adults, all were female with only two reporting to do more than 5 hours of physical activity a week

All parents of children with asthma (N=8) reported that their children were almost always restricted during activity. Six of these parents reported that they had childhood asthma themselves and that they were restricted during exercise as children and therefore now let their children take part in less exercise to avoid any complications. No children were reported to be affected in everyday life by asthma only when doing exercise or physical activity.

Linear regression was also carried out to find out if parental BMI predicted that of their children. Parental BMI did not have a statistically significant relationship with children's BMI (P=0.818) and there was a weak negative correlation reported (t= -0.241)

6. Discussion

6.1 Asthma and fitness

The primary aim of this study was to investigate the potential relationship between BMI and cardiorespiratory fitness in primary school children with and without asthma in a rural Welsh primary school.
Increased fitness has been shown to be a possible mechanism which shows and improvement of asthma. One of the benefits of the fitness increase is linked to the tidal volume on the smooth muscle of the airways which improves the participants breathing abilities that can be caused as an effect of minimal physical fitness (Fredberg et al., 1999).

Following the research of McNarry et al. (2013). There are disagreements reported between studies showing the relationship between asthma and fitness. Many older research papers show that there is no difference in CRF levels for asthmatics compared to their peers who are considered healthy (Pianosi and Davis 2004; Santuz et al. 1997). Although there are more recent but still dated papers which show there are lower CRF levels in asthmatic and obese children (Dolan et al. 2012; Klungland Torstveit and Sundgot-Borgen 2012). McNarry et al. (2013) paper concludes there is a negative independent interaction between obesity and CRF and there this highlights the serious health concerns linked to increased obesity with asthma reported to impact CRF. There are many differences in the methodology of these papers that separate them and therefore the relationship between asthma and fitness remains an assumption.

The results from the multistage fitness test revealed that children with asthma were able to perform significantly fewer shuttles, achieving significantly lower levels on the test compared to non-asthmatics (3.1 ± 1.6 compared to 3.4 ± 1.2, $P=0.034$)). This reflects the findings of McNarry et al. (2013) as they also found that asthma significantly influenced aerobic performance as participants with asthma completed fewer shuttles than those without. Some exceptions occurred, as one participant with asthma scored the highest score in the multistage fitness test, however this participant was an academy level football player so had done the test previously as well as being highly physically active through frequent training. In both groups the children with lower results on the MSFT tended to be those children who also had a higher BMI with data showing a significant negative relationship between the two variables ($t=-2.691$, $P=.009$, $R= 0.088$). BMI in those with asthma and those without is not significantly different although it has been found that the mass between the two groups is significantly different ($P<0.001$). This current study strengthens the previous research done by Lopez et al. (2009) as they reported in their study that weight is significantly different between asthmatics and non-asthmatics in children. Although asthmatics reported slightly higher results in peak flow (205.3 ± 49.1L/min), FVC (2.0 ± 0.6L) and FEV_1(1.8 ± 0.5L) compared to the non-asthmatics (193.8 ±65L/min, 1.9 ± 0.7L, 1.7 ± 0.4L) none were found to be significantly different. These results disagree with those in a systematic review by Noel et al. (2011) who found children with asthma performed worse than those without in the lung function tests. Although children with asthma could produce higher results in this section of the testing, they will have done the peak flow testing procedure multiple times as part of asthma check-ups and diagnosis testing, therefore they were familiar with what they needed to do. Children in this study were only confirmed to have asthma by their parents reporting in the parental questionnaire and the CHAQ form. It has previously been suggested children with asthma might produce different results to their peers due to the restriction to their airways being present or the medication they are on opening their airways to function to the best of their ability which might not restrict results at all (Cox et al., 2006).

Comparing the MSFT results in this study with the Swanlinx data (Marchant, 2019), the average number of shuttles completed by children in Swansea was 28 shuttles compared to 16 shuttles for asthmatics and 19 for non-asthmatics in the current study. This shows that the children in this study were considerably less fit than the children in the Swanlinx even though they have similar living conditions and opportunities. Comparing to one school on the HAPPEN (Marchant, 2019) report the minimum shuttles is 18 therefore the results from the school in the current study are extremely low. When comparing the HAPPEN data to the current study the impact of fitness levels decreasing due to the COVID-19 pandemic must be considered as this has decreased cardiorespiratory fitness levels (Jarnig, Jaunig & van Poppel, 2021). Comparing the data collected to the physical activity report card (Richards et al., 2022) the children in current study are those that fit into the physical activity levels reported as the ‘F’ reported for high sedentary levels and overall physical activity means only 17% completed the recommended 60 minutes of MVPA daily and over 86% were sedentary for 2 hours or more. In the current study parents reported 84% of children were sedentary for 2 hours or more and more than 50% of children completed less than 5 hours of physical activity weekly which indicates the children weren’t active for the full 60 minutes daily. Following the physical activity report card for Wales (Richards et al., 2022) it is clear to see physical activity levels in Wales are poor as overall have been scored an 'F' and reports only 17% of young people completed the recommended 60 minutes of moderate-vigorous physical activity daily.

Welsh, Roberts, and Kemp (2004) reported anecdotal information that suggests children with asthma are not as aerobically fit as non-asthmatic individuals. This is replicated in the current study as children with asthma produce significantly lower results (3.1 ± 1.6 shuttles vs 3.4 ± 1.2 shuttles) compared to the non-asthmatic participants. Although, during the current study the best multistage fitness score was produced by an asthmatic child, from his parental questionnaire it was reported that the individual was an active child that played performance level football in a Football Academy and was therefore familiar with the multistage fitness test through their academy training. It was clear that the children with poor scores were unfit and did not participate in regular physical activity, they seemed unmotivated to perform to the best of their ability due to the negative behaviour they had towards doing physical activity. Duda (1996) addresses the change in motivation among children and adolescents and concludes that a young person is more likely to show increased motivation if they know the task is mastered and they will succeed and perform well in the task as they avoid failure. This can be reflected in the current study as the most children had not done the multistage fitness test before and were asked to perform the test in front of their peers and unfamiliar adults, therefore these factors may have decreased motivation in the children. Fanti-Oren et al. (2020) concludes results that is contradicting to those in this study as they report that if children are properly motivated and encouraged to complete the activity then they will perform well in testing regardless of their BMI. With many children being motivated by many different sources and methods it would have been difficult to find something to maximise motivation although all children were happy to perform and were interested in what was going on during testing and all found it enjoyable.

6.2 Asthma and BMI

The results of the current study agree with Chen et al. (2017) who reported that children with asthma may be at a higher risk of obesity Chen et al. (2017) looked at the effects of rescue medication for asthma whereas this current study focused on physical fitness and obesity. The children in the current study were all grouped within asthma diagnosis reported by parents and by BMI but in the study by Chen et al. (2017) they were all normal weight at the beginning of the study and were grouped into children with asthma and those without and then monitored for 10 years. Both studies found children with asthma were more likely to be obese and those that did more physical activity had increased physical fitness and decreased likelihood of becoming obese. The findings in the current study also support those of Scholtens et al. (2009) as both found a significantly higher body mass in children with asthma compared to those without asthma (46.3 ± 19.1 compared to 37.9 ± 9.4 kg; P=0.031), with 11.7% of children found to be obese in the current study. The additional weight that the children with obesity carry has been suggested to be detrimental to lung function (Forno et al., 2018). The meta-analysis by Forno et al. (2018) shows that being overweight or obese can significantly decrease lung function, capacity, and other asthma related outcomes such as morbidity and resistance to therapy (Dixon et al., 2010). This finding is in accord with the present findings whereby FVC and FEV_1 were negatively related to body mass, regardless of asthma diagnosis. Chen et al. (2017) also reported that children with obesity have a higher prevalence of other diagnoses which are also linked with obesity and can cause asthma such as other metabolic diseases such as pre and type 2- diabetes. Whilst this was not found in the current study as parents completed health questionnaires about their children, and none were found to have any other condition on the CHAQ form which didn't exclude any participants from the study.

Finding 75% of children with asthma to be overweight (20.4 ± 1.4 kg/m2) or obese (26.8 ± 4.3 kg/m2), the current study agrees with the findings of Wood (2015) who proposed the 'obese asthma' phenotype, describing the affect high body weight has on asthma prevalence and characteristics. This recently identified phenotype is rapidly developing as a cause for concern among children as the average BMI scores across the population continue to increase annually, with 1 in 8 children in Wales now considered to be obese and the highest prevalence in 4–5-year-olds (Beynon & Bailey, 2020). In children asthma typically manifests before the age of 6 therefore it is important to observe children in the early stages and younger years for any airway injuries and help treat any illnesses to avoid any increase to the pathogenesis of asthma (Gern, Lemanske & Busse, 1999). These worrying trends of increasing BMI and lack of physical activity are likely to have been further exacerbated by the recent COVID-19 pandemic due to a marked increase in children's sedentary time (Stockwell et al., 2021). Obesity and high body weight have a strong association with a lifestyle with increased sedentary behaviour and limited physical activity (Martínez-González et al., 1999). Indeed, Lang et al. (2018) concluded that childhood obesity is a major cause of paediatric asthma. This highlights the importance of children remaining a healthy weight and engaging in regular physical activity during their childhood to prevent obesity and to ensure the risk of developing diseases such as asthma remains low. This is shown in the results from the current study as parents who reported children that are regularly active had a higher mean FVC score of 1.95 ± 0.7 L versus those who are not regularly active only averaging 1.79 ± 0.4 L.

Although it has been shown that asthma and obesity have a clear relationship. It has been reported that high BMI isn't the main contributor to the development of asthma (Flaherman and Rutherford, 2006). Following on from this research, it has been shown that obesity has a strong influence on airway function as the distribution of fat around the body plays a crucial part of this. Central body fat distribution is shown to have large impact on obstructive lung function although it has been shown that central obesity has a stronger relationship with asthma compared to severe BMI (Boulet, 2013).

6.3 Asthma and PA

The amount of physical activity someone takes part in is significantly associated with their performance in physical fitness testing. Leinaar, Alamian and Wang, (2016) report that children with asthma often demonstrate a reduced energy expenditure due to being prevented from engaging in physical activity due to a perceived risk of asthma symptom exacerbations. The parents in the current study expressed similarly negative views on physical activity and asthma, reporting that they allow their children to do less physical activity as it avoids any asthmatic complications arising. Given that none of the children in the present study were reported to be affected by their asthma in their everyday lives, it is therefore presumed that this restriction of physical activity is due to a lack of parental knowledge around the area and being over cautious about asthma symptom exacerbations (Shone, Conn, Sanders, and Halterman, 2009).

6.4 Fitness and BMI

The results of this study suggest that children having high BMI is predictive of a low shuttle run score during the multistage fitness test (P=0.009) and this suggests the children that are unfit likely are likely to be those with the low levels of regular physical activity reported. This finding is also found in McNarry et al. (2013) research with a significant decline in shuttle run performance once BMI passes the 50th percentile age relative. Aires et al. (2015) reports that obese children have low cardiorespiratory fitness which agrees with the findings in this study, although the participants in the 2015 study was done on older children and adolescents which could change the results as the participants are going through puberty and hormone levels could be influencing results. Todendi et al. (2021) demonstrated that children need high levels of physical activity from a young age to avoid excess weight gain and decrease the risk of becoming obese. They report that children that are at an increased risk of becoming overweight from different medical diagnoses or health implications should especially focus on increasing their physical activity levels as many conditions and medications can increase the risk of becoming obese or overweight. Having a high BMI has been reported by Dumith et al. (2010) to have a negative impact on physical fitness providing support for the negative correlation reported between BMI and shuttles in the current study. This is showing the effect on a child's health that having a high BMI can have and the negative impacts it will have on their lifestyle.

6.5 Fitness and PA

As the participants in this study were between 7 and 11 years old, they are still at an age where healthy behaviours can have a significant influence on them, and this can be a positive influence on their lives as they rely a lot on adults to be positive role models at this age. Jago et al. (2005) states it is important to develop positive behaviours towards 6-8 years of age as it is the age at which children begin to understand behaviour habits will benefit their current and future health. Pojskic and Eslami (2018) also conclude that obesity is not independently associated with physical fitness therefore they report there must be additional factors that combine to decrease physical fitness scores. In this study, increased BMI is the variable that contributes to decrease physical fitness the most as there was a significant negative correlation ($P=0.009$) reported between the variables, therefore these studies disagree with the results here. This shows there is a decrease in fitness levels of those with high BMI and that those individuals are therefore at risk of other health deteriorations linked to high BMI.

6.6 Parental outcomes and influence

A secondary aim was to determine the influence of parental understanding and physical activity levels on these factors. Many of the parents in this study, of both asthmatic and non-asthmatic children, reported that their child did not do enough physical activity outside of school (17%). Many of these children had high levels of sedentary behaviour and it's evident that if parents took part in regular physical activity, then their children were more likely to take part too. Parental participation in activity was found to be significantly different in asthmatic (N=11) parents to non-asthmatic((N=42) P=0.23) with parents with asthma taking part in less activity than those without asthma. This agrees with the results from Sigmund, Sigmundová, and Badura, (2020) who concluded parental participation in physical activity is linked to the offspring being more active. If a parent has a positive influence on the child's activity levels it will keep the risk of obesity low for the children as they naturally follow a healthy lifestyle following the parental influence.

According to Cosper & Erickson (1985), parents reported being unsatisfied with the information that they were provided about their children's conditions. Although Cosper & Erickson was published in 1985 parents still report to be uneducated in controlling their child's condition. In this study, parents who reported their child to be asthmatic were asked if they restrict their children doing activity. All parents confirmed answered yes to this, suggesting that parents are either uneducated on their children's conditions or are overcautious and ignore the advice that has been given. The restrictions the parents in this study put on their asthmatic children can help show the level of understanding the parents have about their children's diagnoses. Some of the parents (N=6) reported to have childhood asthma themselves, but only half of these continued to have asthma into adulthood, with the reports of 'weight loss' and 'quitting smoking' being the reason their childhood asthma didn't continue. The parents who reported being asthmatic as children were among those who restricted their own children doing physical activity stating they had previously had negative experiences themselves and were worried about putting their children through the same negative experiences, this is despite the fact that none of the children in the study were reported to be affected in everyday activities by their asthma. Liu and Feekery (2001) report that increasing parental knowledge about asthma decreases anxieties about their child's condition and decreases child asthma morbidity scores which shows educating parents on their child's condition is essential to increase children's and parental mental health and quality of life.

Lal, Kumar, and Malhotra, (1995) addresses parent's perceptions of what their child can and can't do if they have asthma. They found that that stopping the child doing activity is unnecessarily restrictive and can contribute to a child's health deteriorating and may prevent them from living a normal life. Stopping a child from doing physical activity or leading a ‘normal life’ impact widely on the children’s quality of life and negatively effects everything children do. Kornblit et al. (2018) found the main barrier to children with asthma doing physical activity were due to the parental beliefs about the effect physical activity would have on their child’s asthma symptoms and not how severe the child’s asthma was. Generally, in children that were obese their peak flow (212.2 ±40.6 L/min) was higher than those which lower BMI’s but was not statistically significant. This could be because bigger people both height and mass have higher peak flow (Asthma & Lung UK, 2020). Ji et al, (2013) has found that regular physical activity is positively associated with lung function and growth which this study agrees with as it can be suggested that greater amounts of physical activity which can reduce BMI can positively effect lung capacity of the child. This supports earlier findings by Berntsen, Wisløff, Nafstad, and Nystad (2008), who suggested the highest level of lung function is in children with the highest levels of physical activity.

Overall, BMI for asthmatic parents (N =11) was higher than that of non-asthmatics ((N=42) $P<0.001$) and out of the asthmatic parents only 2 reported doing regular physical activity weekly which is an important indicator of the highly sedentary lifestyles the parents in the current study self-reported to have. Donkor et al. (2017) reports that maternal obesity during pregnancy contributes to an increased risk of the infant becoming obese during early childhood, which in turn increases the risk of reduced lung function and asthma prevalence. Geserick (2018) also agrees with this as they report that children with mothers that are obese are at an increased risk of becoming obese, this is due to the parents leading unhealthy lifestyles which can be reflected on the child (Naess et al., 2018), although comparing this to those that become obese as children with mothers of normal weight there is no difference in the age that the offspring become obese. Of the 11 asthmatic children in this study, 8 of their parents also reported being asthmatic and all of these were the children’s mothers, which is a correlation that the asthma was genetically passed to the child (Bierbaum & Heinzmann, 2007).

6.7 Limitations

This study had a range of children from 7-11 years of age but, due to parental consent requirements, there were not consistent numbers across all age groups. Therefore, it was not possible to look at patterns across the age groups and this could be considered a limitation to the study. Not all parents returned their own parental questionnaires so there was not always alignment of children to parents. However, the overall participation rate of both parents and children involved in the study (69%) was a strength. Due to parents withdrawing from the study by not submitting their parental questionnaires, there was not an equal number of asthmatics against non-asthmatics for parental figures. Although, due to the nature of the study this did not influence results as it helped with some tests but also numbers needed to be bigger to show bigger differences within variables. There was a reasonable distribution of children in each BMI group which helped produce reliable data. Sample size and disparity within groups such as asthmatics and non-asthmatics was something that was a large limitation within the data analysis as there was not enough asthmatic participants to allow analysis to be done with separate groups. Conclusions have been impacted due to the numbers within groups as the ability to compare groups was difficult.

Data collection for this study was impacted due to restrictions linked to COVID. Due to the risks and increased spread of COVID, the testing was delayed significantly as new waves of the virus were founds and local lockdowns were reintroduced. Risk assessments and ethics had to ensure the data collection was completed in a safe environment for both the participants and the researchers. Multistage fitness test had to be completed outside due to the increased risk of COVID spread when aspirations increased. Participants had to complete testing procedures within classroom bubbles which made testing in some groups a longer process. This also had an impact on the formality of the groups as some groups with small number of participants showed more nervous than those in larger groups with more peers around them.

Although BMI isn't as reliable skinfold measures or Bio Impedance analysis (BIA) measurements, as it doesn't account for muscle mass and water retention (Bhurosy & Jeewon, 2013), it is a readily accessible method that can be used at scale, making it the optimal choice for this study. However, this does necessitate that the findings are interpreted with due caution. Using BMI as an indicator of health can be unreliable due to it not accounting for body composition such as muscle mass and water (Bhurosy,and Jeewon, 2013). Due to the testing being done on children and the limited amount of time available for the testing to take place it was accepted to predict children's health.

This study also didn't include any children with severe asthma as there was no children with severe asthma in the school or that returned consent forms which could be why there isn't a significant difference between children with and without asthma in many variables. Finding may differ in children with more severe asthma. From Kippe et al. (2022) research we can see parents often overreport data. This gave the assumption that parents in this study would also overreport. Using the HAPPEN report and Swanlinx data (Marchant, 2019) we can see that children in the area are considerably underachieving the guidelines for PA. Therefore, the set questions for parents were suitable as children were all unfit and underperformed for their age in the MSFT. Results about parents and the information about children participating in regular physical activity was self-reported therefore it could be an over or under estimation (Prince et al., 2008) of what they do so this was also considered when evaluating the results.

The children also worked to their own level of exhaustion which in young children is as soon as they feel tired, therefore a RPE scale may have been useful to help children understand the increasing intensity more and not dropping out of the testing so quickly (Kasai, Parfitt, Tarca, Eston, and Tsiros, 2021). Therefore, the multistage fitness test didn't produce as high numbers as hypothesised but due to large numbers of children it was the best testing method to use. Many children were also unfit and had low motivation when running and when they saw their friends drop out, they also wanted to drop out, so it was hard to convince the children to carry on running after they had seen others dropping out.

Using MSFT as the testing method for fitness was something considered due to the implications linked to COVID-19 restrictions as well as time restrictions. It is recognised that using the MSFT we would not get accurate results for fitness but only an estimation. The unfamiliarity of the test was also a limitation as the children weren't familiar with the testing procedure and dropped out of testing or did not take part due to worries linked to the test (Armstrong and Welsman, 2019).

6.8 Future considerations

This study was conducted on children aged 7-11 years in a rural part of Wales therefore future considerations could investigate comparisons between those living in rural versus more urban areas. This is due to children's health being negatively affected by air pollution in different environments and the causes of increasing in variables that lead to increased sedentary time in both rural or urban areas that can interacting with BMI and children's physical fitness could be considered as well as the effects of air quality in different areas.

Future research could also look at having equal amounts of participants in each age group and an equal amount of parental information and data collection to be able to directly compare to the children's data. This could be analysed and matched up across all variables as in this study not all parental data was collected as many parents withdrew their information and only gave permission for their child to participate. This may allow a greater understanding of the effect on children with parents that have asthma diagnosis or those that also had asthma as children.

7 Conclusion

The findings are in agreement with McNarry et al. (2013) and they reflect the conclusion that the factors do not occur coincidental simultaneously but show there is a clear relationship between the airway inflammation, obesity and physical inactivity.

The main finding of the current study was that children with asthma produced lower results in the multistage fitness test compared to those without asthma, this demonstrates that children with asthma have poorer physical fitness compared to their peers with no asthma diagnosis. This could be linked to the restriction of physical activity parents reported for those children with asthma. However, across both groups children with high BMI had lower scores during the multistage fitness test suggesting BMI can be predictive of physical fitness. Overall, the study supports the notion that parental influence on children's physical activity is important with parental participation in physical activity increasing the likelihood of the children participating too. Many children in the study, particularly those with asthma, were unfit, overweight (or obese) and reportedly not meeting physical activity recommendations. The study findings raise further concern around both parental education for asthma control and physical activity promotion. Intervention is needed to avoid long-term implications for health and wellbeing.

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Appendices

Appendix A

Parental Questionnaire

1. **What is your child's name?**

____

____

2. **What is your child's age?**

7	8	9	10	11

3. **What is your child's sex?**

Male	Female	Prefer not to say

4. **Does your child participate in regular physical activity outside of school physical education lessons?**

Yes	No

If yes, please state what and for how long

____

____

5. **On average how many hours of physical activity would you say your child does a week?**

0	1	2	3	4	5+

6. **On average how many daily hours outside school would you say your child is sedentary? (E.g. watching tv, playing video games- this does not include time sleeping)**

0	1	2	3	4	5+

7. **Does your child have diagnosed asthma?**

Yes	No

If no go to question 11

If yes, please state when they were diagnosed and how and go to question 8

8. **If yes, how often does this stop your child doing activities a child without asthma could do?**

9. **Do you avoid letting your child do some activities due to their asthma diagnosis?**

Yes	No

If yes, please explain why and what activities you would avoid?

10. **Does your child use regular asthma inhalers?**

Yes	No

If yes, which inhalers do they have (colour is fine) and how often do they use them?

If yes, do exercise and physical activity effect the amount your child uses their asthma inhalers?

11. What is your sex?

Male	Female	Prefer not to say

12. What is your age?

18-24	25-34	35-44	45-54	55-64	65-74	75+

13. Do you have a job?

Yes	No

If yes, please go to question 14

If no, please go to question 16

14. Do you have a sedentary (desk-based) job or an active job?

Sedentary	Active

15. On average, how many hours do you work a day?

1	2	3	4	5	6	7	8	9+

16. Do you participate in regular physical activity?

Yes	No

If yes, please state what?

17. On average, how many hours do you spend doing physical activity weekly?

1	2	3	4	5+

18. On average, how many hours do you spend sedentary daily? (sitting, watching tv, reading? This does not include sleeping)

1	2	3	4	5	6	7	8	9+

19. Do you have diagnosed asthma?

Yes	No

If yes, please state when you were diagnosed? (year) and what inhalers you use and how often and then go to question 20

If no, go to question 21

20. Does having asthma hold you back from doing certain activities?

Yes	No

If yes, please state what activities

21. Did you have asthma as a child?

Yes	No

If yes, please go to question 21

If no, please go to question 22

22. Did having asthma as a child make you feel any different to the other children?

Yes	No

If yes, please state why

____

____

23. What is your height (cm)?

	CM	Prefer not to say

24. What is your body weight (kg)?

	KG	Prefer not to say

Appendix B

PATIENT REF NO: **DATE:**

CHILDHOOD HEALTH ASSESSMENT QUESTIONNAIRE

In this section we are interested in learning how your child's pain affects his/her ability to function in daily life. Please feel free to add any comments on the back of this page. In the following questions, please tick the one response which best describes your child's usual activities OVER THE PAST WEEK. If most children at your child's age are not expected to do a certain activity, please mark it as "Not Applicable". For example, if your child has difficulty in doing a certain activity or is unable to do it because he/she is too young but not because he/she is RESTRICTED BY PAIN or ILLNESS, please mark it as "NOT Applicable".

	Without ANY Difficulty	With SOME Difficulty	With MUCH Difficulty	UNABLE To do	Not Applicable
DRESSING & PERSONAL CARE					
Is your child able to:					
- Dress, including tying shoelaces and doing buttons?	□	□	□	□	□
- Shampoo his/her hair?	□	□	□	□	□
- Remove socks?	□	□	□	□	□
- Cut fingernails?	□	□	□	□	□
GETTING UP					
Is your child able to:					
- Stand up from a low chair or floor?	□	□	□	□	□
- Get in and out of bed or stand up in a cot?	□	□	□	□	□
EATING					
Is your child able to:					
- Cut his/her own meat?	□	□	□	□	□
- Lift up a cup or glass to mouth?	□	□	□	□	□
- Open a new cereal box?	□	□	□	□	□
WALKING					
Is your child able to:					
- Walk outside on flat ground?	□	□	□	□	□
- Climb up five steps?	□	□	□	□	□

* **Please tick any AIDS or DEVICES that your child usually uses for any of the above activities**:

- Walking stick	□	- Devices used for dressing (button hook, zip pull, long-handled shoe horn, etc.)	□
- Walking frame	□	- Built up pencil or special utensils	□
- Crutches	□	- Special or built up chair	□
- Wheelchair	□	- Other (Specify:_____________________________)	□

* **Please tick any categories for which your child usually needs help from another person BECAUSE OF PAIN or ILLNESS:**

- Dressing and personal care	□	- Eating	□
- Getting up	□	- Walking	□

HYGIENE

Is your child able to:

- Wash and dry entire body?	□	□	□	□	□
- Take a bath (get in and out of bath)?	□	□	□	□	□
- Get on and off the toilet or potty?	□	□	□	□	□
- Brush teeth?	□	□	□	□	□
- Comb/brush hair?	□	□	□	□	□
REACH					
Is your child able to:					
- Reach and get down a heavy object such as a large game or books from just above his/her head?	□	□	□	□	□
- Bend down to pick up clothing or a piece of paper from the floor?	□	□	□	□	□
- Pull on a jumper over his/her head?	□	□	□	□	□
- Turn neck to look back over shoulder?	□	□	□	□	□

GRIP					
Is your child able to:					
- Write or scribble with pen or pencil?	□	□	□	□	□
- Open car doors?	□	□	□	□	□
- Open jars which have been previously opened?	□	□	□	□	□
- Turn taps on and off?	□	□	□	□	□
- Push open a door when he/she has to turn a door knob?	□	□	□	□	□
ACTIVITIES					
Is your child able to:					
- Run errands and shop?	□	□	□	□	□
- Get in and out of a car or toy car or school bus?	□	□	□	□	□
- Ride bike or tricycle?	□	□	□	□	□
- Do household chores (e.g. wash dishes, take out rubbish, hoovering, gardening, make bed, clean room)?	□	□	□	□	□
- Run and play?	□	□	□	□	□

* **Please tick any AIDS or DEVICES that your child usually uses for any of the above activities:**			
- Raised toilet seat	□	- Bathrail	□
- Bath seat	□	- Long-handled appliances for reach	□
- Jar opener (for jars previously opened)	□	- Long-handled appliances in bathroom	□
* Please tick any categories for which your child usually needs help from another person BECAUSE OF PAIN:			
- Hygiene	□	- Gripping and opening things	□
- Reach	□	- Errands and chores	□

PAIN:
How much pain do you think your child has had IN THE PAST WEEK?
Place a mark on the line below, to indicate the severity of the pain

No Pain 0 ____ 100 Very severe pain

GENERAL EVALUATION: Considering all the ways that your child's pain or illness affects him/her, rate how he/she is doing by placing a single mark on the line below.

Very Well 0 ____ 100 Very Poor

Person/s completing questionnaire:-

- Mother □
- Father □
- Child □
- Other □

Date of completion:- ___________________

1990 Original version Singh G et al.

1998 Cross-cultural adapted version Woo P, Murray KJ, Nugent J for PRINTO

PATIENT REF NO: **DATE:**

CHILD HEALTH QUESTIONNAIRE - Parent Report
CHQ-PF50
INSTRUCTIONS

This booklet asks about your child's health and well-being. Your individual answers will not be shared with anyone.

If you choose not to participate it will not affect the care you receive.

Answer the questions by marking the appropriate box .

Certain questions may look alike but each one is different. Some questions ask about problems your child may not have, but it's important for us to know that too. Please answer each question.

There are no right or wrong answers. If you are unsure how to answer a question, please give the best answer you can and make a comment in the margin.

All comments will be read, so please feel free to make as many as you wish.

SECTION 1: YOUR CHILD'S GENERAL HEALTH

1.1 In general, would you say your child 's health is:

☐	☐	☐	☐	☐
Excellent	Very good	Good	Fair	Poor

SECTION 2: YOUR CHILD'S PHYSICAL ACTIVITIES

The following questions ask about physical activities your child might do during a day.

2.1 During the past 4 weeks, has your child been limited in any of the following activities due to health problems?

	Yes, limited a lot	Yes, limited somewhat	Yes, limited a little	No, not limited
a. Doing things that take a lot of energy, such as playing football or netball running?	☐	☐	☐	☐
b. Doing things that take some energy such as riding a bike or roller skating?	☐	☐	☐	☐
c. Ability (physically) to get around the neighbourhood, playground or school?	☐	☐	☐	☐
d. Walking 100 metres or climbing one flight of stairs?	☐	☐	☐	☐
e. Bending, lifting, or stooping?	☐	☐	☐	☐
f. Taking care of him/herself, that is, eating, dressing, bathing, or going to the toilet?	☐	☐	☐	☐

SECTION 3: YOUR CHILD'S EVERYDAY ACTIVITIES

3.1 During the past 4 weeks, has your child's school work or activities with friends been limited in any of the following ways due to EMOTIONAL difficulties or problems with his/her BEHAVIOUR?

	Yes, limited a lot	Yes, limited somewhat	Yes, limited a little	No, not limited
a. limited in the KIND of schoolwork or activities with friends he/she could do	☐	☐	☐	☐
b. limited in the AMOUNT of time he/she could spend on schoolwork or activities with friends	☐	☐	☐	☐
c. limited in PERFORMING schoolwork or activities with friends (it took extra effort)	☐	☐	☐	☐

3.2 During the past 4 weeks, has your child's schoolwork or activities with friends been limited in any of the following ways due to problems with his/her PHYSICAL health?

	Yes, limited a lot	Yes, limited somewhat	Yes, limited a little	No, not limited
a. limited in the KIND of schoolwork or activities with friends he/she could do	☐	☐	☐	☐
b. limited in the AMOUNT of time he/she could spend on schoolwork or activities with friends schoolwork or activities with friends	☐	☐	☐	☐

SECTION 4: PAIN

4.1 During the past 4 weeks, how much bodily pain or discomfort has your child had?

☐	☐	☐	☐	☐	☐
None	Very mild	Mild	Moderate	Severe	Very severe

4.2 During the past 4 weeks, how often has your child had bodily pain or discomfort?

☐	☐	☐	☐	☐	☐
None of the times	Once or twice	A few times	Fairly often	Very often	Every/almost every day

SECTION 5: BEHAVIOUR

Below is a list of items that describe children's behaviour or problems they sometimes have.

5.1 How often during the past 4 weeks, did each of the following statements describe your child?

	Very Often	Fairly Often	Some-times	Almost Never	Never
a. argued a lot	☐	☐	☐	☐	☐
b. had difficulty concentrating or paying attention	☐	☐	☐	☐	☐
c. not told the truth	☐	☐	☐	☐	☐
d. taken things which didn't belong to them	☐	☐	☐	☐	☐
e. had tantrums or a hot temper	☐	☐	☐	☐	☐

5.2 Compared to other children your child's age, in general would you say his/her behaviour is:

❑	❑	❑	❑	❑
Excellent	Very good	Good	Fair	Poor

SECTION 6: WELL-BEING

The following phrases are about children's moods.

6.1 During the past 4 weeks, <u>how much of the time</u> do you think your child:

	All of the time	Most of the time	Some of the time	A little of the time	None of the time
a. felt like crying?	☐	☐	☐	☐	☐
b. felt lonely?	☐	☐	☐	☐	☐
c. acted nervous?	☐	☐	☐	☐	☐
d. acted bothered or upset?	☐	☐	☐	☐	☐
e. acted cheerful?	☐	☐	☐	☐	☐

SECTION 7: SELF-ESTEEM

The following ask about your child's satisfaction with self, school, and others. It may be helpful if you keep in mind how other children your child's age might feel about these areas.

7.1 During the past 4 weeks, how satisfied do you think your child has felt about:

	Very satisfied	Somewhat satisfied	Neither satisfied nor dissatisfied	Somewhat dissatisfied	Very dissatisfied
a. his/her school ability?	☐	☐	☐	☐	☐
b. his/her athletic ability?	☐	☐	☐	☐	☐
c. his/her friendships?	☐	☐	☐	☐	☐
d. his/her looks/appearance?	☐	☐	☐	☐	☐
e. his/her family relationships?	☐	☐	☐	☐	☐
f. his/her life overall?	☐	☐	☐	☐	☐

SECTION 8: YOUR CHILD'S HEALTH

The following statements are about health in general.

8.1 How true or false is each of these statements for your child?

	Definitely true	Mostly true	Don't know	Mostly false	Definitely false
a. My child seems to be less healthy than other children I know.	☐	☐	☐	☐	☐
b. My child has never been seriously ill.	☐	☐	☐	☐	☐
c. When there is something going around my child usually catches it.	☐	☐	☐	☐	☐
d. I expect my child will have a very healthy life.	☐	☐	☐	☐	☐
e. I worry more about my child's health than other people worry about their children's health.	☐	☐	☐	☐	☐

8.2 Compared to one year ago, how would you rate your child's health now:

☐	☐	☐	☐	☐
Much better now than 1 year ago	Somewhat better now than 1 year ago	About the same now as 1 year ago	Somewhat worse now than 1 year ago	Much worse now than 1 year ago

SECTION 9: YOU AND YOUR FAMILY

9.1 During the past 4 weeks, how MUCH emotional worry or concern did each of the following cause YOU?

	None at all	A little bit	Some	A lot	A great deal
a. Your child's physical health	☐	☐	☐	☐	☐
b. Your child's emotional well-being or behaviour	☐	☐	☐	☐	☐
c. Your child's attention or learning abilities	☐	☐	☐	☐	☐

9.2 During the past 4 weeks, were you LIMITED in the amount of time YOU had for your own needs because of:

	Yes, limited a lot	Yes, limited somewhat	Yes, limited a little	No, not limited
a. Your child's physical health?	☐	☐	☐	☐
b. Your child's emotional well-being or behaviour?	☐	☐	☐	☐
c. Your child's attention or learning abilities?	☐	☐	☐	☐

9.3 During the past 4 weeks, <u>how often</u> has your child's <u>health or behaviour</u>:

	Very often	Fairly often	Some-times	Almost never	Never
a. limited the types of activities you could do as a family?	☐	☐	☐	☐	☐
b. interrupted various everyday family activities (eating meals, watching tv)?	☐	☐	☐	☐	☐
c. limited your ability as a family to "get-up and go" on a moment's notice?	☐	☐	☐	☐	☐
d. caused tension or conflict in your home?	☐	☐	☐	☐	☐
e. been a source of disagreements or arguments in your family?	☐	☐	☐	☐	☐
f. caused you to cancel or change plans (personal or work) at the last minute?	☐	☐	☐	☐	☐

9.4 Sometimes families may have difficulty getting along with one another. They do not always agree and they may get angry. In general, how would you rate your family's ability to get along with one another?

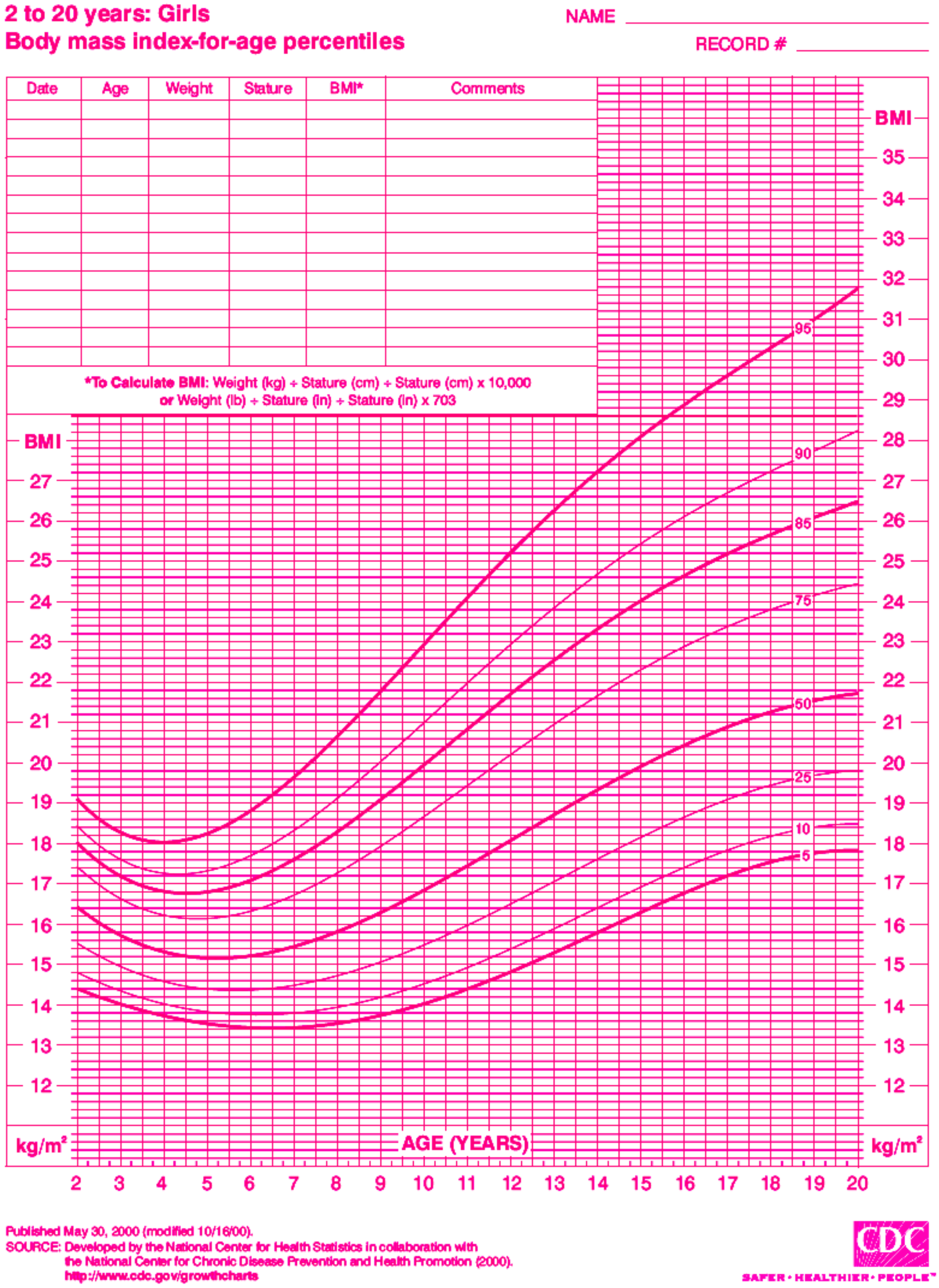
☐	☐	☐	☐	☐
Excellent	Very good	Good	Fair	Poor

Appendix C

	All (N=77)	Asthmatic (11)	Non-Asthmatic (42)	Condition Difference	
	Mean (±SD)	Mean (±SD)	Mean (±SD)	F	P Value
Physical activity weekly (hours)	4.17 ± 1.05	4.34 ± 0.92	4.14 ± 1.07	.360	.549
Hours sedentary daily (hours)	3.24 ± 1.38	3.34 ± 1.41	3.23 ± 1.39	.062	.803

*P is significant at the <0.05 level

Appendix D


2 to 20 years: Girls
Body mass index-for-age percentiles
NAME
RECORD #
Date
Age
Weight
Stature
BMI*
Comments
*To Calculate BMI: Weight (kg) ÷ Stature (cm) ÷ Stature (cm) x 10,000
or Weight (lb) ÷ Stature (in) ÷ Stature (in) x 703
BMI
kg/m²
AGE (YEARS)
95
90
85
75
50
25
10
5
Published May 30, 2000 (modified 10/16/00).
SOURCE: Developed by the National Center for Health Statistics in collaboration with
the National Center for Chronic Disease Prevention and Health Promotion (2000).
http://www.cdc.gov/growthcharts
CDC
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Appendix E

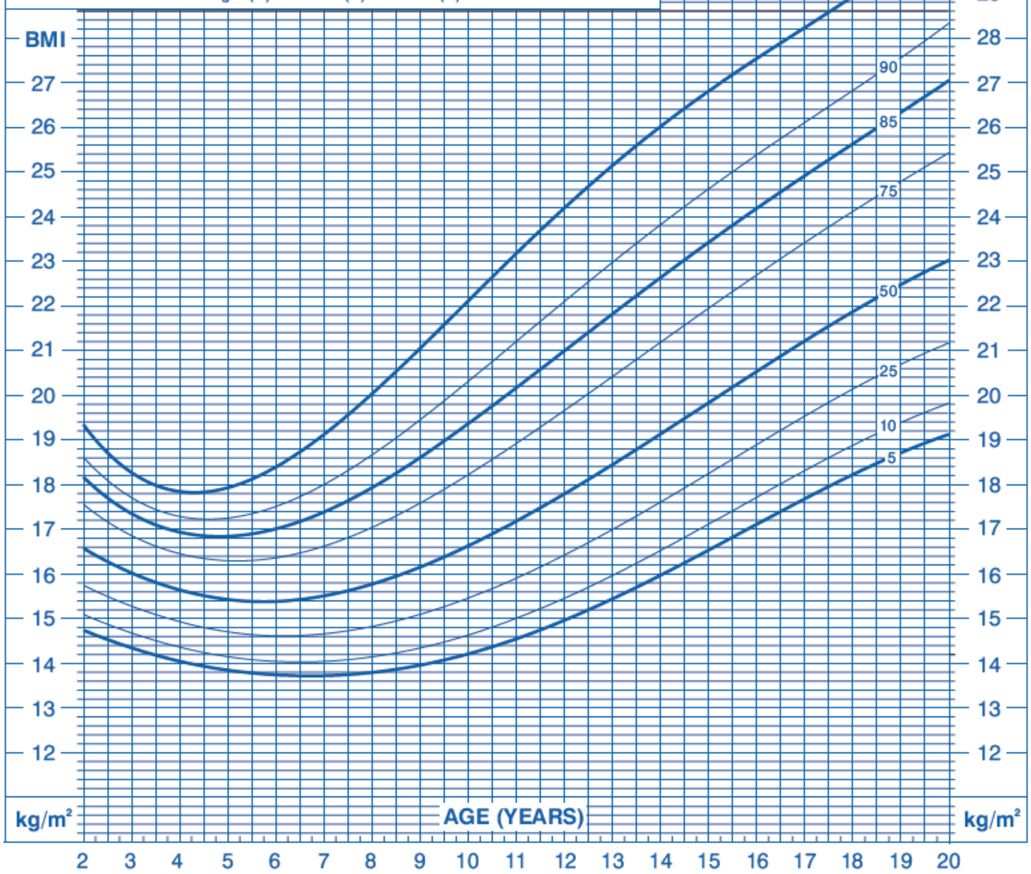
2 to 20 years: Boys
Body mass index-for-age percentiles

NAME ______________________

RECORD # ____________

Date	Age	Weight	Stature	BMI*	Comments

***To Calculate BMI**: Weight (kg) ÷ Stature (cm) ÷ Stature (cm) x 10,000
or Weight (lb) ÷ Stature (in) ÷ Stature (in) x 703



Published May 30, 2000 (modified 10/16/00).
SOURCE: Developed by the National Center for Health Statistics in collaboration with the National Center for Chronic Disease Prevention and Health Promotion (2000).
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