Evaluating the Associations between Physical Activity, Weight Gain and Academic Attainment in Primary School Children

Michael McCluskey[1,*], Janine Bridges[2], Neil Gilson[2,3], Jaap H Buurke[4,5], Hermanus J Hermens[4], Anand D Pandyan[1]

[1]School of Health and Rehabilitation, Keele University, UK
[2]Stoke on Trent City Council, UK
[3]Education through the Physical, UK
[4]Roessingh Research and Development, Enschede, the Netherlands
[5]Biomedical Signals and Systems, TechMed Centre, University of Twente, Enschede, The Netherlands
*Corresponding author: m.mccluskey@keele.ac.uk

Abstract **Objective** The aim of this study was to identify if there is an association between physical activity, body mass and academic attainment in primary school children. **Methods** Eighty-six children at a UK primary school were included in this cohort analysis. Physical activity status was determined using the Physical Activity Questionnaire – Children. Weight and height was measured, and BMI calculated at 4-time points. Academic attainment was measured from national standardised tests. **Results** Children who are less active demonstrated lower height (mean difference (MD) 0.49 95% CI 0.08 to 0.90), weight (MD 0.58 95% CI 0.12 to 1.04) and BMI z-scores (MD 0.48 95% CI -0.04 to 1.00) than children who are more active. They also had a higher rate of weight gain (0.06 z-score units/month), than children who are more active (0.05*z-core units/ month), and had greater fluctuations in weight. Children who were more active performed significantly better than children who are less active in writing (χ^2 16.40, p=0.003) and mathematics (χ^2 12.18, p=0.02). **Conclusion** There does appear to be an association between physical activity, body mass and academic attainment in primary school children, such that lower activity levels negatively effects growth and academic performance. These differences could not be solely explained by physical activity level due to unaccounted socio-economic factor.

Keywords: physical activity, academic attainment, growth, BMI, primary school, children

Cite This Article: Michael McCluskey, Janine Bridges, Neil Gilson, Jaap H Buurke, Hermanus J Hermens, and Anand D Pandyan, "Evaluating the Associations between Physical Activity, Weight Gain and Academic Attainment in Primary School Children." *Journal of Physical Activity Research*, vol. 4, no. 2 (2019): 90-96. doi: 10.12691/jpar-4-2-2.

1. Introduction

Childhood obesity is one of the most serious global health challenges of the 21st century [1]. Several factors including genetics, food consumption, physical inactivity, personal psychology and societal influences can contribute to the occurrence of obesity [2]. It is a complex concern occurring when a child is categorised above the normal weight range based on their age and height, and this can negatively affect a child's health status [3]. Children who are obese are twice as likely to develop into obese adults when compared to children of a normal weight [4]. In England, the prevalence of childhood obesity is increasing, with 19.8% of 10-11 year olds being categorised as obese [5], and regional variation from 16.2% in the South West to 23.6% in London [6].

In children, growth is monitored using body mass index (BMI), a ratio of height and weight measurements taken in relation to age and gender and compared to national reference charts. BMI thresholds are often defined as z-scores or centiles. Individually height and weight can also be plotted on a growth chart to determine patterns of growth and proximity to percentile lines [7,8]. Normal variations of between 1-2 percentiles are typically expected until the age of 3 years, beyond this, variability in growth trajectories are seen as a sign of growth disturbance [9]. In the UK, monitoring of BMI is not performed routinely, but may be undertaken by a health professional if it is medically indicated or within the National Child Measurement Program [10]. This program assesses overweight and obesity levels in children aged 4-5 years and 10-11 years, to allow the NHS to plan and provide services for children. Parents are informed of the assessment outcomes and may be offered advice on weight management if appropriate.

The use of BMI as an outcome measure may be limited as it does not consider body composition components of central adiposity, bone mass and muscle mass of the child and this may lead to misclassification of obesity [11] In addition to this, children who have a normal BMI, but who are at risk of experiencing increased rates of weight gain due to their behaviour may not be identified and supported, as risk factors for the development of obesity are not being routinely monitored. Consequently, resources and interventions to prevent or manage obesity may not be being directed to those individuals most in need and alternative approaches to monitoring growth in children is therefore indicated. One approach to this could be comprehensive monitoring of physical activity levels in primary school.

Physical activity is a vital component in the healthy growth and development of children, with physically active children demonstrating a reduced risk of developing obesity during their lifetime [12]. UK guidelines state that young people aged 5-18 years should engage in at least 60 minutes of moderate to vigorous physical activity every day [13]. However, the number of children achieving the minimum activity requirement is low, with only 20% of girls and 23% of boys meeting these recommendations [14].

It is becoming more widely acknowledged that increased measures of physical activity are associated with higher levels of academic achievement. More specifically, higher levels of cardiorespiratory fitness and reduced sedentary time are positively correlated to higher academic attainment [15,16,17]. Although the evidence base supporting the role of physical activity in improved academic attainment is growing, there has been little research published on this in primary school children in the United Kingdom. Due to the nature of the National Curriculum in the UK and its standardised testing, it represents a novel opportunity to study academic attainment in relation to the clear expectations set for student achievement nationally.

A significant number of UK citizens live in poverty despite the UK being one of the richest countries in the world. 4.1 million inhabitants were said to live below the poverty line in 2016/17 and it is widely predicted that this figure will continue to rise, with over 5 million inhabitants expected to be living in poverty by 2021 [18] Within the UK, Stoke-on-Trent is one of the most deprived local authorities in England and Residents have a lower than average income and levels of professional qualifications. This has resulted in over 27.5% of the city's 0-19 year olds classified as living in poverty, well above the national average of 19.9% [19]. Understanding the affect of physical activity on growth and academic attainment in children in an area of high deprivation can provide a novel insight into the potential impact of increasing childhood poverty in the UK.

The aim of this retrospective study is to identify if there is an association between physical activity, body mass and academic attainment in primary school children.

2. Methods

2.1. Participants

Children and their parents from Years 4, 5 and 6 at one primary school in Stoke-on-Trent Staffordshire, UK, were invited to participate in this cohort analysis. Children and parents were asked to provide assent and written consent respectively in order for participation. All children participated in regular physical education at school as recommended in the National Curriculum in England for Physical Education [20]. Additionally, children participated in 60 minutes of interval training via indoor rowing, completed at self-selected intensities and delivered by a qualified rowing instructor once a week for 24 weeks. Children in year 6 had carried this out for 3 years, year 5 for 2 years and year 4 for 1 year. Approval was granted to conduct this study by an Institutional Review Board.

2.2. Outcome Measures

Physical Activity. Physical activity status was determined using the Physical Activity Questionnaire – Children (PAQ-C) [21]. This is a self-administered, 7 day recall questionnaire that measures moderate to vigorous activity during the school year and has been shown to have acceptable validity, reliability and internal consistency [21,22,23]. This study utilised a modified version which had been validated for use in the United Kingdom [24].

It is a 10 item questionnaire with each question scored 1-5 with 1 indicating none/low physical activity and 5 indicating high physical activity. Based on the student's responses a mean score was calculated. An overall score of 2.9 or less indicates a student who is less physically activity and a score of 3 or above indicates a student who is more active. Children completed this at the beginning and end of the academic year and an average score calculated for each child.

Height and Weight. Measurements of weight and height were recorded at 4 time points during the academic year; in September, December, January and April. Measurements were recorded by the respective teachers of each year group. All staff were trained to ensure measurements were consistently taken and recorded. Weight was measured using a standard set of personal weighing scales with digital display and recorded in kilograms (kg) and height using a standard Leicester height measure and recorded in centimetres (cm) with clothes on and shoes off. After these measures were taken, z-scores for height, weight and BMI were calculated in a Microsoft Excel add-in [25] using the LMSgrowth method [26]. Normal BMI was classified as having a BMI between 2-85th percentile, overweight 85-95th percentile and obese was >95th percentile.

Academic Attainment. Academic attainment was measured using results from end of stage examinations. The national curriculum sets the program for study and attainment for all school children in the UK who attend a local authority maintained school [20]. Children study 3 core subjects (writing, Mathematics and Science). A student who was performing below expectations would be awarded level 1 or level 2c, a student who was meeting expectations at the end of Key stage 1 would be awarded Level 2b, a student exceeding expectations would be awarded Level 2a or Level 3. All children who participated in the study had completed key stage 1; year 6 in 2015, year 5 in 2016 and year 4 in 2017.

2.3. Data Analysis

IBM SPSS Statistics for Windows, Version 24.0. Armonk, NY: IBM Corp, was used to analyse the results. Changes in mean weight, height and BMI during the academic year was analysed using a paired samples t-test and an independent samples t test to determine differences between groups at each time point. A Chi-square test of homogeneity was ran to determine if the probability distributions of academic attainment in reading, writing and mathematics for less active and active groups.

3. Results

In total, there were 86 (37 male and 49 female) children who took part in this study. It included 28 in year 4 (8.99 ±.25 years), 26 in year 5 (10.01 ±.18 years), and 32 in year 6 (11.08 ±.3 years). In total 43 were found to be 'less active' and 33 as 'more active'. 10 children did not receive a physical activity classification, due to absence on the day when PAQ-C was completed in September (n=5), April (n=3) or both (n=2). There were no differences in physical activity levels based on gender (p=0.12) or year of study (p=0.34) as assessed by Pearsons chi square.

At baseline, there was a difference in weight, height and BMI between groups (Table 1) with children who are less active in this cohort having a lower weight, height and BMI. 62 (72.3%) children had a BMI within the normal range, 14 (16.3%) had a BMI in the overweight range and 10 (11.6%) had a BMI in the obese range. There were no differences in BMI category based on physical activity level as assessed by Pearsons chi square (p=0.22).

3.1. Changes in Weight, Height and BMI during the Academic Year

As expected over the course of the academic year children experienced increases in weight and height consistent with the maturation process. There was a significant increase in overall mean weight of 3.21kg, (95% CI 2.81 to 3.62), and in weight z-score of 0.44 (95% CI 0.39 to 0.49). There was a significant increase in mean height of 4cm (95% CI 3.41 to 4.59) and in height z score of 0.62 (95% CI 0.53 to 0.71). There was a significant increase in mean BMI Centile of 6.04% (95% CI 2.76 to 9.33) and in BMI z-score of 0.23 (95% CI 0.13 to 0.33). The vast majority of children BMI category remained unchanged during the academic year, with only 3 children experiencing a BMI centile increase significant enough to change from the normal to overweight range and 3 from the overweight to obese range.

Table 1. Baseline Statistics showing height, weight and BMI in September

| | Mean (SD) | | Mean Difference | 95% CI | | Significance |
	Less Active	More Active		Lower	Higher	
Weight (kg)	33.014 (7.42)	37.53 (7.47)	4.52	1.09	7.45	0.01*
Weight z-score	0.05 (.99)	0.63 (1.0)	0.58	0.12	1.04	0.01*
Height (cm)	138.98 (7.7)	143.15 (7.5)	4.17	0.66	7.69	0.02*
Height z-score	0.15 (.91)	0.64 (.86)	0.49	0.08	0.90	0.02*
BMI Centile	46.48 (31.65)	61.04 (32.96)	14.56	-0.30	29.52	0.06
BMI z-score	-0.06 (1.1)	0.42 (1.2)	0.48	-0.04	1.0	0.07

Level of Significance p=0.05. * indicates statistically significant difference.

Table 2. Showing Difference between groups in Weight, Height and BMI in December, January and April

| | | Mean (SD) | | Mean Difference | 95% CI | | Significance |
		Less Active	More Active		Lower	Higher	
December	**Weight (kg)**	35.83	41.15	5.33	1.49	9.16	0.01*
	Weight z-score	.50	1.02	.52	0.06	0.97	0.03*
	Height (cm)	142.65	147.52	4.87	0.94	8.79	0.02*
	Height z-score	.71	1.32	0.61	0.18	1.05	0.01*
	BMI Centile	53.26	64.76	11.50	-3.09	26.09	0.121
	BMI z-score	0.20	0.57	0.37	-0.16	0.89	0.168
January	**Weight (kg)**	34.54	38.48	3.94	0.14	7.74	0.04*
	Weight z-score	0.28	0.75	0.47	-0.003	0.95	0.05
	Height (cm)	139.43	144.13	4.70	0.90	8.51	0.02*
	Height z-score	0.25	0.73	0.49	0.65	0.91	0.02*
	BMI Centile	52.85	61.03	8.18	-7.54	23.90	0.30
	BMI z-score	0.21	0.41	0.20	-0.38	0.77	0.50
April	**Weight (kg)**	33.82	38.74	4.92	1.17	8.66	0.01*
	Weight z-score	0.18	0.78	.59	.11	1.07	0.02*
	Height (cm)	140.24	144.30	4.06	.38	7.74	0.03*
	Height z-score	0.38	0.90	.43	.01	0.84	0.04*
	BMI Centile	47.67	63.93	16.26	.87	31.65	0.04*
	BMI z-score	-0.04	0.53	0.57	.01	1.13	0.05

Level of Significance p=0.05. * indicates statistically significant difference.

Table 3. Table showing differences in Regression coefficient showing gain of BMI z-score in school year groups

			Mean *b*	St. Dev	95% CI		Significance
					Lower	Higher	
Regression coefficient (*b*)	**Year 4**	Less Active	0.08	0.03	0.0005	0.04	0.04*
		Active	0.06	0.02			
	Year 5	Less Active	0.05	0.03	-0.27	0.03	0.85
		Active	0.05	0.04			
	Year 6	Less Active	0.05	0.04	-0.33	0.32	0.98
		More Active	0.05	0.04			

Level of Significance p=0.05. * indicates statistically significant difference.
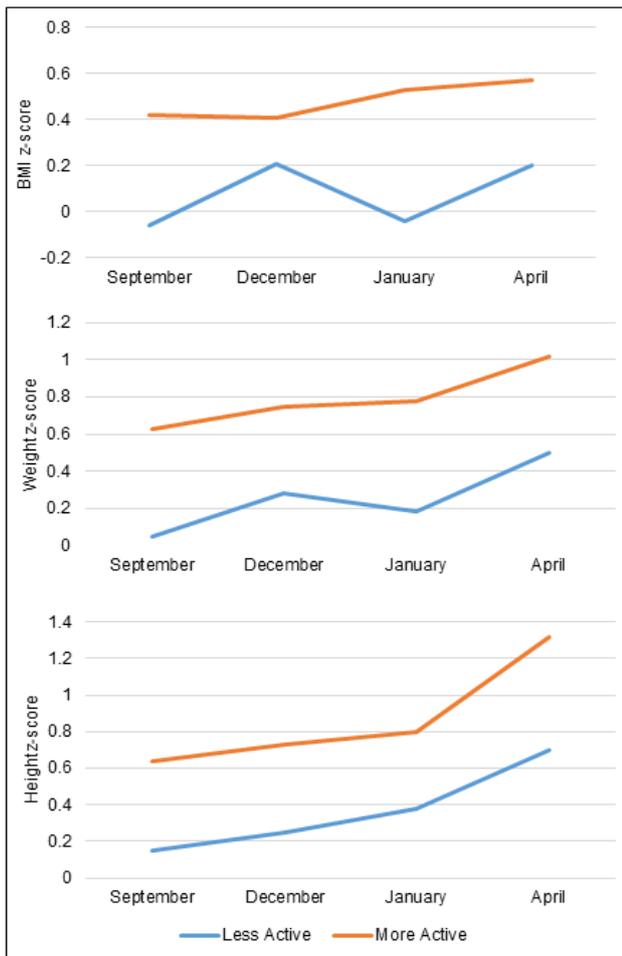
Figure 1. Line graphs showing BMI, Weight and Height z-score change during 2016/17 academic year

3.2. Comparison of Changes in Weight, Height, BMI between Groups

At baseline, the less active group had lower outcomes on all measures when compared to the more active group. These differences were maintained at each time point over the academic year (Figure 1 and Table 2). There appears to be a difference in rate of mean weight gain during the academic year between children who are more active and those who are less active. The rate of weight z score gain for children who are less active 0.06 z-score units/month is higher in comparison to that of children who are more active at 0.05 z-score units/month, however, the rate of rate growth seems to be more prominent in year 4, but appears to converge in year 5 and becomes almost parallel in year 6 (Table 3). Furthermore the mass gain was more consistent in the active group compared to the less active

group indicated by a by a reduction in mass between December and January in the children who are less active (Figure 1).

3.3. Educational Attainment

Educational attainment is presented in Figure 2. In the Reading examination, although there appears to be a trend indicating that children who are more active as measured by PAQ-C, achieving higher levels on Key Stage 1 Reading than their peers who are less active, a chi-square test of homogeneity has indicated that there was no significant difference between the two groups $\chi^2 (4) = 6.422$, p=0.17. In the Writing and mathematics, the distributions were not equal indicating a significant difference among the children, with those catagorised as being more active by PAQ-C, achieving higher than their peers who are less active ($\chi^2 (4) = 16.40$, p=0.003 and $\chi^2 (4) = 12.18$, p=0.02 respectively).
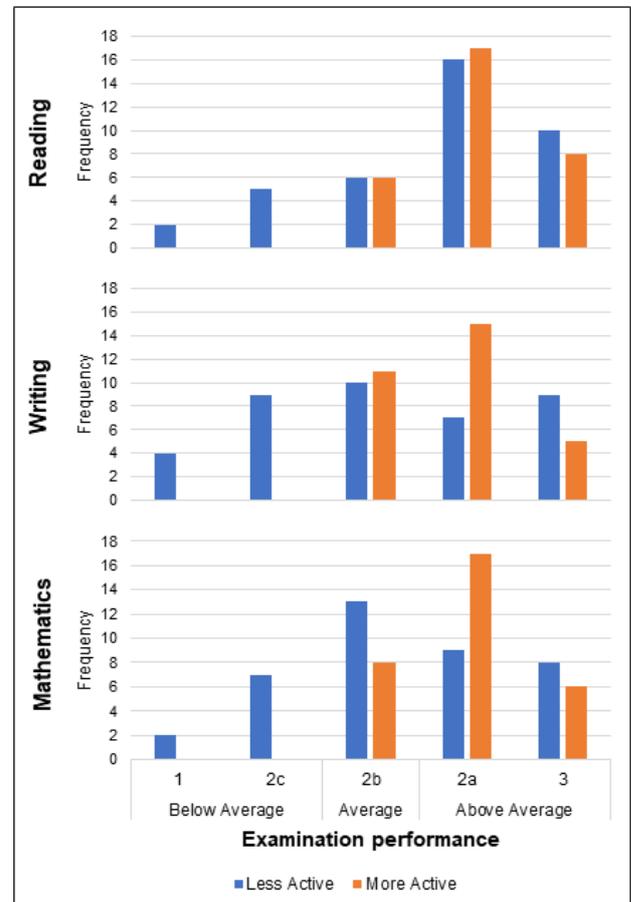
Figure 2. Bar chart showing educational attainment in Reading, Writing and Mathematics

4. Discussion

4.1. Effect of Physical Activity on Weight, Height and BMI

Results from this study show that there is a statistically significant difference in body mass between primary school children who are active and less active. Children that are less active have a lower weight, height and BMI when compared to children who are physically active. This statistically significant difference was present at baseline, and was maintained throughout the academic year. This finding is contrary to the well established theory that physical activity is inversely related with weight [27]. It is generally acknowledged that a child who was less physically active over a prolonged period of time would expend less energy, which, unless accompanied by a reduction in calorie consumption, could lead to an increase in the accumulation of adiposity, weight gain and BMI [28]. However, the population in this study is socially and culturally different from those studied previously [29,30]. For example, the demographic in this sample is from an area in the UK that has high levels of deprivation who access a greater number of free school meals, with some areas of affluence.

The children who are more active demonstrate behaviour consistent with normal physical development, however, the less active group demonstrate a greater variability in their weight gain and in BMI. There is literature that demonstrates that people who show greater variability in mass are at risk of becoming overweight or obese in later life [31]. It is possible that the children who are less active in our sample are from families from a lower socioeconomic background. Fluctuations in the less active groups mass, seen as a decrease in mean weight and BMI z-score occur during the holiday period, where access to free school meals, regular meal times and physical activity are not available. This is in comparison to the more active group that see a normal increase in weight during the academic year. This is consistent with findings from Jones, Hendricks, Draper [32] and Baharudin, Zainuddin, Manickam, Ambak, Ahmad, Naidu, Cheong, Ying, Saad, Ahmad [33] who have also observed this in south African and Malaysian populations. It should also be noted that the overall trajectory of BMI change is greater for children who are less active which may lead to them accumulating weight at a greater rate, despite weight loss over the holiday period which may have attenuated the rate of weight gain in students who are less active. As a result, it could be hypothesised, that there are children in this cohort that currently have a normal BMI and would be deemed developing normally, however, their behaviour puts them at a risk of being of an abnormal weight in the future.

Although the children who are less active have a higher trajectory of weight gain when compared to children who are more active, this difference appears to be attenuated by year of study. There is a statistically significant difference in BMI z score regression coefficient at year 4, however, no difference is observed at year 5 and 6. A key difference between year groups, is the length of time participating in weekly interval training in the form indoor rowing in addition to their physical education curriculum. It could be possible this additional exercise intervention is conveying a health benefit to children who are less active, although, it cannot be concluded with any certainty at this time. There is literature supporting short bouts of daily exercise which leads to improvements in health; interval training for as little as 10 minutes per day has been shown to be health protective [34]. Further research on the effect of this additional physical activity intervention would be beneficial.

4.2. Academic Attainment

These results show that physically active children achieve higher levels of academic attainment than their less physically active peers in this cohort. All physically active children achieved average or above average performance in Key Stage 1 Reading, Writing and Mathematics. Only those children categorised as children who are less active achieved levels equating to below average level performance. It was interesting to note that the highest level of performance in Key Stage 1 testing, level 3, was achieved more frequently by children who are less active. At this time, there is not sufficient information to explain this difference, however, it may be related to these children who are less active having a preference for sedentary activities relating to academia such as reading and writing, limiting time available for physical activity.

These results are in keeping with recent findings that physical activity is associated with academic achievement, with higher levels of cardiorespiratory fitness and reduced sedentary time correlating to positive academic attainment [15,16,17,35]. There a number of current explanations for this which include: increases in size of the cerebellum, motor cortex and hippocampus, angiogenesis, neurogenesis, increased density of grey matter volume, glial cells concentration increases and changes in cerebral blood flow and oxygenation [36]. This is thought to lead to functional improvements with positive changes in memory, critical thinking [37], decision-making and concentration [38]. However, it must be acknowledged that academic achievement is also influenced by, individual, biological, environmental and socioeconomic factors which cannot be accounted for in this study.

4.3. Limitations

This was a retrospective analysis of previously collected data. In such circumstances, it is possible to study associations in behaviour but causality cannot be demonstrated. Confounding factors could not be documented or controlled and in this study the confounding factors were; socioeconomic status of children and their families, school attendance, classroom behaviour, health status, access to extra-curricular activities, special needs such as dyslexia, prior academic performance. Relating to outcome measures, we could not differentiate between fat mass and fat free mass and due to the nature of data collection in primary schools. Although common approaches to outcome measurement were taken, errors in data collection could exist due to local variation and the implementation of the protocol.

5. Conclusion

The aim of this study was to identify if there was an association between levels of physical activity, body mass and academic attainment in primary school children. There does appear to be an association, such that lower activity levels negatively affects growth and academic performance. It was worth noting that children who are less active had greater fluctuation in weight during their academic year and had a greater overall trajectory of BMI gain. As such there may be value in regularly monitoring physical activity in children with a view to identifying children who may be at risk of future growth disturbances or would benefit from additional academic support.

However, it is not possible to conclude with any certainty that these differences are explained solely by physical activity level, given the confounding variables we have already discussed. A pragmatic explanation could be that children from a higher socioeconomic background could have more opportunity to engage in intellectual and physical activities and demonstrate normal developmental milestones and perform better academically. It is recommended that further analysis of the associations between physical activity, growth and academic attainment are conducted accounting for the personal, economic, societal and environmental factors that lead to inequality.

Conflict of Interest Statement

Sources of Funding

Acknowledgements

References

[1] World Health Organization. Report on the commisson on Ending Childhood Obesity. Implementation Plan: Executive Summary. In. Geneva: World Health Organisation; 2017.

[2] Public Health England. Making Every Contact Count (MECC): Consensus Statement. In. Leeds: Public Health England; 2016.

[3] Reilly JJ, Methven E, McDowell ZC, et al. Health consequences of obesity. *Archives of Disease in Childhood.* 2003; 88(9): 748.

[4] Serdula MK, Ivery D, Coates RJ, Freedman DS, Williamson DF, Byers T. Do Obese Children Become Obese Adults? A Review of the Literature. *Preventive Medicine.* 1993; 22(2): 167-177.

[5] NHS Digital Lifestyles Team. National Child Measurement Programme England 2015/16 School Year. In. Leeds: Health and Social Care Information Centre; 2016.

[6] Public Health Profiles: Child and maternal Health. Public Health England; 2016. https://fingertips.phe.org.uk/profile/child-health-profiles/data#page/1/gid/1938133228. Accessed 01/10/2018.

[7] Mei Z, Grummer-Strawn LM, Thompson D, Dietz WH. Shifts in Percentiles of Growth During Early Childhood: Analysis of Longitudinal Data From the California Child Health and Development Study. *Pediatrics.* 2004; 113(6): e617.

[8] Cole TJ. The development of growth references and growth charts. *Annals of human biology.* 2012;39(5):382-394.

[9] Canadian Paediatric Society. A health professional's guide to using growth charts. *Paediatrics & Child Health.* 2004; 9(3): 174-176.

[10] NHS Digital. National Child Measurement Program. 2018; https://digital.nhs.uk/services/national-child-measurement-programme/.

[11] Griffiths C, Gately P, Marchant Paul R, Cooke Carlton B. Cross-Sectional Comparisons of BMI and Waist Circumference in British Children: Mixed Public Health Messages. *Obesity.* 2012; 20(6):1258-1260.

[12] Riner WF, Sellhorst SH. Physical activity and exercise in children with chronic health conditions. *Journal of Sport and Health Science.* 2013; 2(1): 12-20.

[13] Department of Health. UK Physical Activity guidelines Fact Sheet 3: Children and young People (5-18 Years old). In. London: Department of Health; 2011.

[14] NHS Digital. Health Survey for England, 2015. In. London: Health and Social Care Information Centre; 2016.

[15] Oliveira T, Pizarro A, Costa M, et al. Cardiorespiratory fitness, but not physical activity, is associated with academic achievement in children and adolescents. *Annals of Human Biology.* 2017; 44(4): 309-315.

[16] Asigbee FM, Whitney SD, Peterson CE. The Link Between Nutrition and Physical Activity in Increasing Academic Achievement. *J Sch Health.* 2018;88(6):407-415.

[17] Garcia-Hermoso A, Marina R. Relationship of weight status, physical activity and screen time with academic achievement in adolescents. *Obesity Research & Clinical Practice.* 2017; 11(1): 44-50.

[18] Marsh A, Barker K, Ayrton C, Treanor M, Haddad M. *Poverty: The Facts.* London 2018.

[19] Stoke-on-Trent City Council. *Health Profile 2017.* Stoke-on-Trent 2017.

[20] Department for Education. The national curriculum in England: Key stages 1 and 2 framework document. In. London: Department for Education; 2013.

[21] Kowalski KC, Crocker P, M Donen R, Honours B. The Physical Activity Questionnaire for Older Children (PAQ-C) and Adolescents (PAQ-A) Manual. 2004.

[22] Kowalski KC, Crocker PRE, Faulkner RA. Validation of the Physical Activity Questionnaire for Older Children. *Pediatric Exercise Science.* 1997; 9(2): 174-186.

[23] Janz K, Lutchy E, Wenthe P, Lecy S. Measuring Activity in Children and Adolescents Using Self-Report: PAQ-C and PAQ-A. *Medicine and science in sports and exercise.* 2008; 40(4): 467-472.

[24] Aggio D, Fairclough S, Knowles Z, Graves L. Validity and reliability of a modified english version of the physical activity questionnaire for adolescents. *Archives of Public Health.* 2016; 74: 3.

[25] Pan H, Cole T. LMSgrowth, a Microsoft Excel add-in to access growth references based on the LMS method. 2011; Version 2.74: http://www.healthforallchildren.co.uk/.

[26] Cole T. *The LMS method for constructing normalized growth standards.* Vol 441990.

[27] Kong IG, Lee HJ, Kim SY, Sim S, Choi HG. Physical Activity, Study Sitting Time, Leisure Sitting Time, and Sleep Time Are Differently Associated With Obesity in Korean Adolescents: A Population-Based Study. *Medicine (Baltimore).* 2015; 94(44): e1965.

[28] Schwarzfischer P, Weber M, Gruszfeld D, et al. BMI and recommended levels of physical activity in school children. *BMC Public Health.* 2017; 17: 595.

[29] Hussey J, Bell C, Bennett K, O'Dwyer J, Gormley J. Relationship between the intensity of physical activity, inactivity, cardiorespiratory fitness and body composition in 7-10-year-old Dublin children. *Br J Sports Med.* 2007; 41(5): 311-316.

[30] Wang H, Blanco E, Algarín C, et al. Weight Status and Physical Activity: Combined Influence on Cardiometabolic Risk Factors Among Adolescents, Santiago, Chile. *Global Pediatric Health.* 2016; 3: 2333794X16674561.

[31] Li S, Chen W, Sun D, et al. Variability and rapid increase in body mass index during childhood are associated with adult obesity. *International Journal of Epidemiology.* 2015; 44(6): 1943-1950.

[32] Jones S, Hendricks S, Draper CE. Assessment of Physical Activity and Sedentary Behavior at Preschools in Cape Town, South Africa. *Childhood Obesity.* 2014; 10(6):501-510.

[33] Baharudin A, Zainuddin AA, Manickam MA, et al. Factors Associated With Physical Inactivity Among School-Going Adolescents: Data From the Malaysian School-Based Nutrition Survey 2012. *Asia Pacific Journal of Public Health.* 2014; 26(5_suppl): 27S-35S.

[34] Eddolls WTB, McNarry MA, Stratton G, Winn CON, Mackintosh KA. High-Intensity Interval Training Interventions in Children and Adolescents: A Systematic Review. *Sports Med.* 2017; 47(11): 2363-2374.

[35] El Ansari W, Stock C. Relationship between attainment of recommended physical activity guidelines and academic achievement: undergraduate students in Egypt. *Glob J Health Sci.* 2014; 6(5): 274-283.

[36] Thomas AG, Dennis A, Bandettini PA, Johansen-Berg H. The Effects of Aerobic Activity on Brain Structure. *Frontiers in Psychology.* 2012; 3: 86.

[37] Castelli DM, Hillman CH, Hirsch J, Hirsch A, Drollette E. FIT Kids: Time in target heart zone and cognitive performance. *Preventive Medicine.* 2011; 52: S55-S59.

[38] Mahar MT. Impact of short bouts of physical activity on attention-to-task in elementary school children. *Preventive Medicine.* 2011; 52: S60-S64.