Associations between swimming & cycling abilities and fitness in 9-11 year old boys and girls

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Abstract

The associations between swimming and cycling abilities and fitness levels in 9–11-year-old children were examined. A cross-sectional study involving 2258 children (50.7% boys; aged 10.52 ± 0.6 years) from 33 schools across Wales, participated in Swan/BridgeLinx health, fitness, and lifestyle programmes between 2013–2019. Health and fitness data were collected; namely body composition, cardiorespiratory fitness, muscular strength, flexibility, power, and speed using standardised measures. Children completed an online survey collecting data on swimming and cycling abilities and sports club attendance. Multivariate multilevel regressions were used to examine the associations between measures. The ability to swim and cycle was significantly ($p < 0.05$) associated with all components of fitness when accounting for age, body mass index (BMI), deprivation, gender, and sports club attendance. Boys outperformed girls with significant interactions between swimming, cycling and cardiorespiratory fitness for gender by swim ($p = 0.001$) and gender by cycle ($p = 0.015$). The gender by cycle interaction significantly predicted grip strength and power ($p < 0.05$). Swimming and cycling are important "milestones" in the journey of motor development and are associated with higher levels of fitness. These activities should be promoted to allow for an optimal development of motor skills, fitness, and health. ***KEYWORDS:*** *children, fitness, swimming, cycling, motor competence.*

1.Introduction

Swimming and cycling are foundational movement competencies (Hulteen, et al., 2018) that provide a gateway to a plethora of health promoting physical activity opportunities. The term "foundational movement skills" has been developed to incorporate both traditional fundamental movement skills, that are necessary for participation in physical activity, together with additional supporting skills that, developed correctly, will increase opportunities for participation (Hulteen et al., 2018). Moreover, children's ability to swim or cycle are important to reduce the risk of drowning (Asher et al., 1995) and improve road safety (Corden et al., 2005). Both swimming and cycling are highly accessible activities to children, through national curriculum policy, which helps with achieving physical activity recommendations and promoting fitness. Longitudinal studies on children between 6 and 13years of age, within Europe, emphasise the potential long-term impact that developing motor competence has on physical activities (Fransen et al., 2014; Lima et al., 2019). Developing motor competence improves the way that someone can control and move their body. Therefore, children who are unable to swim and cycle may be lacking in foundational movement skills which would aid in promoting an active lifestyle and fitness across the lifespan (Stodden et al., 2009).

Studies have demonstrated decreases in both children's and adult's fitness levels through time; this includes both muscular (Müllerová et al., 2015) and cardiorespiratory fitness (Vaara et al., 2020). Cardiorespiratory fitness is arguably the most important component of fitness, as early research found strong associations between poor cardiorespiratory fitness and all-cause mortality (Blair, 1989). With children's cardiorespiratory fitness declining in high and middle income countries (Tomkinson et al., 2019), communities and schools have placed interventions to combat this; finding that appropriate school-based physical activity programmes, which include aerobic activities such as skipping, dancing and running, are effective in increasing cardiorespiratory fitness in children (Pozuelo-Carrascosa et al., 2018) . These school-based physical activity programmes can be run as extra-curricular sports clubs and being a member of a sports club has also shown positive associations with fitness levels in children (Larsen et al., 2017). Children from more affluent families are more likely to attend extra-curricular or community sports clubs than their more deprived peers (Basterfield et al., 2015). Socioeconomic status is also associated with swimming ability, where more deprived children are less likely to be able to swim 25m than their more affluent peers (Sport England, 2019). A study by Henrique et al. (2016) found that organised sport participation in early childhood significantly increased the likelihood of continuation throughout childhood. Providing both structured and context-specific unstructured opportunities for children to learn motor skills, play a critical role in both the quality and quantity of physical activity individuals engage in across the lifespan (Brain et al., 2020).

The positive relationship between physical activity and motor competence in children has received attention (Stodden et al., 2008), finding that associations increase in strength as children age, yet fewer studies have examined relationships between foundational movement skills such as swimming and cycling and fitness. While there is some evidence that fundamental movement skills are related to fitness in children (Jaakkola et al., 2019), cycling or swimming competence is largely missing from the extant literature. This is surprising given the high value placed on the importance of children learning to swim and cycle. Associations have been found between health outcomes such as bone health in swimming (Gómez-Bruton et al., 2013) and obesity in cycling (Ming Wen and Rissel, 2008), however, there is a lack of evidence on associations between these factors and fitness levels in children, particularly where both swimming and cycling are considered.

The purpose of this study was therefore to examine the associations between fitness and swimming and cycling proficiency in primary school boys and girls. We hypothesised that a) being able to swim and cycle would be positively associated with fitness and b) that there would be gender interactions between boys and girls fitness and swimming and cycling abilities.

2.Methods

2.1 Participants and Settings

Thirty-three, primary schools took part in the SwanLinx and BridgeLinx programmes (Sheldrick, et al. 2018; Tyler, et al. 2019) to assess multiple components of fitness, health, wellbeing and lifestyle behaviours in a local further or higher education setting. All children in school years 5 and 6 were invited to take part in the study and written consent was sought from parents, headteachers and assent from children. The inclusivity of the programmes meant that children with registered disabilities took part in the project, but their data was not used. Between 2013 and 2019, consent was obtained, and data collected for 2258 children (50.7% boys; aged 10.52±0.6years; BMI 19.14±3.79).

2.2 Instruments and Procedures

Fitness Fun Days

Children attended a "fitness fun day" in an indoor sports hall where they completed a battery of six fitness assessments selected from the EuroFit battery (Adam et al., 1988). The fitness fun days have previously been described (Taylor et al., 2004) and the measures have shown acceptable test/re-test reliability (Boddy et al., 2010). All fitness assessments were conducted by trained assessors.

Skill-Related Components of Fitness

Children completed the following assessments to measure skill-related components of fitness: standing long jump (power), the 10x5m shuttle run (speed) and the speed bounce test (speed and coordination). Power was measured using a standing long jump mat and distance jumped was measured in cm; children had three trials of this assessment and their best jump was recorded. The 10x5m shuttle run was measured in seconds and therefore lower scores indicate a higher performance. Children took part in speed bounce twice and their best effort was recorded as their final score.

Health-Related Components of Fitness

The health-related components of fitness included measures of strength, cardiorespiratory fitness, flexibility, and BMI. Strength was measured in kilograms (kg) using a handgrip dynamometer [Takei Corp Ltd., Tokyo, Japan] to provide an indication of overall muscular strength. The standard EuroFit protocol for using the handgrip dynamometer was adhered to. Cardiorespiratory fitness was measured using the 20m multistage fitness test (MSFT), where children's performance was assessed by number of shuttles that they completed before failing to meet the requirements of the test. Flexibility was measured using the sit and reach protocol. Anthropometric measures were taken including standing height, sitting height and body mass. A portable height stadiometer [Seca 213 portable stadiometer, Seca Ltd, Birmingham, Uk], a sitting height stadiometer [Harpenden Sitting Height Table, Holtain Ltd, Pembrokeshire, UK] and electronic weighing scales [Seca 813, Seca Ltd, Birmingham, UK] were used. BMI was calculated (BMI=body mass (kg)/height2(m)) and BMI z-scores were obtained from the UK 1990 growth reference curves (1995), using the 2nd centile to categorise as underweight, 85th as overweight and 95th as obese.

CHAT Survey (Child Health & Activity Tool)

Children also completed a self-report online survey as a routine measure during their school day. They completed the CHAT survey (Todd et al., 2016) that has acceptable validity (Everson et al., 2019) under supervision of their teachers who used a standardised information sheet and video to explain the aims of the study, confidentiality and withdrawal information. The survey is child-friendly and captures a wide range of lifestyle behaviours. The data used in this study included whether the children could i) ride a bike, ii) swim 25 m and iii) whether they were a member of a sports club.

Confounding Variables

Demographic characteristics such as date of birth, gender and postcode were collected from the school. Date of birth was used to calculate the children's decimal age. Home postcodes were used to calculate deprivation scores using the Welsh Index of Multiple Deprivation (WIMD). The WIMD uses eight domains, weighted in the following order: income, employment, health, education, access to services, housing, community safety and physical environment; to rank the areas within Wales from 1 being the highest deprivation area to 1909 being the least deprived.

3. Design and Analysis

Of the 2258 participants, 7 were found to be ≥12years of age and were excluded due to our target age being 9–11years of age, a further 1 was removed due to not having any fitness data recorded. There were a small number of outliers detected (18) and removed from the analysis. Seventeen consecutive participants were identified with a standing long jump score of more than 3 standard deviations away from the mean, whilst one participant's height was above a realistic range. A further 114 participants were removed as they were missing at least one of the dependent variables, decimal age, BMI, WIMD or had not completed the CHAT survey. Therefore, the final sample included 2,118 participants.

Statistical Analysis

Given that the data was collected across 33 schools, it is likely children from the same school share some characteristics. Intraclass correlations (ICC) indicated that schools accounted for between 5.2% and 23.9% of the variance in the dependant variables. Therefore, to account for the nested structure of the data, a multivariate, multilevel model with a random intercept was fitted to investigate whether being able to swim and cycle predicted the various components of fitness. MLwiN (version 3.05) was used for the analysis. At level 1 multiple responses (the fitness scores) from individuals were treated as repeated measures nested within that respondent. Three models were fitted sequentially. First, the "null model" containing only the individual and school-level structure was fitted (model 1). The main variables of interest, swimming, and cycling together with covariates decimal age, gender, BMI z-scores, deprivation and sports club attendance were then added (model 2). Finally, to test the moderating effect of gender, two-way interactions (gender-by-swim and gender-by-cycle) were added to the model (model 3). The −2loglikelihood values were compared using Chi-squared to ensure a step-by-step increase in variance captured for each model. The alpha level for significance was set at $p < 0.05$ for all analyses. The regression coefficient and their standard error were used to evaluate the significance of the relationship generating a p-value within MLwiN using the compare models' window. Significance values were derived using the Wald statistic (2007).

3. Results

Descriptive data are included in Table 1. To summarise the children had a mean age of 10.51±0.6years. Almost 60% of children were of a healthy weight, the remaining 23.49%, 15.44% and 1.32% being obese, overweight, and underweight respectively. A fifth of children reported that they were unable to swim (20.10%) whereas less than one in ten were unable to ride a bike (7.80%). Over 85% of children reported being a member of a sports club. Table 2 shows means and standard deviations for each fitness variable, split by gender, swim and cycle proficiency and sports club attendance. As shown in Table 2 boys outperformed girls in all fitness components except flexibility where girls outperformed boys.

Each regression model (1 through 3) increased the variance accounted for (−2logliklihood values) resulting in model 3 providing the main results (Table 3). The step-by-step increase in variance from models of the multivariate multilevel analysis can be seen from the −2loglikelihood values and Chi-squared significance levels in Table 4. It shows how the final model (model 3) was built and how each model significantly improved on the previous one, by adding extra variables; this can be seen by the significant chances in the −2 Log Likelihood ($p<0.001$).

3.1 Swimming

After controlling for school level differences, and adjusting for decimal age, BMI, gender, deprivation, and sports club attendance, swimming was a significant predictor of all six fitness variables ($p<0.05$) (Table 3). Children who could swim significantly outperformed their non-swimming counterparts in all measures of fitness. Moreover, there was a significant gender x swimming interaction for cardiorespiratory fitness ($\beta=4.846$, p =<0.001). Boys who could swim completed over 7 more shuttles (140 m) on the MSFT than those who could not. This difference was less marked in girls, as those who could swim completed 2.3 (46 m) more shuttles than those who could not. Girls in the could not swim group, on average, achieved higher grip strength scores than boys in the same group.

3.2 Cycling

Children who could ride a bike performed significantly better ($p<0.05$) than those who could not in all fitness tests (Table 3). A significant gender x cycling interaction was evident for grip strength ($\beta=1.699$, $p=0.02$), cardiorespiratory fitness ($\beta=5.513$, $p=0.015$) and power ($\beta=6.554$, $p=.049$). Interestingly, girls who could not cycle had a superior grip strength than boys who could not cycle. However, boys who could cycle had 2.52 kg stronger grip strength than boys who could not cycle whereas girls who could cycle were only 0.83 kg stronger than girls who could not cycle, meaning that boys who could cycle then outperformed girls who could cycle in this component of fitness. The other significant gender x cycling interactions occurred in the MSFT and standing long jump, where girls in both cycle and non-cycle groups were outperformed comparatively by boys. The difference between boys who could and could not cycle exceeds the difference in girls for cardiorespiratory fitness and power. Boys who could cycle could jump 15.38 cm further than boys who could not, whilst the girl's difference was half this, at 8.83 cm. In the MSFT, the difference was almost double, again, where boys would achieve 9.69 shuttles more if they could cycle and girls 4.18 shuttles.

The strength of the predictions of fitness varied but it was noticeable that the only fitness test where swimming was a stronger predictor than cycling was the 10x5m shuttle run, measuring speed. Children who could swim were 0.92 seconds faster than children who could not; whereas children who could cycle were 0.81 seconds faster than those that could not. In all other fitness tests, being able to cycle had a greater impact on performance than being able to swim.

4. Discussion

The purpose of this study was to explore relationships between fitness and swimming and cycling proficiency in primary school boys and girls. We hypothesised that (i) being able to swim and cycle would be positively associated with fitness and (ii) there would be gender interactions between boys and girls fitness and swimming and cycling abilities.

Being able to swim and cycle were significant predictors of all components of fitness, after controlling for decimal age, BMI, gender, deprivation and sports club attendance. Cycling was a stronger predictor of fitness than swimming for all components of fitness except for the 10x5m shuttle. In addition, gender interactions showed that both cycling and swimming were stronger predictors of cardiorespiratory fitness in boys than girls. Gender and cycling proficiency interactions were evident for strength and power. For cardiorespiratory fitness gender interactions showed that both cycling and swimming were stronger predictors of fitness performance in boys than girls.

The significant predictions outlined above suggest that these movement competencies should be developed as part of the life course to increase fitness and subsequent health. Research has shown that being fit as a child has many benefits, physically, mentally and socially (Bangsbo et al., 2016) together with longitudinal benefits of increased fitness and health into adulthood (Ruiz et al., 2009). In our analysis, the ability to cycle was a stronger predictor of fitness than the ability to swim. Studies have shown positive relationships between cycling and cardiorespiratory fitness in children and subsequent inverse associations with all-cause mortality in adults (Oja et al., 2011). It has previously been implied that children's physical activity behaviours transfer into adulthood (Boreham and Riddoch, 2001). Therefore, encouraging cycling at a young age could contribute to higher fitness levels and quality of life during both childhood and into adulthood.

Across all components of fitness, cycling had larger positive predictions than swimming, apart from the 10x5m shuttle, where the opposite trend was observed. Participation rates, school involvement and accessibility may be influencing factors, with one study showing that only 7% of children reported their school offering cycle lessons/tests (Sustrans, 2015). In Wales, almost 55% of primary school PE coordinators strongly disagreed that their school has sufficient access to bicycles to deliver training, also reporting that swimming was a more widely offered activity during school hours than cycling (Sport Wales, 2018). Despite this emphasis on swimming, in Wales, cycling is more popular outside of school (Sport Wales, 2018). Moreover, the availability of swimming infrastructure including supervision, is less obvious than having space to cycle on the road or in nature. This implies that children who can cycle may have higher fitness levels across all components of fitness than children who can swim because of higher participation rates and possibilities, increasing their physical activity and subsequently fitness (Stodden, et al., 2008).

The number of sports clubs attended was taken into consideration in this study, but swimming and cycling are both common leisure-time activities contributing to levels of physical activity (Hulteen et al., 2017). Consequently, the children may have reported no sports club attendance, but may have still participated in swimming and cycling activities in unorganised settings with family and friends. These settings could include cycling to school as it has been found that 5% of children living in a similar area to those in this study cycle to school (Sustrans, 2015). This would have increased their physical activity levels and therefore fallen in line with previous research highlighting the positive association between physical activity and fitness in children (Hall et al., 2018). Therefore, measuring and controlling for physical activity levels would have further strengthened our study.

Our finding that swimming and cycling were significant predictors of all components of fitness could suggest that these skills encompass the fundamental movement skills (FMS) that have previously been associated with fitness (Jaakkola et al., 2019). Recent developments in research surrounding children's cycling abilities have highlighted that cycling interventions should include activities to improve balance and coordination (Kavanagh et al., 2020). Both balance and coordination are evaluated regularly in common FMS assessments, although usually encompassed in the stability realm. Therefore, if a child can cycle, they are likely to have higher levels of motor competence, particularly balance and coordination.

Although, not the primary aim, we found significant gender interactions for both swimming and cycling with cardiorespiratory fitness. There were no other significant interactions for swimming and gender, whilst cycling and gender interactions were significant for the handgrip test and standing long jump. In these significant interactions, boy's fitness was higher than girls when comparing the "cannot swim/cycle groups" to the "can swim/cycle groups". These gender interactions demonstrate a stronger association between swimming and/or cycling for boys rather than girls. Previous research indicates that girls cycle less frequently than boys (Sport Wales, 2018); resulting in a lower volume of activity that may be insufficient to promote their fitness. Baquet's seminal work (Baquet et al., 2003) demonstrated that activity had to be vigorous to increase fitness in prepubertal children. Thus, the findings may imply that cycling may promote short duration vigorous intensity activity aligned with children's pattern of activity in general and thus for boys at least stimulate an increase in fitness. These gender interactions imply that being able to swim and/or cycle promotes boy's fitness more so than girls. Moreover, if boys swim and cycle more often than girls throughout childhood and adolescence then the gender gap in fitness that has previously been reported (Tyler et al., 2019) will grow.

Collectively, previous studies comparing boys and girl's fitness levels show that boy's fitness is higher than girls, with the exemption of flexibility and balance (Marta et al., 2012). However, our study found that for some components of fitness girl's results were higher than boys. Girls in the "could not swim" and "no cycle" groups achieved, higher grip strength scores than boys in the same respective group. This suggests that previous research that has identified boys as being stronger than girls (Omar et al., 2018) may have only used children with high levels of motor competence or did not account for foundational movement skills, which are rarely measured (Hulteen et al., 2018). Although our study did include the movement skills of cycling and swimming, the data did not include quality of the skill, frequency, intensity or time, which is considered a limitation of the study.

Having the ability to swim and cycle are strongly associated with children's fitness levels, particularly their cardiorespiratory fitness. Cardiorespiratory fitness has been strongly associated with health outcomes. Therefore, swimming and cycling, and their associated skills such as balance and coordination should be developed and encouraged from a young age. These activities will not only improve fitness levels but also expand the range of activities and leisure time opportunities that children can participate in due to the development of specific movement skills, balance and coordination. Schools should continue to offer swimming lessons and incorporate cycling based programmes into their physical education curriculum to remove any common barriers; including affluence (Sport England, 2019) and parents swimming ability (2009). Given the health benefits of sport in general, and specifically swimming and cycling, designing learning environments that offer a rich and safe landscape of outdoor and indoor opportunities is important. This will serve to promote lifelong participation in the plethora of water related activities and for cycling as active transport and recreational or competitive sport practice.

To our knowledge, this is the first study to have examined swimming and cycling proficiency and their association with children's fitness. The main strengths of this study include a large sample size, across two contrasting geographical locations, Swansea and Bridgend, in South Wales, while controlling for other variables such as deprivation, age, BMI and sports club attendance. Furthermore, this study also measured and analysed multiple fitness measures to allow for a deeper understanding of the associations of swimming and cycling on fitness. In addition, a multilevel analysis approach was used to take into account the variation between schools. Nevertheless, the following limitations are acknowledged. Although the study uses data over a 5-year period, it is cross sectional and so does not have the strengths that a longitudinal study has and is therefore not possible to establish a cause and effect of the associations that have been established. Self-reported sports club attendance and proficiency for swimming and cycling was reported using a dichotomous scale (yes/no) and did not consider the degree of proficiency or the frequency and intensity of participation. More detailed assessment of cycling and swimming competence using the national cycling standards or British Swimming (formally Amateur Swimming Association, ASA) achievement metrics such as aquatic skills or distance achieved would allow for further interpretation of these findings; although existing assessment methods for measuring children's swimming competence are limited (Chan et al., 2020) and do not cover the wider activity of aquatic competence. Device based measures of activity during cycling or swimming would also permit greater insight into the patterns, frequency, intensity and duration of cycling and swimming. Future studies should therefore focus on including more detailed swimming and cycling skills, frequency of participation as well as other physical activity, sport, dance and play behaviours that are related to fitness.

5. Conclusion

In conclusion, swimming and cycling abilities are associated with all components of fitness and may have several implications in the field of motor development, fitness and physical activity. The ability to swim and cycle can be considered as important "milestones" in the journey of motor development and our results suggest these abilities are positively associated with fitness levels. Children should therefore be encouraged to participate in cycling and swimming regularly, executing more complex motor/aquatic skills at more advanced levels in appropriate learning situations to facilitate transfer of learning (Guignard et al., 2020). Moreover, barriers to participation should be reduced to allow maximum exposure, allowing for optimal development of motor skill, fitness and health. Being proficient in swimming or cycling is associated with fitness regardless of whether a sports club is attended or not. Therefore, physical activity promotion should not only focus on sufficient levels of physical activity, but also on supporting the development of foundational movement skills.

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Tables

Table 1: Characteristics of participants who were included in the analysis for this study

Variable	All		Boys		Girls	
	Frequency	%	Frequency	%	Frequency	%
Gender			1077	50.80	1041	49.20
Age (Years)						
<10	505	23.84	254	23.58	251	24.11
≥10 & <11.0	1040	49.10	517	48.00	523	50.24
≥11.0 & <12	573	27.05	306	28.41	267	25.65
BMI Category						
Underweight	28	1.32	15	1.39	13	1.25
Normal weight	1266	59.77	638	59.24	628	60.33
Overweight	326	15.39	152	14.11	174	16.71
Obese	498	23.51	272	25.26	226	21.71
WIMD						
10% most deprived	310	14.64	166	15.41	144	13.83
10-20% most deprived	301	14.21	144	13.37	157	15.08
20-30% most deprived	171	7.40	94	8.73	77	7.40
30-50% most deprived	453	22.00	224	20.80	229	22.00
50% least deprived	883	41.69	449	41.69	434	41.69
Swim						
Yes	1693	79.90	874	81.20	819	78.70
No	425	20.10	203	18.80	222	21.30
Cycle						
Yes	1952	92.2	989	91.80	963	92.50
No	166	7.8	88	8.20	78	7.50
Sports Club						
Yes	1804	85.20	921	85.50	883	84.80
No	314	14.80	156	14.50	158	15.20

Table 2: Fitness test results for each variable including means and standard deviations split by gender, swim and cycle ability and sports club attendance

	Fitness Tests											
	10x5m *Speed*		Speed Bounce *Speed & Coordination*		Grip Average *Strength*		Sit & Reach *Flexibility*		MSFT *Cardiorespiratory*		Standing Jump *Power*	
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
All	20.20	2.65	40.65	12.11	16.83	3.83	17.92	7.47	28.48	15.99	133.79	23.77
Girls	20.62	2.64	39.18	11.82	16.33	3.79	20.49	7.28	23.56	12.35	127.70	22.19
Boys	19.80	2.60	42.06	12.23	17.32	3.81	15.42	6.79	33.20	17.59	139.68	23.77
Swim = Yes	20.05	2.58	41.66	12.04	17.12	3.80	18.30	7.47	29.72	16.29	135.91	23.23
Swim =No	20.82	2.86	36.61	11.56	15.68	3.77	16.36	7.29	23.43	13.61	125.33	23.69
Cycle = Yes	20.09	2.60	41.32	11.96	16.98	3.84	18.13	7.49	29.28	16.11	135.08	23.46
Cycle = No	21.53	2.87	32.65	11.10	15.05	3.26	15.27	6.75	18.91	10.60	118.59	22.18
Sports Club = Yes	20.17	2.61	40.99	11.99	16.94	3.87	18.16	7.51	29.09	16.05	134.06	23.48
Sports Club = No	20.42	2.89	38.75	12.63	16.20	3.60	16.50	7.08	24.95	15.19	132.26	25.35

Table 3: Results table for model 3 of the multivariate multilevel analysis including Beta values, standard error and p vales.

	10x5m Run			**Speed Bounce**			**Grip Strength**			**Sit & Reach**			**MSFT**			**Standing Long Jump**		
	beta	**SE**	**95% CI**	**beta**	**SE**	**95% CI**	**beta**	**SE**	**95% CI**	**beta**	**SE**	**95% CI**	**beta**	**SE**	**95% CI**	**beta**	**SE**	**95% CI**
Intercept	22.735***	0.39	21.98 – 23.49	30.828***	1.50	27.88 – 33.77	14.716***	0.45	13.83 - 15.60	14.87***	0.93	13.04 – 16.70	14.918***	1.89	11.22 – 18.62	112.942***	2.88	107.29 – 118.59
Age	-0.376***	0.09	-0.54 - -0.21	3.293***	0.41	2.50 – 4.09	1.825***	0.12	1.58 - 2.07	-0.424	0.25	-0.92 - 0.07	3.045***	0.51	2.05 – 4.04	5.794***	0.75	4.32 – 7.27
British Growth Reference (BMI)	0.014***	0.00	0.01 – 0.02	-0.092***	0.01	-0.12 - -0.08	0.035***	0.00	0.03 - 0.04	-0.001	0.01	-0.01 – 0.01	-0.177***	0.01	-0.20 - -0.16	-0.196***	0.01	-0.22 - -0.17
Gender **(ref: F)**	-0.648	0.38	-1.38 – 0.09	0.804	1.81	-2.75 – 4.36	-0.481	0.56	-1.57 - 0.61	-2.876*	1.15	-5.12 - -0.63	1.143	2.28	-3.33 – 5.61	6.356	3.35	-0.22 – 12.93
Deprivation (WIMD)	0.00	0.00	0.00 – 0.00	0.001	0.00	0.00 – 0.00	0.00**	0.00	0.00 – 0.00	0.00	0.00	- 0.00 – 0.00	0.002**	0.00	0.00 – 0.00	0.001	0.00	-0.00 – 0.00
Sports Club **(ref: no)**	-0.444**	0.14	-0.72 - -0.17	1.24	0.68	-0.09 – 2.57	0.402	0.21	-0.01 - 0.81	0.95*	0.43	0.12 – 1.78	2.534**	0.85	0.87 – 4.20	1.334	1.26	-1.13 – 3.80
Swim **(ref: no)**	-0.916***	0.18	-1.27 - -0.57	3.706***	0.86	2.03 – 5.38	0.737**	0.26	0.22 – 1.25	2.202***	0.54	1.15 – 3.26	2.306*	1.08	0.19 – 4.42	6.952***	1.59	3.84 – 10.06
Cycle **(ref: no)**	-0.813**	0.27	-1.35 - -0.28	4.885***	1.31	2.31 – 7.46	0.833*	0.40	0.05 – 1.62	3.075***	0.83	1.45 – 4.70	4.175*	1.66	0.92 – 7.43	8.828***	2.44	4.05 – 13.60
Gender x Swim (ref: no x F)	0.319	0.25	-0.17 – 0.81	-0.538	1.20	-2.90 - 1.82	-0.28	0.37	-1.01 – 0.45	-0.464	0.76	-1.95 – 1.02	4.846***	1.51	1.88 – 7.81	-0.547	2.23	-4.92 – 3.83
Gender X Cycle (ref: no x F)	-0.553	0.37	-1.29 – 0.18	2.753	1.80	-0.78 – 6.28	1.699**	0.55	0.62 – 2.78	-1.877	1.14	-4.11 – 0.36	5.513*	2.26	1.08 – 9.95	6.554*	3.33	0.02 – 13.09

*p<.05, **p<.01, ***p<.001

Table 4: The variables included in each model of the multivariate multilevel analysis, -2 Loglikelihood data and p values.

Variables	**Model 1**	**Model 2**	**Model 3**
Intercept	X	X	X
Decimal Age		X	X
BMI British Growth Reference		X	X
Gender		X	X
Deprivation (WIMD)		X	X
Sports Club		X	X
Swim		X	X
Cycle		X	X
Gender X Swim			X
Gender X Cycle			X
-2 Log Likelihood	86044.904	82774.61	82732.628
Chi^2 (p-value)		<0.001	<0.001