TITLE: Weight status associations with physical activity intensity and physical self-perceptions in 10-11 year old children

ABSTRACT

The study examined associations between children's weight status, physical activity intensity, and physical self-perceptions. Data were obtained from 409 children (224 girls) aged 10-11 years categorized as normal-weight or overweight/obese. Physical activity was assessed using accelerometry, and children completed the Physical Self-Perception Profile. After controlling for the effects of age, maturation, and socio-economic status vigorous physical activity was significantly associated with normal-weight status among boys (OR = 1.13, $p = 0.01$) and girls (OR = 1.13, $p = 0.03$). Normal-weight status was significantly associated with perceived Physical Condition (Boys: OR = 5.05, $p = .008$; Girls: OR = 2.50, $p = 0.08$), and Body Attractiveness (Boys: OR = 4.44, $p = 0.007$; Girls: OR = 2.56, $p = 0.02$). Weight status of 10-11 year old children was significantly associated with time spent in vigorous physical activity and self-perceptions of Body Attractiveness and Physical Condition.

INTRODUCTION

Overweight and obesity are global public health issues implicated in the onset and development of a number of degenerative conditions through the life course (5, 7). The causes of overweight and obesity are complex but the basic physiological premise is that positive energy balance over time leads to weight gain as more energy is taken in than expended (48). On this basis, increased energy expenditure through physical activity should help maintain energy balance and therefore a stable body weight. For these reasons physical activity is implicated in the cause and prevention of pediatric overweight and obesity (10). Although it is suggested that obesity prevalence among young people may have 'leveled off' in the last decade (30), the existing high incidence of obesity has coincided with low levels of habitual physical activity in most developed countries (37, 39). Despite the intuitive logic that declining physical activity levels influence the increased prevalence of overweight and obesity, a recent review of children's objectively assessed physical activity and changes in adiposity reported weak and inconsistent associations between the variables of interest (48). One factor implicated in the equivocal conclusions reached was a lack of studies assessing specific intensities of physical activity (48). In particular, the influences of moderate (MPA), and vigorous intensity physical activity (VPA) on adiposity may differ, with more intense activity often reported to be of greater benefit (24). Self-perceptions contribute to a person's self-esteem, which reflects their evaluation of the good or worth inherent in their self-description (45). With regard to health-related changes to lifestyle, self-esteem and motivation are interlinked and can be viewed as 'common concepts' (46). Competence motivation theory (16) suggests that people will be motivated to engage in activities where they feel competent, and on this basis self-perceptions are important predictors of physical activity and other volitional behaviors (44). Physical self-perceptions such as perceived physical competence are recognized as positive correlates of youth physical activity (42), and specific components of the physical self are thought to influence motivated behavior (11). Studies have shown significant associations between physical self-perceptions and physical activity in youth, with boys typically reporting stronger self-perceptions than girls (9). Furthermore, associations exist between overweight/obesity and physical activity (1), and evidence suggests that overweight and obese children may have lower self-perceptions than normal-weight counterparts (23). Moreover, excess adiposity impacts on selected domains of self-perception, which often relate to physical activity participation and physical appearance (12). The relationships between specific components of children's physical self-perceptions, physical activity, and weight status are under researched but improved understanding of these factors may help inform future childhood obesity interventions. Thus, the study purpose was to examine associations between weight status, physical activity intensities, and physical self-perceptions among English primary school children.

METHODS

Participants

Eight schools situated in urban and suburban areas of a large north-west England town were recruited to the study during the autumn school terms of 2008 and 2009. In these schools all children in Year 6 (aged 10-11 years; N = 602; 307 in 2008, 295 in 2009) received project and consent information and were invited into the study. Five hundred children consented to participate (230 in 2008 (116 girls), 270 in 2009 (139 girls)) resulting in an 83.1% participation rate. The ethnic origin of all the children was white British, which roughly reflects the ethnic demographic of the town's school-age population which is 96% white British (47). During 2008 and 2009 data were collected in one school per week between October and December. Ethical approval was obtained from the University Ethics Committee.

Instruments and procedures

Socio-economic status

Socio-economic status was calculated using the 2007 Indices of Multiple Deprivation (IMD) (6). IMD scores were derived from the children's home postcodes using the National Statistics Postcode Directory database (2).

Anthropometry

Stature and sitting height were measured to the nearest 0.1 cm using a portable stadiometer (Leicester Height Measure, Seca, Birmingham, UK). Leg length was calculated by subtracting sitting height from stature. Body mass was measured to the nearest 0.1 kg using calibrated scales (Seca, Birmingham, UK). All measurements were taken by trained research staff with the children in light clothing and barefooted. The International Obesity Task Force age and sex-specific BMI cut-points were used to classify children as either normal-weight, overweight, or obese (3). Overweight and obese children's data were then collapsed to create an overweight/obese grouping category.

Maturity status

Somatic maturity status was estimated by determining years from attainment of peak height velocity. Attainment of peak height velocity reflects the age at maximum growth rate in stature during adolescence. Maturity offset (i.e., years from attainment of peak height velocity) for each child was predicted using sex-specific regression equations that included stature, sitting height, leg length, chronological age and their interactions (19). This non-invasive method has demonstrated acceptable agreement when correlated against skeletal age (r = 0.83) (19) and is commonly used in physical activity research (9, 32)

Physical self-perceptions

Physical self-perceptions were assessed using the Children and Youth version of the Physical Self-Perception Profile (CY-PSPP) (45). The CY-PSPP follows a hierarchical structure with global self-esteem at the apex and Physical Self-Worth positioned at the domain level. Subordinate to Physical Self-Worth are four sub-domains of Sport Competence, Physical Condition, Body Attractiveness, and Physical Strength. Each domain is measured on a 1 to 4 scale by six items that utilize a structured alternative format to reduce socially desirable responses. The CY-PSPP was administered in the children's classrooms by research staff who provided verbal and visual examples of how and where to respond to items on the profile.

Physical activity

Physical activity was objectively measured every 5 seconds using ActiGraph accelerometers (GT1M, ActiGraph LLC, Pensacola, FL). The children were instructed to wear the ActiGraph over the right hip using a waist mounted nylon belt, from waking in the morning until bedtime. In 2008 children were asked to wear the accelerometers for 5 consecutive days, including 2 weekend days. In 2009 increased availability of ActiGraphs meant that the wear time protocol increased to 7 consecutive days, including 2 weekend days. At the end of the data collection period ActiGraphs were downloaded using Actlife software (ActiGraph LLC, Pensacola, FL). Downloaded files were initially checked for compliance to the monitoring protocol using customized software (MAHUffe; www.mrc-epid.cam.ac.uk). Sustained 20 minute periods of zero counts indicated that the ActiGraph had been removed, and total 'missing' counts for those periods represented the duration that monitors were not worn. Children were included in the data analysis if they wore the monitors for at least 600 minutes each day for a minimum of 3 days (18). Published cut-points for different intensity levels in children vary substantially [e.g., between 906 (41) and 3200 counts • min^{-1} for MPA (26)], and in the absence of individual calibration data there is no consensus as to the most appropriate cut-points to use. Thus, we chose the values reported by Ekelund and colleagues (2007) in the European Youth Heart Study (8) because they fell between the most extreme values reported (26, 41) and were appropriate to the age group of interest. The ActiGraph count cut-points for minutes spent in sedentary activity, MPA and VPA were <500, 2000, and 4000 counts • min^{-1}, respectively (8).

Data analysis

Descriptive statistics were calculated for all measured variables and weight status differences were examined by independent *t*-tests. Sex-specific binomial logistic regression was used to establish the association between normal weight status, and physical activity and physical self-perceptions. Analyses were adjusted for age, maturity status, and socio-economic status. Specific predictor variables were minutes spent in sedentary time, MPA, and VPA, and perceived Sport Competence, Physical Condition, Body Attractiveness, Physical Strength, and Physical Self-Worth. Effect sizes were computed as adjusted odds ratios (ORs) and 95% confidence intervals. All analyses were conducted using SPSS v. 15 (SPSS Inc; Chicago, IL) and statistical significance was set at $p < 0.05$.

RESULTS

Preliminary analyses confirmed that the data were normally distributed, and that the assumptions of linearity of logit and collinearity (Tolerance and VIF statistics) were met. Strong internal consistencies were demonstrated for each of the physical self-perception sub-domains. Cronbach's alpha coefficients for boys and girls ranged from 0.75 - 0.76 (Sport Competence), 0.78 – 0.79 (Physical Condition), 0.83 – 0.87 (Body Attractiveness), 0.76 - 0.83 (Physical Strength), and 0.74 – 0.84 (Physical Self-Worth). In 2008 and 2009, 47 (20.4%) and 44 (16.3%) of children, respectively did not meet the minimum ActiGraph wear time criteria and so were excluded from the data set. The main reason for exclusion was non-compliance, but one ActiGraph was lost in 2008 and six malfunctioned in 2009. Overall, 409 children were included in the analyses (224 girls) giving an overall compliance rate of 81.8%. There were significant differences in time spent sedentary and in MPA between included and excluded children (sedentary: excluded = 339.9 minutes vs. included = 578.5 minutes, $p < .0001$; MPA: excluded = 31.2 minutes vs. included = 40.0 minutes, $p < 0.0001$). Nineteen percent of children provided data on 7 valid measurement days, 15.4% on 6 days, 33.4% on 5 days, 19.5% on 4 days, and 12.7% on 3 days. Physical activity levels did not differ between children with 7, 6, 5, 4, or 3 days of valid data. Mean duration of daily monitoring was 11.8 hours for boys and girls.

Descriptive analyses

There were no significant differences in age, stature, body mass, BMI, or maturation between the 2008 and 2008 cohorts ($p < 0.05$). Overweight/obese boys and girls were significantly taller, heavier, and somatically more mature than normal weight peers (Table 1). The majority of children were categorized as normal-weight (Boys: 78.5%; Girls: 76.2%), with 18.3% and 18.8% of boys and girls, respectively overweight, and 3.2% (boys) and 4.9% (girls) categorized as obese. These values are broadly representative of the town's school-age population when the IOTF BMI cut-points are applied (36). Stature and body mass were similar for boys and girls although girls' maturity offset values (-1.26 years) were more advanced than boys (-2.97 years).

TABLE 1 ABOUT HERE

Sedentary time was similar between sex and weight status groups (Table 2). Normal-weight and overweight/obese boys' MPA differed by around 0.7 minutes, compared to 1.3 minutes for girls. Significant differences in VPA were observed among normal-weight and overweight/obese boys ($t_{185} = 3.93$, $p = 0.001$) and girls ($t_{221} = 2.68$, $p = 0.008$). Sixty six percent of normal-weight boys achieved the recommended minimum of 60 minutes moderate-to-vigorous physical activity (MVPA) per day, compared to 47.5% of overweight/obese boys ($\chi^2_1 = 4.56$, $p = 0.03$). Sixty minutes of MVPA was achieved by 30% and 22.6% of normal-weight and overweight/obese girls, respectively ($\chi^2_1 = 1.08$, $p = 0.30$). Significant differences in normal-weight and overweight/obese boys' and girls' physical self-perceptions were evident in all sub-domains, with the exception of Sport Competence, and Physical

Strength (Table 2). The greatest differences in normal-weight and overweight/obese boys' and girls' physical self-perceptions were in perceived Physical Condition and Body Attractiveness.

TABLE 2 ABOUT HERE

Main analyses

After controlling for the effects of boys' age, maturation, and socio-economic status, normal-weight status was significantly associated with VPA but not with MPA or sedentary time (OR = 1.13 (1.03, 1.23), p = 0.01; Table 3). Furthermore, normal-weight status was significantly associated with boys' self-perceptions of Physical Condition (OR = 5.05 (1.52, 16.75), p = .008) and Body Attractiveness (OR = 4.44 (1.51, 13.06), p = 0.007). Following adjustment for girls' age, maturation and socio-economic status, analysis revealed a significant association between normal-weight status and VPA (OR = 1.13 (1.02, 1.25), p = 0.03, but not MPA or sedentary time (Table 3). Moreover, among girls, normal-weight status was significantly associated with self-perceptions of Physical Condition (OR = 2.50 (0.90, 6.98), p = 0.08) and Body Attractiveness (OR = 2.56 (1.14, 5.71), p = 0.02).

TABLE 3 ABOUT HERE

DISCUSSION

This study investigated associations between primary school children's weight status, physical activity levels and physical self-perceptions. VPA was significantly different between normal-weight and overweight/obese children and VPA was significantly and positively associated with normal-weight status, although the strength of the effect sizes was modest. Normal-weight children accumulated 5.8 minutes (boys) and 3.04 minutes (girls) more VPA per day than their overweight/obese peers. Differences in VPA between normal-weight and overweight and obese children have previously been reported in the range of 6.4 minutes for boys and girls combined (40), 2 minutes for boys (35), and ~1 minute for girls (38). Comparisons with the present study are difficult due to the different accelerometer protocols, analyses, and cut-points used to classify VPA. Two studies (35, 38) used higher VPA cut-points than in our investigation, which may explain in part why smaller differences in VPA were observed. Although Trost and colleagues used a similar VPA cut-point to the one used in our study, boys' and girls' VPA was combinedwhich precludes comparisons by gender. These observed differences in VPA may not have accurately reflected energy expenditure of the normal-weight and overweight/obese groups. It is reported that the energy cost of participating in higher intensity physical activity can be greater for overweight/obese or low fit youth than for leaner or fitter peers (33). Using age-related reference values for children's physical activity energy expenditure (15) we estimated that 5.8 minutes VPA (i.e., walking at 5.6 km • h^{-1}) for the normal-weight boys would yield an energy cost of 24.6 kcal, but the same duration of MPA (i.e., walking at 4 km • h^{-1}) for the overweight/obese boys would require a greater energy cost at 26.2 kcal. Thus, it is possible that the overweight/obese children were doing more VPA than indicated by the accelerometer counts in terms of energy expended, but this was misclassified as MPA because accelerometers are unable to assess the physiological strain of physical activity. This issue may have partially influenced the magnitude of the associations between VPA and weight status.

MPA was not associated with weight status, which concurs with previous studies (49), although others have reported moderate correlations between MPA and body fat (31). Our results suggest that regardless of weight status most children in the sample engaged in health-enhancing physical activity at the minimal, moderate intensity level. Sedentary time did not differ by weight status which supports a recent investigation into associations between children's objectively assessed sedentary time and body composition (34). Although significant relationships between self-reported time spent TV viewing and video gaming, and body fat have been observed, the reported effect sizes were small, possibly due to the use of single, self-report, discrete markers of sedentary behavior, rather than objective measures (17). Differences in the measurement and classification of sedentary activity and weight status, as well as the affect of confounders such as socio-economic status, sleep duration, and food intake may be contributory factors explaining the lack of consistency between studies investigating sedentary behaviors and weight status (21).

Normal-weight children reported significantly stronger physical self-perceptions than overweight/obese peers. Furthermore, overweight/obese girls scored lower in all domains than overweight/obese boys. Similar weight status and gender-related differences in self-perceptions have been observed elsewhere, particularly in relation to perceived physical competence and appearance (14). Body dissatisfaction is common among overweight/obese youth and is related to comparisons with societal body shape ideals and resultant social stigmatization (13). Recently it was reported how body dissatisfaction mediated associations between different aspects of physical self-perception and BMI in boys but not in girls (20). The authors of this study suggested that improved physical self-perceptions achieved through physical activity experiences could reduce body dissatisfaction of overweight and obese boys, but in girls body dissatisfaction might be linked more to aesthetic appearance than physical activity-related competence, hence the stronger mediating effects of physical self-perceptions among boys (20). Considering the influence of body dissatisfaction the significant associations between perceived Body Attractiveness and weight status were anticipated, although the magnitude of these effects (Boys: OR = 4.44; Girls: OR = 2.54) revealed differences in the relative influence of Body Attractiveness between the sexes. These effect size differences reflect the higher ratings of Body Attractiveness among boys, which were consistent with other studies in similarly aged children (4, 9). Although girls typically attach more importance to Body Attractiveness (46) their perceptions are often unable to match their expectations, possibly because pressure to conform to a societal and cultural stereotype body shape is greater on girls than boys, and girls experience more obvious physical changes during puberty than boys (22).

Perceived Physical Condition was also significantly associated with normal-weight status, with these associations strongest in boys (OR = 5.05 vs. 2.5 in girls). The strength of the associations observed for the normal-weight boys and girls reflects the relative differences in their ratings of Physical Condition, which concur with those described previously (9). In the current sample perceptions of Physical Condition, conceptualized in the CY-PSPP as fitness and exercise (45) were lowest among children with the highest BMI values. Previous studies have reported moderate correlations between perceived Physical Condition and cardiorespiratory fitness (44), while the inverse association between cardiorespiratory fitness and adiposity/weight status is well established (8). Thus, it is likely that the children's perceived Physical Condition was based in part on their actual levels of cardiorespiratory fitness (44). These perceptions of Physical Condition may have been manifested through class-based norm-referenced assessments (e.g., multi-stage fitness test) and/or direct comparisons with peers during play and physical activity (e.g., effort and exertion during sports or vigorous games) (43). Although cardiorespiratory fitness was not assessed in this study the strong associations between perceived Physical Condition and weight status may reflect differing levels of cardiorespiratory fitness between the normal-weight and overweight/obese children, which have been observed previously (28). Cardiorespiratory fitness is inversely and independently associated with clustered cardiovascular risk, although fatness may partly mediate this association (29). Though physical activity engagement is beneficial to both cardiorespiratory fitness and clustered cardiovascular risk, actual engagement in activity may be compromised among overweight and obese children without a reduction in abdominal fat (29). Nonetheless, physical activity interventions can be effective among children with unfavorable cardiovascular risk profiles, when such protocols are of sufficient duration, have appropriate volumes of activity, and are implemented by expert personnel (27).

Study limitations and strengths

This study had several limitations which need acknowledging. The cross-sectional nature of the study precludes any claims about causality and direction in relation to the variables of interest. The selection of accelerometer cut-points had an influence on the extent of the associations with weight status. As there is no consensus about the most appropriate accelerometer cut-points to use with pediatric populations we employed previously published values (8) that have been used to address similar research questions to ours with comparable populations (34). Moreover, accelerometers assess movement and are unable to assess the physiological strain of physical activity. For this reason the energy cost of the normal-weight and overweight/obese children's physical engagement was unknown. Data were collected in the autumn and winter when temperatures averaged 8.5°C and daylight hours were limited to between 10 and 7.8 hours. For these reasons physical activity levels may have been lower than during the spring and summer. Although BMI has limitations as a measure of adiposity, it is strongly associated with body fat among youth (25) and so is a most appropriate measure for school-based studies such as this. Strengths of this study were the use of a large sample of children, objective measures of physical activity to assess physical activity at different intensities, and analyses which were adjusted for common confounders.

Conclusions

This novel investigation studied associations between children's weight status, different intensities of physical activity, and physical self-perceptions. Significant modest associations were observed between normal-weight status and time spent in VPA. Time spent sedentary and in MPA were similar regardless of weight status. Normal-weight children had more positive physical self-perceptions than overweight/obese counterparts, particularly with regards to perceptions of Body Attractiveness and Physical Condition. Moreover, the magnitude of these associations was greatest among boys. Future research needs to confirm causal relationships between the correlates investigated in this study through longitudinal and interventional type investigations.

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Table 1. Descriptive characteristics of normal-weight and overweight/obese boys and girls (*M* ± *SD*)

	Boys			Girls		
	Normal-weight (*n* = 146)	Overweight/obese (*n* = 40)	*p*	Normal-weight (*n* = 170)	Overweight/obese (*n* = 53)	*p*
Age (years)	10.66 (0.33)	10.74 (0.30)	0.14	10.65 (0.33)	10.66 (0.32)	0.80
Stature (cm)	142.72 (7.37)	146.44 (5.03)	0.003	143.75 (6.97)	146.88 (6.80)	0.005
Body mass (kg)	34.43 (5.88)	49.02 (6.38)	<0.0001	34.98 (5.97)	49.42 (6.60)	<0.0001
BMI (m • kg^{-2})	16.80 (1.77)	22.80 (2.17)	<0.0001	16.83 (1.93)	22.95 (3.31)	<0.0001
Maturity offset (years)	-3.07 (0.48)	-2.59 (0.38)	< .0001	-1.38 (0.50)	-0.87 (0.49)	< .0001
[a]SES ([b]IMD score)	18.60 (11.63)	17.82 (10.69)	0.71	17.22 (10.43)	20.10 (13.18)	0.11

[a]SES = socio-economic status; [b]IMD = indices of multiple deprivation

Table 2. Objectively assessed physical activity and physical self-perceptions of normal-weight and overweight/obese boys and girls (*M* ± *SD*)

	Boys			Girls		
	Normal-weight (*n* = 146)	Overweight/obese (*n* = 40)	*p*	Normal-weight (*n* = 170)	Overweight/obese (*n* = 53)	*p*
Physical activity (min/day)						
Sedentary	572.33 (74.02)	582.64 (78.90)	0.44	590.75 (68.25)	581.31 (77.90)	0.40
[a]MPA	43.23 (11.16)	42.46 (11.58)	0.70	36.60 (8.25)	35.33 (8.25)	0.37
[b]VPA	23.79 (10.12)	17.99 (7.26)	0.001	17.92 (7.53)	14.88 (5.93)	0.008
Physical self-perceptions						
Sport Competence	3.11 (0.64)	2.91 (0.60)	0.09	2.93 (0.56)	2.73 (0.54)	0.03
Physical Condition	3.18 (0.64)	2.69 (0.51)	<0.0001	3.02 (0.58)	2.75 (0.59)	0.004
Attractive Body	2.91 (0.68)	2.38 (0.59)	<0.0001	2.84 (0.67)	2.31 (0.54)	<0.0001
Physical Strength	2.91 (0.67)	2.86 (0.50)	0.60	2.65 (0.60)	2.68 (0.54)	0.79
Physical Self-Worth	3.07 (0.64)	2.82 (0.56)	0.03	3.02 (0.61)	2.77 (0.60)	0.01

[a]MPA = moderate intensity physical activity; [b]VPA = vigorous intensity physical activity

Table 3. Associations between boys' and girls' physical activity, physical self-perceptions and normal weight status

	Boys				Girls			
Predictor	*B (SE)*	*p*	*OR*	*95% CI*	*B (SE)*	*p*	*OR*	*95% CI*
Constant	-12.16 (11.45)				-34.31 (10.21)			
Physical activity (min)								
Sedentary	0.004 (0.004)	0.22	1.0	1.0, 1.01	0.002 (0.003)	0.48	1.0	1.0, 1.01
[a]MPA	-0.06 (0.03)	0.05	0.94	0.89, 1.0	-0.04 (0.03)	0.19	0.96	0.90, 1.02
[b]VPA	0.12 (0.05)	0.01	1.13	1.03, 1.23	0.12 (0.05)	0.03	1.13	1.02, 1.25
Physical self-perceptions								
Sport competence	-0.39 (0.67)	0.56	0.68	0.18, 2.53	-0.54 (0.59)	0.36	0.58	0.18, 1.85
Physical condition	1.62 (0.61)	0.008	5.05	1.52, 16.75	0.92 (0.51)	0.08	2.50	0.90, 6.98
Attractive body	1.49 (0.55)	0.007	4.44	1.51, 13.06	0.94 (0.41)	0.02	2.56	1.14, 5.71
Physical strength	-0.67 (0.52)	0.20	0.51	0.19, 1.41	-0.69 (0.51)	0.17	0.50	0.19, 1.35
Physical self-worth	-1.03 (0.68)	0.13	0.36	0.09, 1.36	-0.61 (0.60)	0.31	0.54	0.17, 1.77

[a]MPA = moderate intensity physical activity; [b]VPA = vigorous intensity physical activity