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Abstract

Objectives: Several important research questions have been addressed: (1) What are the cross-sectional associations between sports club participation, objectively measured physical activity, and adiposity? (2) Do measures of physical activity and adiposity predict subsequent sports club participation? (3) Does sports club participation predict subsequent measures of physical activity and adiposity? and (4) Do changes in sports club participation predict changes in objective measures of physical activity and adiposity? **Design:** Longitudinal and cross-sectional. **Methods:** Data from the Gateshead Millennium Study birth cohort (n = 609 at age 7 years) were analysed for associations between adiposity, sports club participation and accelerometer-measured physical activity from ages 7y to 9y to 12y. **Results:** Seventy-two per cent of 9 year olds and 63% of 12 year olds took part in a sports club. Sports club participation was significantly associated with overall accelerometer-measured physical activity at 12y (coefficient = 0.009; 95% CI: 0.01-0.16) but not 9y. An inverse relationship between fat mass (estimated from bioelectric impedance) and sport club participation, and between fat mass and accelerometer-measured physical activity was observed at 12y, but not 9y. Sports club participation at 9y was highly predictive of participation at 12y. Sports club participation was significantly associated with socioeconomic status; fewer children from poorer areas took part. **Conclusions:** Sports club participation in adolescence may be associated with decreased levels of adiposity. Furthermore, the potential benefits of sports club participation for adiposity are likely generated from continuous participation in sports, rather than any long-term protective effects.

Keywords

physical, participation, sports, between, associations, longitudinal, body, composition, activity, adolescence, childhood

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Original research

Longitudinal associations between sports participation, body composition and physical activity from childhood to adolescence



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ABSTRACT

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Design: Longitudinal and cross-sectional.

Methods: Data from the Gateshead Millennium Study birth cohort ($n=609$ at age 7 years) were analysed for associations between adiposity, sports club participation and accelerometer-measured physical activity from ages 7y to 9y to 12y.

Results: Seventy-two per cent of 9 year olds and 63% of 12 year olds took part in a sports club. Sports club participation was significantly associated with overall accelerometer-measured physical activity at 12y (coefficient = 0.0.09; 95% CI: 0.01–0.16) but not 9y. An inverse relationship between fat mass (estimated from bioelectric impedance) and sport club participation, and between fat mass and accelerometer-measured physical activity was observed at 12y, but not 9y. Sports club participation at 9y was highly predictive of participation at 12y. Sports club participation was significantly associated with socioeconomic status; fewer children from poorer areas took part.

Conclusions: Sports club participation in adolescence may be associated with decreased levels of adiposity. Furthermore, the potential benefits of sports club participation for adiposity are likely generated from continuous participation in sports, rather than any long-term protective effects.

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1. Introduction

Paediatric obesity is at epidemic proportions, and is associated with significant short- and long-term medical, psychological and social morbidities.¹ Although, the Global Advocacy for Physical Activity recommend sports participation as a key strategy to address the growing burden of childhood inactivity² it is currently unclear whether sports participation can be an effective tool for the prevention of paediatric obesity.³ Significant limitations in this body of literature must be addressed before evidence-based

policies can be articulated under the assumption that sports participation provides a buffer against the onset of paediatric obesity.

A recent systematic review has highlighted the substantial limitations that are present within the research examining the relationships between sports participation, physical activity and obesity.³ An over-reliance on cross-sectional designs makes causal inferences impossible. In the few longitudinal studies that have been reported, none have used either objective measures of physical activity or body composition, relying on simple proxies for body composition such as the body mass index (BMI). The use of self-reported measures of physical activity is likely to inflate the observed relationships between sports participation and physical activity, particularly if reported concurrently. Further, while BMI is an adequate measure of adiposity in childhood,⁴ it can potentially bias results towards findings of no difference in sporting contexts

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due to an inability to observe the differences between overweight non-participants and muscular participants.⁵ In those longitudinal studies that have also used objective measures of physical activity,⁶ none have addressed the issue of bi-directionality specifically between sports participation and adiposity/physical activity. Furthermore, issues such as these have been articulated as important limitations beyond the literature pertaining to sports participation, and are also pertinent to research in physical activity.⁷

The purpose of this study was to address the limitations of previous research by investigating longitudinal associations between sports club participation, objectively measured physical activity, and adiposity [as measured by both BMI and fat mass index (FMI)]. Specifically, several important research questions (RQ) have been addressed: (1) What are the cross-sectional associations between sports club participation, objectively measured physical activity, and adiposity? (2) Do measures of physical activity and adiposity predict subsequent sports club participation? (3) Does sports club participation predict subsequent measures of physical activity and adiposity? and (4) Do changes in sports club participation predict changes in objective measures of physical activity and adiposity? As a secondary objective, this study also compared the strength of the associations between sports participation and BMI/FMI.

2. Methods

The Gateshead Millennium Study (GMS) is a birth cohort of adolescents born between May 1999 and June 2000, described in detail elsewhere.⁸ Briefly, all children born to Gateshead-resident mothers in pre-specified recruiting weeks were invited to participate. There were no exclusion criteria. Mothers were primarily from the white ethnic majority (98%). The sample has remained socioeconomically representative of northern England throughout the study.⁸

Data for the current analyses were collected at three separate data sweeps: in 2006–2007, 2008–2009 and 2012, corresponding to age 6–8, 8–10 and 11–13 years, hereafter referred to as 7, 9 and 12y. For each phase, all families who had not previously opted-out from the cohort were sent a letter and information leaflet inviting them to take part. Informed written consent was obtained from the main carer of each child, and children provided assent to their participation. Ethical approval for the study was granted by Gateshead and South Tyneside LREC (for the 7y data sweep) and Newcastle University Ethics Committee (9 and 12y).

At each timepoint, height was measured to 0.1 cm with a Leicester portable height measure (Chasmors, London, UK) and weight measured to 0.1 kg in light indoor clothing, and BMI and BMI z-score according to UK 1990 data⁹ were derived. The fat mass index (FMI)¹⁰ was the measure of body fatness used in the present study. We have shown previously that having a fat mass outcome greatly increased the ability to detect associations compared to having only a proxy for fat mass as the outcome measure between ages 7 and 9y.¹¹ Fat mass was estimated from TANITA bioelectrical impedance (TBF-300MA) by applying constants for the hydration of fat-free mass¹² having first estimated total body water using validated sex and age-specific prediction equations.¹³ FMI was then calculated by dividing fat mass by height squared.¹⁰

At 7, 9 and 12y children were asked to wear an Actigraph GT1M accelerometer on the right hip for 7 days, removing it only for bed and water-based activities. They were also given a time sheet to log when the monitor had been worn. Data were collected in 15 s sampling intervals (epochs) but collapsed to 60 s epochs when summarised. Data were reduced manually as described previously.¹⁴ Three constructs of physical activity (total volume of physical activity in mean counts per minute, cpm; amount of time spent in moderate-vigorous intensity physical activity (MVPA)

(minutes, and proportion of time spent in MVPA); and one of sedentary behaviour (proportion of time spent in SB)) were used in the present study. The cut-point of 3200 cpm¹⁵ was used to define the threshold for MVPA, and 1100 cpm for sedentary behaviour^{16,17} (defined as no trunk movement as measured by accelerometry).¹⁷ The Actigraph GT1M model has been shown to have a consistent bias of 9% relative to model 7164¹⁸ which has been used widely in previous research. A +9% correction was therefore applied to the data before applying cutpoints. Previous analysis of this cohort showed that 3 days of recording provided test–retest reliabilities of approximately 70% for each of the constructs¹⁴ with a minimum of 6 h recording per day.

At 9 and 12y children self-completed the ‘Youth Sports Survey’ questionnaire (adapted from Godin and Shepherd 1985¹⁹) assessing which school- and outside-school sports clubs they had participated in recently, time spent at each club and how many times per week they attended. Total time spent in each club per week was calculated, and times for all clubs summed and used in analyses.

Analyses were performed in STATA 12 and SPSS19. Sample size was fixed by the size of the cohort. Linear regression analyses were used to test for both cross-sectional and longitudinal associations; β coefficients and 95% CI are reported, with R^2 and p value. Significance was set at $p < 0.05$. Socio-economic status (SES) was described using Townsend scores,²⁰ an area-based measure derived from the UK census in 2001, and divided into quintiles. Sports club participation was the initial dependent variable, before being one of the independent variables in the analyses with 12y FMI, 12y BMI and 12y BMI z-score as dependent variables. The adjusted models are presented with each independent variable included one at time with adjustment for SES and sex, due to their role as likely confounders of all the associations tested, but not including the other independent variables due to likely collinearity.

3. Results

A total of 609 participants were involved in data collection at 7y, 585 at 9y and 525 at 12y. Not all children provided data for each variable of interest. Participant characteristics are displayed in Table 1.

At 9y, 581 children answered the questions on sports club participation. Four hundred and sixteen children (72%) took part in a sports club. Of these, 209 (50%) children took part in a school-sports club, and 342 (82%) in an outside-school sports club. One hundred and thirty-five (32%) children participated in both a school- and an outside-school club. At 12y, 512 children answered the question, 324 participated in any club (63%); 208 (64%) took part in a school-sports club and 252 (78%) in an outside-school sports club. One hundred and thirty-six (42%) children participated in both a school- and an outside-school sports club. This corresponded to more than 40 different sports and activities clubs. Two hundred and thirty-six children participated in a sports club at both 9y and 12y.

In univariate analyses, 12y sports club participation was significantly associated with all accelerometry variables. After adjustment for sex and SES, 12y sports club participation was positively associated with total cpm and negatively associated with %SB, but no longer associated with MVPA (Table 2). At 9y, sports club participation was not associated with 9y accelerometer measured physical activity or sedentary behaviour (data not shown).

In univariate regression analyses, 12y FMI was significantly inversely associated with 12y sports club participation, and MVPA and total activity as measured by accelerometry. These associations remained after adjustment for sex and SES (Table 3). Neither 12y BMI nor BMI z score were associated with 12y sports club

Table 1
Participant characteristics (median and interquartile range unless otherwise specified).

Variable	All children ^a					
	7y (n = 609)		9y (n = 585)		12y (n = 525)	
Age (y) (mean, range)	7.5	6.4, 7.5	9.3	8.4, 10.2	12.5	11.6, 13.3
Boys (n, %)	302	49.6%	292	49.9%	257	49.0%
Girls (n, %)	307	50.4%	293	50.1%	268	51.0%
Sports club participation (min wk ⁻¹)	N/A	–	105	60, 150	133	60, 225
Total physical activity (mean cpm)	722	604, 867	643	527, 780	481	390, 620
MVPA (min d ⁻¹)	25.8	17.7, 37.3	23.4	15.2, 34.9	22.6	13.2, 33.6
MVPA (% of time)	3.9	2.6, 5.8	3.5	2.3, 5.1	3.0	1.9, 4.7
Sedentary behaviour (% of time)	77.9	73.8, 81.8	81.2	76.8, 84.5	86.1	82.2, 89.3
BMI	16.3	15.2, 17.8	17.4	16.0, 19.5	19.8	17.8, 22.4
BMI z score	0.32	–0.33, 1.08	0.53	–0.17, 1.27	0.69	–0.12, 1.51
Fat mass index	3.7	2.8, 4.8	4.3	3.1, 6.0	4.7	3.1, 7.1

^a n for individual variables varies.

Table 2
Associations between sports club participation (min wk⁻¹) and objectively measured physical activity at 12 years.

	Sample (n)	Coefficient	CI	P
Exposure	Outcome measure: 12y sports club participation			
12y total activity (mean cpm)	262	0.09	0.01, 0.16	0.022
12y MVPA (min day ⁻¹)	262	0.86	–0.08, 1.80	0.073
12y sedentary behaviour (% of time)	262	–4.10	–6.90, –1.30	0.004
12y MVPA (% of time)	262	5.03	–1.62, 11.67	0.137

Adjusted for sex and SES.

Table 3
Associations between 12y body composition, and 12y sports club participation (min wk⁻¹) and accelerometer-measured physical activity.

	Sample (n)	β coefficient	CI	P
Exposure	Outcome measure: 12y FMI			
12y sports club participation	278	–0.003	–0.006, –0.00008	0.044
12y total activity (mean cpm)	363	–0.002	–0.004, –0.001	0.004
12y MVPA (min day ⁻¹)	363	–0.030	–0.050, –0.009	0.005
12y sedentary behaviour (% of time)	363	0.030	–0.028, 0.097	0.278
12y MVPA (% of time)	363	–0.191	–0.326, –0.055	0.006
9y sports club participation	330	–0.006	–0.011, –0.002	0.008
	Outcome measure: 12y BMI			
12y sports club participation	319	–0.003	–0.007, 0.0002	0.067
12y total activity (mean cpm)	404	–0.002	–0.004, –0.0001	0.040
12y MVPA (min day ⁻¹)	403	–0.030	–0.054, –0.006	0.014
12y sedentary behaviour (% of time)	403	0.025	–0.047, 0.097	0.491
12y MVPA (% of time)	403	–0.164	–0.321, –0.008	0.039
9y sports club participation	331	–0.005	–0.010, –0.0003	0.038
	Outcome measure: 12y BMI z score			
12y sports club participation	319	–0.001	–0.002, 0.0002	0.110
12y total activity (mean cpm)	403	–0.0005	–0.001, 0.00005	0.072
12y MVPA (min day ⁻¹)	403	–0.009	–0.016, –0.002	0.016
12y sedentary behaviour (% of time)	403	0.006	–0.016, 0.028	0.573
12y MVPA (% of time)	403	–0.046	–0.094, 0.002	0.058
9y sports club participation	331	–0.002	–0.003, –0.00004	0.044

Adjusted for sex and SES.

participation, although both were significantly inversely associated with MVPA min, and BMI was also associated with total activity.

Sports club participation at 9y was highly predictive of participation at 12y, even after adjustment for sex and SES ($p=0.001$). No other measure of either accelerometry or body composition at 9y predicted sports club participation at 12y. None of the 7y variables were associated with 9y sports club participation, although FMI ($p=0.089$) and BMI z score ($p=0.065$) approached significance (data not shown). At 9y, sports club participation predicted all 12y body composition measures. Including 12y sports club participation as a covariate introduced co-linearity issues so analyses were performed separately (Table 3). Sports club participation at 9y did not predict physical activity as measured by accelerometry at 12y.

There were no significant associations between percentage change in sports club participation and percentage change in FMI or accelerometry from 9y to 12y. Percentage change in sports club

participation from 9y to 12y did not predict 12y body composition.

4. Discussion

Longitudinal associations between sports club participation, body composition and physical activity from childhood to adolescence. This study addressed important limitations from previous research in order to provide evidence on the associations between sports club participation, objectively measured physical activity, and adiposity in childhood and adolescence. Several pertinent results serve to address these limitations. Firstly, we found that sports club participation at the age of 12 years was not associated with BMI or BMI z-score at the same age, but was associated with FMI. This highlights the benefits of our study relative to previous work, as despite its prevalence as a measure of adiposity in

paediatric sports participants,³ simple proxies of adiposity (BMI) have been unable to detect associations convincingly in the way that our body composition measure has. Regular physical activity in childhood, including sports participation, is associated with increases in bone density and skeletal muscle power. Such benefits render BMI as potentially ineffective as a measure of adiposity, and this may underpin the lack of association between sports participation and paediatric obesity that is currently evident in the literature.³

In contrast, this study found no cross-sectional association between sports club participation and either BMI, BMI z score, or FMI at 9 years of age. Given that the contribution of sports club participation to improved levels of adiposity is achieved directly through its contribution to physical activity,²¹ this finding may reflect greater levels of active free play outside of sports at age 9, or increased levels of sedentary behaviours outside of sports at age 12, although in our study there was no association between sports club participation and accelerometry at 9y. In a US sample, at age 9 children engaged in approximately 54 min of MVPA on every day of the week, however, by the age of 12 this dropped to approximately 36 min per day.²² The recorded levels of MVPA in the current sample were even lower, probably due to the use of different cutpoints. Thus, sports participation may become an increasingly significant source of physical activity over late childhood and early adolescence when physical activity is likely to decline dramatically and rates of obesity incidence are highest.²³

We found that physical activity and body composition at age 9 did not predict sports club participation at age 12. This provides some evidence that sports club participation is the source of increased physical activity and decreased levels of adiposity, rather than a consequence of these variables. This finding reinforces that sports can be an appropriate avenue to promote health for all children, regardless of weight status or physical activity levels. National studies conducted in the United States have concluded that more than half of all youth who are obese participate in organised sports, and more than one quarter of organised sport participants are overweight or obese.^{24,25}

Sports club participation at age 9 was strongly associated with sports club participation at age 12. This finding shows that sports club participation in childhood tracks into late childhood and early adolescence. This is unsurprising given typically low levels of dropout from organised sports in this age group. It remains unclear however, whether sports club participation would track far beyond early adolescence because adolescence is a period of rapid acceleration in the dropout rate from organised sports.²⁶ Evidence shows that there are low to moderate levels of tracking of physical activity from childhood to adolescence.²⁷ However, more research is needed to assess the level of tracking of organised sports participation and its associated health trajectories through this period and into adulthood.

Importantly, we found that sports club participation at age 9 predicts measures of body composition at age 12. Given the degree of tracking from 9y to 12y, sports club participation predicts body composition longitudinally in part because sports club participation tends to track from ages 9 to 12. The long-term health benefits of sports club participation are most likely evident because children maintain their participation in sports clubs, rather than sports club participation providing any long-term protective effects. Although participation in sports clubs may contribute to concurrent levels of physical activity, they are unlikely to provide children with the skills or motivation to maintain healthy lifestyles. For example, we found that sports club participation at age 9 did not predict levels of physical activity at age 12. Therefore, it is imperative that if organised sports are to be used to promote physical activity and reduce the burden of adiposity in childhood the focus of policy and intervention should be on preventing drop out from organised

sports, and for encouraging uptake in children from poorer areas. The time period of late childhood/early adolescence appears to be critical for both declining MVPA, increasing incidence of new cases of obesity,²³ and increased excess weight gain,²⁸ so preventing the decline in physical activity in late childhood should be a priority. This is particularly so in areas such as Britain where the participation rate in organised sports is already high²⁹ and while the impetus of the Olympic Legacy is still strong. It is important to also consider non-sport MVPA as this should make an important contribution to overall MVPA, even for those children and adolescents involved in sports clubs.

This study has two significant strengths which add weight to the novel findings. Firstly, the use of objectively measured physical activity removes potential biases in the concurrent self-reporting of sports club participation and physical activity. The beta coefficients presented in the results are also likely to be conservative estimates; differences in intra-individual variation in physical activity produce an intraclass correlation coefficient of approximately 0.5, and this value can be used to correct measurement error (β coefficient/ICC), assuming that all measurement error stems from intra-individual variability.³⁰ The true associations are therefore potentially double those suggested.³⁰ Secondly, the use of FMI, in addition to BMI, as a measure of body composition allows a greater sensitivity to detect the health benefits of sports club participation. One limitation of the present study was that sedentary behaviour was defined as no movement of the trunk¹⁷ and based on a cutpoint derived from a calibration study of preschool children. Lower cutpoints are more popular now, but the optimum cutpoint is unclear at present, and one recent study found that the cutpoint used in the present study provided stronger associations with cardiometabolic health than alternative cutpoint.¹⁶ Further limitations include the necessity of a self-report measure of sports club participation, with the potential problems of recall bias. However, as we are asking the children about regular events we believe the questionnaire is robust enough to deal with this issue. The increased associations observed at 12y over 9y may reflect greater accuracy of recall when the children are older, or an increase in the intensity and focus of their sports club participation. The conservative choice of accelerometer cutpoints may have reduced the levels of MVPA observed, but this is unlikely to have affected the associations; rather there would be a different dose-response. Present study findings are tentative, as the use of objective measures of physical activity and a measure of adiposity will need to be replicated in other populations/settings.

5. Conclusion

This study suggests that that sports club participation may be associated with decreased levels of adiposity. Furthermore, the health benefits of sports club participation in childhood are likely generated from continuous participation in sports clubs, rather than any long-term or protective effects that may be provided by participation.

Practical implications

- Participation in sports clubs tracks strongly from childhood to early adolescence.
- Participation in sports clubs at age 12 years was associated with lower body fat.
- Children's participation in sports clubs could be encouraged as a way to minimise an increase in body fat.
- Participation in sports clubs should be encouraged in young children at risk of overweight or obesity, particularly those from more deprived areas.

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