Physical activity, quality of life, weight status and diet in adolescents

Spencer E Boyle
Georgina L Jones
Stephen J Walters

Medical Statistics Group, School of Health and Related Research, University of Sheffield, Sheffield, S1 4DA, UK.

Email address:
spencer_boyle@yahoo.com
s.j.walters@sheffield.ac.uk

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Abstract

Purpose

This cross-sectional study aimed to investigate the relationship between quality of life (QoL), physical activity (PA), diet and overweight status in children 11 to 15 years old.

Study participants

Participants (N=1,771) children with self-reported physical activity and QoL outcome data.

Methods

Cross-sectional survey of four secondary schools, using the PedsQL and EQ-5D QoL instruments; the CAPANS physical activity instrument and a food intake screener questionnaire.

Results

The correlational analysis indicates little or no relationship between self-reported QoL, BMI and moderate to vigorous PA. We found no statistically significant differences between the two groups of children, who achieved the recommended PA guidelines and those who did not, on any of the dimensions of the PedsQL and the EQ-5D utility score. Only on the EQ-5D VAS dimensions score was there a statistically significant difference. Children who self reported a BMI of overweight to obese had significantly lower QoL on both dimensions of the EQ-5D and every dimension of the PedsQL apart from School functioning.

Conclusion

Overall this study showed mixed results for pupils achieving the recommended targets for physical activity and diet and their relationship with QoL. Hence further study into PA and diet and their effects on QoL is needed.

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Introduction

Physical activity (PA) and its associated benefits to health are now well established. Examples of these benefits include skeletal health, obesity prevention (coupled with dietary intervention), psychological health and esteem, and prevention of Cardiovascular disease (CVD) risk factors [1, 2, 3, 4, 5].

The American College of Sports Medicine (ACSM) and the American Heart Association (AHA) have explicitly quantified the amounts and intensities of PA that should be accumulated for optimum health. Adults are recommended to participate in aerobic PA of at least 30 minutes of a moderate intensity level on at least 5 days of the week or 20 minutes of vigorous intensity cardio on 3 days a week (or a combination of the two) alongside 8 to 10 strength based exercises twice per week [6]. In the UK the Department of Health recommends that children take part in 60 minutes of PA per day on each day of the week and at least twice per week the activity should be muscle strength and flexibility based [7].

A positive association between PA and a higher perceived health related quality of life (HRQoL) in adults has also been documented [8]. Some evidence exists that children who regularly participate in PA are more likely to report higher quality of life than those who had never participated [9]. However, PA and QoL studies in children are often confined to populations with a chronic condition or specific health problem. For example Shoup and colleagues reported physical, psycho-social and total quality of life scores were significantly lower in obese children compared to overweight children [10]. Further studies by Schwimmer, Friedlander and Pinhaus-Hamiel and colleagues all examined overweight compared to normal weight children and all found normal weight children reporting higher quality of life scores [11,12,13].

Few studies are available that examine whether English secondary school pupils who meet the recommended guidelines for PA show any difference in self-reported QoL to those

children not attaining the recommendations. Therefore the main aim of this cross-sectional survey was to explore the relationship between self-reported physical activity and QoL (as measured by the PedsQL and EQ-5D) in English school children aged 11 to 15. Secondary objectives were to investigate the relationship between self-reported dietary intake, Body Mass Index (BMI) and QoL.

Methods

Design and setting

Four comprehensive secondary schools were matched according to characteristics described in Office for Standards in Education (Ofsted) reports; two were in the northwest of England, two in the southwest. The schools were selected on the basis of a close match in: examination results, percentage of children on free school meals, and percentage of children with special educational needs (SEN). The participating schools were part of a cross-sectional study examining physical activity, diet and quality of life. Questionnaires were completed in class in the presence of a teacher and the same questionnaires were completed twice, once in the summer term and once in the winter term.

University of Sheffield research ethics committee approval was obtained for this study and the Local Education Authority was consulted in order to gain initial contact with the secondary schools involved. Consultation with the heads of the secondary schools followed this. Initially the study details were circulated in a school newspaper, which every parent receives, at each school. After this process the whole school populations were given an information letter to take home with a consent slip to be returned by a parent or guardian. As children were of secondary school age it was thought they could sign consent to fill out a survey on the day of the study, if a parental slip had not been returned [14].

Participants

Two thousand eight hundred and fifty-eight pupils aged 11-15 in four secondary schools in England (2 in the northwest (NW) and 2 in the southwest (SW) region) were sent a letter with consent slip attached explaining the survey study and invited to participate in an

anonymous survey on two occasions (summer and winter). The participating children had to give written consent to take part in the study. Eight hundred and sixty-nine children (869/2858 or 30%) responded to the winter survey and had valid self-reported physical activity data, and 35% (1000/2858) responded to the summer survey, an overall response rate of 33% (1869/5716) (see Table 1). Of these 1,771 also completed the PedsQL and had valid QoL and physical activity outcome data and were analysed in this study. There were no differences between the children who completed the QoL assessments and declined to complete the QoL assessment, on self reported physical activity, BMI, fruit intake, fat intake, sex and receipt of free school meals. The only significant differences were that those who did not complete the QoL assessments were more likely to be younger (mean of 12.2 vs. 13.2 years of age); more likely to be at school in the SW (6.8% vs. 4.4%) and of white ethnicity (6.6% vs. 3.1%). As this was an anonymous survey no information was collected on the characteristics of the non-respondents to the questionnaire, therefore a comparison of respondents to non-respondents cannot be made. Also since this was an anonymous survey we have no information on how many children completed the survey twice in the winter and summer.

Measures

Self-reported demographic information was collected from the pupils such as age, sex, ethnicity, entitlement to free school meals, height and weight.

Physical activity

The self-completed Western Australian Child and Adolescent Physical Activity and Nutrition Survey (CAPANS) questionnaire was used to assess physical activity [15]. The CAPANS consists of 24 questions and was first successfully used in a sample of 2274 children aged 7 to 16 years in 2003 [16]. The CAPANS asks children to select the type of physical activity (from a comprehensive list of activities) they usually do in a typical week; and then to record the number of times they did the activity and the time spent on that activity. The total time spent on physical activity per week was calculated by totaling the time children spent in moderate or vigorous activity per day and then dividing this figure by seven to give an average for the week. The UK government recommends children are

physically active at a moderate intensity for 60 minutes per day [7]. Therefore the physical activity data was further classified into whether or not children were meeting the recommendations or not.

Diet

The Block food intake screener [17] was used to assess diet and the intake of fat, fibre, fruit and vegetables. The responses to the screener can then be used to estimate the amount of fat and fruit and vegetables a child is consuming in their diet. Fat and fruit intake for each child was then further classified as achieving the optimal of fats (<35% of calories consumed per day) or fruit and vegetable (at least 5 portions per day) or not.

Body Mass Index (BMI)

The pupils estimated their own height and weight which was then used to calculate each child's BMI. UK specific BMI reference values and cut-points were then used to classify each child as having normal weight or being overweight or obese [18, 19].

Quality of life

The Pediatric Quality of Life Inventory (PedsQL version 4.0) and European Quality of Life 5 Dimension measure (EQ-5D) were used to assess QoL [20, 21]. The 23-item PedsQL instrument is designed to measure QoL in children aged 4-18 and includes four QoL scales of 1) Physical Functioning (PF- 8 items), 2) Emotional Functioning (EF - 5 items), 3) Social Functioning (SF- 5 items) and 4) School Functioning (Sch F 5 items). Two further scales can be created a Total scale and a Psychosocial health summary score. The Psychosocial health summary score is computed as the sum of the items over the number of items answered in the Emotional, social and School functioning scales. The Total scale score is computed as the sum of all the items over the number of items answered on all of the scales. Responses to the items are scored and transformed to a 0-100 scale, so that a higher scored indicates better QoL [21].

The six-item EQ-5D (previously referred to as the EuroQol) is a generic quality of life instrument, designed to assess health outcomes. We used the youth version, EQ-5D-Y,

which differs from the adult version in changes of words which especially were adapted for children [22, 23]. It was divided into two sections; section one addresses mobility, self-care, usual activities, pain/discomfort, and anxiety/depression, to which are each assessed by a single question on a three point ordinal scale (no problems, some problems, extreme problems). An EQ-5D 'health state' is defined by selecting one level from each dimension. A total of 243 health states are thus defined. Values or preference weights for a sample of these health states were obtained from a general community sample using a time-trade-off (TTO) technique. Estimates for all health states were extrapolated from this sample by statistical regression modeling. The EQ-5D preference-based measure can be regarded as a continuous outcome scored on a -0.59–1.00 scale, with 1.00 indicating 'full health' and 0 representing dead [24]. The negative EQ-5D scores represent certain health states valued as worse than dead. The sixth item consists of a 100-point Visual Analogue, which asks responders to rate their overall health today on 0 (worst possible health) to 100 (best possible health) scale.

Statistical analyses

We used statistical methods to analyse the QoL outcome data as described in Walters [25]. The association between the QoL outcomes and BMI and minutes of physical activity per day was examined using Pearson correlation coefficients. Two independent sample *t*-tests were used to compare mean QoL scores between those children meeting or not meeting the recommended guidelines for: physical activity; fat dietary consumption; fruit and vegetable dietary consumption and weight status. Finally a multiple linear regression analysis was used to compare QoL outcomes between the above groups and allow for the potential confounding factors of age, sex (male vs. female), ethnicity (white vs. non-white), receipt of free school meals (yes/no), and area (NW/SW). Ninety-five percent confidence intervals for the mean difference in QoL scores between the groups are reported for the unadjusted and adjusted analyses. This was an anonymous survey and we have no information about whether or not the children completed the survey twice in the winter and summer, therefore the majority of the statistical analyses were performed and reported separately by season. To interpret the mean differences we assumed a minimal important difference (MID) of 4.5 points for the PedSQL dimensions [26] and 0.07 for the EQ-5D utility score

[27]. A P-value of less than 0.05 was regarded as statistically significant. SPSS version 14.0 was used for analysis of the data.

Results

Table 2 shows the demographic, QoL and PA levels of the responders to the survey. Just over half (51.7%) of the recruited children were boys and the average age of the participants was 13.2 years (SD 1.2). Forty percent of the participants were non-white. In addition, approximately 25% of the participants were meeting the recommended guidelines for physical activity and 23.5% of participants were classified as overweight/obese.

Table 3 shows the correlations between BMI, PA and QoL. The correlations between QoL and PA; QoL and BMI suggested a very weak relationship ($r < 0.20$). The strongest correlations were for the intra-dimension correlations of the PedsQL.

Table 4 shows that there were no statistically significant differences between the two groups of children, those who achieved the physical guidelines and those who did not, on any of the dimensions of the PedsQL and the EQ-5D utility score. When a multiple linear regression model was applied, to adjust the comparison between the groups for age, gender, ethnicity, free school meals, area, again there was no significant difference between those achieving the PA recommendation and those who did not on any of the dimensions of the PedsQL and the EQ-5D utility score. The EQ-5D VAS scores for summer and winter showed those achieving the 60 minutes of PA per day recommendations reported significantly better scores than those who did not achieve the recommendations. However the observed differences in EQ-5D VAS scores between the groups were less than four points suggesting that these differences are small in magnitude and may not be of any clinical or practical importance.

Table 5 shows the mean QoL scores by weight status. Statistically significant differences were observed between the Normal and Overweight/obese groups for the PF, EF, SF, PHSS and Total dimensions of the PedsQL and the EQ-5D VAS in summer and winter, with the

Normal weight group reporting better QoL. These differences remained after adjustment for covariates. However, the observed differences in PedsQL and EQ-5D VAS scores between the groups were generally between four and five points, around the MID of 4.5 points for the PedsQL, suggesting that these differences are potentially of some clinical or practical importance.

Table 6 shows the mean QoL scores by dietary fat consumption status. Statistically significant differences were observed between the optimal (< 35% of daily calorie intake in fats) and fat intake too high groups only for the EF dimension of the PedsQL in the winter survey and this difference remained after adjustment for covariates, with the optimal fat intake group reporting better QoL. However the observed difference in EF scores between the two groups was 3.9 points, less than the MID of 4.5 points for the PedsQL, suggesting that this difference is small in magnitude and may not be of any clinical or practical importance.

Table 7 shows the mean QoL scores by dietary consumption of fruit and vegetables. Statistically significant differences were observed between the optimal consumption (5 or more portions of fruit and vegetables per day) and not optimal consumption groups for the EF, SF, PHSS and Total dimensions of the PedsQL in the winter survey, with those who achieved the optimal consumption reporting poorer QoL. These differences remained after adjustment for covariates. In the summer survey the pattern was less clear with only the statistically significant differences being observed between the optimal consumption (5 or more portions of fruit and vegetables per day) and not optimal consumption groups for the PedsQL SF and EQ-5D VAS dimension with those who achieved the optimal consumption again reporting poorer QoL. However all of these observed differences were small, less than the MID of 4.5 points for the PedsQL suggesting that these differences are small in magnitude and may not be of any clinical or practical importance.

Discussion

The correlations observed in this study indicate little or no relationship between self-reported QoL, BMI and moderate to vigorous PA. We also found no statistically significant

differences between the two groups of children, who achieved the recommended PA guidelines and those who did not, on any of the dimensions of the PedsQL and the EQ-5D utility score. Only on the EQ-5D VAS score was there a statistically significant difference between the groups.

This difference on the EQ-5D VAS dimension is the only evidence from this study which agrees with several reports on adult physical activity and QoL [28 29 30 31 32] and studies on children examining obesity, QoL and PA [9, 10]. It may be that our measures of QoL (the PedsQL and EQ-5D) in this relatively healthy group were not sensitive enough to detect differences between the more active and less active children. Or it could be that at this younger age the differences of being active or not may not yet have impacted on the pupils' health [33]. Wendel-Vos and colleagues [33] found some cross-sectional associations between leisure time activity and physical components of QoL, whereas longitudinal associations were predominantly observed for mental components of QoL. This shows that there is possibly a beneficial effect of PA on QoL over a longer sustained period of time.

While physical activity showed little relationship to QoL and diet showed some relationships; children who self-reported a BMI of overweight to obese (according to UK cut-points [18]) had significantly lower QoL on both dimensions of the EQ-5D and every dimension of the PedsQL apart from the School Functioning dimension. These findings lend further support to an existing evidence base of overweight/obese children reporting lower quality of life. De Beer and colleagues found in their study of 31 obese adolescents to 62 normal weight 12-18 year olds that the obese subjects reported significantly lower PedsQL dimension scores compared to the normal weight subjects [34]. Friedlander's study, using a different measure of QoL in a younger (8-11 years) group of children also found similar results [12]. Of the 371 children involved in this study the overweight children had increased odds of lower scores on various health related quality of life dimensions. Similarly, Schwimmer and colleagues found that overweight children were five times more likely to report low QoL scores when compared to healthy weight children [11]. Several other studies have similarly shown that overweight or obese children and adolescents

report lower QoL scores in at least some if not all dimensions compared to healthy weight subjects [13, 35, 36, 37, 38].

In terms of diet and QoL this study found that those eating more fat reported a significantly worse emotional functioning than healthy eaters although conversely those whose fruit intake was optimal reported that their QoL was significantly worse than those eating less fruit and vegetables. However both effects were small in magnitude and may not be of any clinical or practical importance. There are several studies which would also support the idea of a 'healthy' diet supplementing a higher QoL. However most of these studies have been conducted in populations with specific diseases or conditions. In a trial investigating diet and its implications on hypertension a controlled diet of the recommended intakes of vegetables and fat improved participant's perception of their quality of life [39]. Hassan and colleagues in the examination of the BRFSS (Behavioural Risk Factor Surveillance System) data, in which 182,372 US adults participated, also reported that better diet supported by exercise in the overweight and obese participants was associated with better QoL [40].

The study has several strengths and limitations. We had a large sample of over 1,700 children self-reporting QoL and physical activity. We believe that the participants in this study represented an ethnically diverse cross section of the secondary school population that is broadly similar to many comprehensive secondary schools in England. The data was collected over the same period of time in all schools which should account for any differences in activity due to holiday periods or seasonality.

The generalisability of this study, to other schools and areas in England, is likely to have been affected by the low response rate of 33% (1869/5716). This study involved only four schools in two regions, and is not a random sample of pupils or schools, so therefore the results must be interpreted cautiously and cannot be wholly representative of other schools in the NW and SW or indeed England. The low response rate may have potentially caused a bias in the estimated differences in QoL between the various groups. Unfortunately as this was an anonymous survey no information was collected on the

characteristics of the non-respondents to the questionnaire, therefore a comparison of respondents to non-respondents cannot be made. Also since this was an anonymous survey we have no information on how many children completed the survey twice in the winter and summer. So we cannot rule out that some bias may have been introduced into the sample. However, 23.5% of our survey participants were classified as obese which is similar to previous estimates for English school children aged 11-15 of 21%; although only 25% of our sample met the physical activity guidelines compared to around 52% reported nationally [41]. Our sample appeared to have similar levels for receipt of free school meals (18% vs. 16.5%) compared to school roll information.

We believe that the responders, to our survey, are more likely to be a well motivated group of students, who are more likely to report higher levels of QoL, physical activity and better levels of diet and lower levels of BMI (due to overestimating their height and underestimating their weight). If this is so then we believe the results and observed differences between the groups are potentially likely to be smaller than the true differences as we have a self-selected sample of students who eat and exercise well and generally have a good QoL.

The cross-sectional design is less robust than a longitudinal study. So it must be clearly acknowledged that the data represents merely a snap shot of information on physical activity and QoL. The diet questionnaire although validated and piloted by the authors has mainly been used in an adult non-UK population, which again may have an effect.

Pragmatically, we used self report methods rather than objective measures such as pedometers or accelerometers to estimate physical activity. This may have resulted in an overestimate of activity particularly if this was a well motivated group of students. However, the use of objective measures, such as pedometers, is not without problems as the use of these tools tends to alter the behavior of people being observed and again may result in an over estimate of activity. In general, the potential 'bias' of self-reporting survey methods for diet or PA is of concern to any researcher and the over-reporting in activity or under-reporting fat intake maybe a particular worry in studies of children[42]. However in

previous studies of children and PA the self-report survey shows some promise of being a quality research instrument with a young population [43] and remains the most widely used measurement tool [44]. For practical reasons (since we had a large sample) we used the self-reported CAPANS instrument to assess PA, which has been shown to be reliable and valid measure in children [16]. In several studies self-reported BMI in children has shown that students tend to underestimate their BMI. Those students who are overweight or obese tend to underestimate their BMI to a greater extent than normal weight students. However, further studies have found that differences between self-reported and measured height and weight in young people were not statistically significant and there was reasonable agreement between actual and self-reported measurements [14, 45]. In other studies, which found differences, they reported that over 90% of adolescent participants estimated weight and height was in the correct BMI (Overweight/obese or Normal) classification group [46 47].

Conclusion

Those children aged 11-15 achieving the recommended 60 minutes of moderate to vigorous physical activity per day had similar QoL (as assessed by the PedsQL) to those who did not achieve the recommended physical activity guidelines. In this sample those reporting a normal BMI had better QoL outcomes on both the EQ-5D and PedsQL measures (apart from the School Functioning dimension) than overweight/obese children, thus confirming previous studies. Overall this study showed mixed results for pupils achieving the recommended targets for physical activity and diet and their relationship with QoL. Hence further study into PA and diet and their effects on QoL is needed.

Abbreviations

SEN Special Educational needs

GSCE General Secondary Certificate Examination

BMI Body Mass Index

PedsQL PF PedsQL Physical Functioning dimension

PedsQL EF PedsQL Emotional Functioning

PedsQL SF PedsQL Social Functioning

PedsQL SchF PedsQL School Functioning

PedsQL PHSS PedsQL Psychosocial Health Summary Score

PedsQL Total PedsQL Total Scale Score

EQ-5D VAS Visual Analogue Scale

EQ-5D Utility Overall Utility (Tariff)

Table 1: Survey response rates and school characteristics

	School 1	2	3	4	Totals
Number of children role	1198	923	922	671	3714
GSCE Examination Results (2004)					National Average =
% five or more passes with grades A to C	43%	52%	42%	51%	54.5%
Key stage 3 assessment results (2004)					England Average
(average point score)	32.8	32.5	31.9	33.9	Point Score = 34.1
Percentage of SEN pupils on statement (2005)	1.8%	2.1%	7.1%	3.4%	National Average SEN with Statement =
Percentage, with SEN but not on statement	25.1%	27.1%	5.9%	16.7%	2.9% without statement = 14.9%
1st wave: winter 2006					
No. of children sent letters	965	744	567	582	**2858**
Questionnaires returned	438	343	213	64	**1058**
Incomplete questionnaires	81	83	25	0	**189**
Responders	357	260	188	64	**869**
1st wave overall response rate	357/965 (37%)	260/744 (35%)	188/567 (33%)	64/582 (11%)	**869/2858 (30%)**
2nd wave: summer 2007					
No. of children sent letters	965	744	567	582	**2858**
Questionnaires returned	543	261	225	279	**1308**
Incomplete questionnaires	118	84	53	53	**308**
Responders	425	177	172	226	**1000**
2nd wave overall response rate	425/965 (44%)	177/744 (24%)	172/567 (30%)	226/582 (39%)	**1000/2858 (35%)**

SEN (Special Educational Need); GCSE (General Certificate of Secondary Education Examination)

Table 2: Demographic characteristics of sample by season

		Season							
		Winter			Summer		Total		
		N	Mean	SD	N	Mean	SD	N	Mean	SD
Age (years)		814	13.1	1.2	957	13.3	1.3	1771	13.2	1.2
Self reported height (metres)		706	1.6	0.1	558	1.6	0.1	1264	1.60	0.11
Self reported weight (kg)		696	48.9	11.2	465	48.6	12.6	1161	48.76	11.80
Estimated BMI (kg/m2) from estimated height and weight		691	19.1	3.8	423	18.8	3.7	1114	19.00	3.76
Minutes of sedentary behaviour per day (last 7 days)		814	307.2	173.2	956	241.6	122.0	1770	271.8	151.3
Minutes of (mod/vig) Physical Activity per day		813	36.5	36.4	957	50.5	39.1	1770	44.1	38.5
PedsQL Physical Functioning		814	89.5	15.3	957	90.8	14.0	1771	90.2	14.6
PedsQL Emotional Functioning		814	81.6	20.9	957	83.5	19.5	1771	82.6	20.2
PedsQL Social Functioning		814	88.2	18.5	957	89.1	17.4	1771	88.7	17.9
PedsQL School Functioning		814	79.8	20.3	957	81.0	19.8	1771	80.5	20.0
PedsQL Psychosocial Health Summary Score		814	83.2	17.1	957	84.5	15.6	1771	83.9	16.3
PedsQL Total Scale Score		814	84.8	15.8	957	86.1	14.2	1771	85.5	14.9
EQ-5D VAS		772	78.7	16.9	819	78.1	17.1	1591	78.4	17.0
EQ-5D Overall Utility (Tariff)		779	0.90	0.16604	896	0.89	0.21	1675	0.90	0.19
								N	%	
School year	*7*	199	(24.4%)		355	(37.1%)		554	(31.3%)	
	9	369	(45.3%)		344	(35.9%)		713	(40.3%)	
	10	246	(30.2%)		258	(27.0%)		504	(28.5%)	
		814	(100.0%)		957	(100.0%)		1771	(100.0%)	
Gender	*Male*	407	(50.0%)		508	(53.1%)		915	(51.7%)	
	Female	407	(50.0%)		449	(46.9%)		856	(48.3%)	
		814	(100.0%)		957	(100.0%)		1771	(100.0%)	
Achieving 60 mins of moderate/vigorous	*No*	673	(82.7%)		652	(68.1%)		1325	(74.8%)	
Physical Activity per day	*Yes*	141	(17.3%)		305	(31.9%)		446	(25.2%)	
		814	(100.0%)		957	(100.0%)		1771	(100.0%)	

Ethnicity	*Non-white*	328	(40.3%)	371	(38.8%)	699	(39.5%)
	White	486	(59.7%)	586	(61.2%)	1072	(60.5%)
		814	(100.0%)	957	(100.0%)	1771	(100.0%)
Child in receipt of school meals	*No*	655	(80.6%)	789	(82.5%)	1444	(81.6%)
	Yes	158	(19.4%)	167	(17.5%)	325	(18.4%)
		813	(100.0%)	956	(100.0%)	1769	(100.0%)
Optimal Fruit/vegetable intake	*No, not optimal*	403	(49.7%)	413	(43.2%)	816	(46.2%)
of 5 or more portions of fruit/vegetables per day	*Yes, optimal*	408	(50.3%)	544	(56.8%)	952	(53.8%)
		811	(100.0%)	957	(100.0%)	1768	(100.0%)
Optimal Fat intake of < 35% of calary intake	*No, not optimal*	624	(77.1%)	751	(78.5%)	1375	(77.9%)
	Yes, optimal	185	(22.9%)	206	(21.5%)	391	(22.1%)
		809	(100.0%)	957	(100.0%)	1766	(100.0%)
BMI of pupils grouped by normal or overweight/obese	*Overweight/obese*	173	(25.1%)	89	(21.0%)	262	(23.5%)
according to UK BMI cut points	*Normal*	517	(74.9%)	334	(79.0%)	851	(76.5%)
		690	(100.0%)	423	(100.0%)	1113	(100.0%)

Table 3: Correlations between physical activity, BMI and quality of life

		BMI (kg/m2)	Physical Activity (min/day)	PedsQL PF	PedsQL EF	PedsQL SF	PedsQL SchF	PedsQL PHSS	PedsQL Total	EQ-5D VAS	EQ-5D Utility
BMI (kg/m2)	*Correlation*	1									
	P-value										
	N	1114									
Physical Activity	*Correlation*	-0.14	1								
(min) per day	*P-value*	<0.001									
	N	1114	1770								
PedsQL PF	*Correlation*	-0.08	-0.01	1							
	P-value	0.009	0.677								
	N	1114	1770	1771							
PedsQL EF	*Correlation*	-0.07	0.03	0.57	1						
	P-value	0.026	0.276	<0.001							
	N	1114	1770	1771	1771						
PedsQL SF	*Correlation*	-0.09	-0.02	0.61	0.60	1					
	P-value	0.003	0.378	<0.001	<0.001						
	N	1114	1770	1771	1771	1771					
PedsQL SchF	*Correlation*	-0.04	0.03	0.54	0.57	0.50	1				
	P-value	0.154	0.147	<0.001	<0.001	<0.001					
	N	1114	1770	1771	1771	1771	1771				
PedsQL PHSS	*Correlation*	-0.08	0.02	0.68	0.87	0.82	0.83	1			
	P-value	0.009	0.471	<0.001	<0.001	<0.001	<0.001				
	N	1114	1770	1771	1771	1771	1771	1771			
PedsQL Total	*Correlation*	-0.08	0.01	0.80	0.85	0.82	0.81	0.98	1		
	P-value	0.006	0.626	<0.001	<0.001	<0.001	<0.001	<0.001			
	N	1114	1770	1771	1771	1771	1771	1771	1771		
EQ-5D VAS	*Correlation*	-0.19	0.14	0.33	0.28	0.28	0.25	0.33	0.35	1	
	P-value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001		
	N	1047	1590	1591	1591	1591	1591	1591	1591	1591	
EQ-5D Utility	*Correlation*	-0.05	0.04	0.42	0.42	0.33	0.29	0.42	0.45	0.26	1
	P-value	0.135	0.076	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	
	N	1077	1674	1675	1675	1675	1675	1675	1675	1583	1675

Table 4: Mean scores of QoL dimensions by physical activity status and season

	Achieving 60 minutes of moderate/vigorous Physical Activity per day													
	No			Yes			Mean	95% CI			Adjusted	95% CI		
	N	Mean	SD	N	Mean	SD	Difference	Lower	Upper	P-value*	Difference	Lower	Upper	P-value#
Winter														
PedsQL PF	673	89.9	14.0	141	87.8	20.1	-2.1	-4.8	0.7	0.144	-0.7	-3.6	2.3	0.659
PedsQL EF	673	81.7	20.6	141	80.9	22.6	-0.8	-4.6	3.0	0.672	-1.1	-5.1	2.8	0.572
PedsQL SF	673	88.8	17.3	141	85.2	23.3	-3.6	-6.9	-0.2	0.036	-1.9	-5.5	1.6	0.287
PedsQL SchF	673	80.2	19.4	141	77.9	24.1	-2.3	-6.0	1.4	0.219	-2.5	-6.4	1.4	0.216
PedsQL PHSS	673	83.6	16.1	141	81.3	20.9	-2.2	-5.3	0.9	0.157	-1.8	-5.1	1.4	0.268
PedsQL Total	673	85.1	14.7	141	83.0	20.1	-2.2	-5.1	0.7	0.133	-1.5	-4.6	1.5	0.315
EQ-5D VAS	685	78.2	17.4	141	82.5	13.5	4.3	1.3	7.4	0.006	1.7	-1.5	4.8	0.293
EQ-5D Utility	693	0.90	0.17	141	0.92	0.11	0.02	-0.01	0.05	0.200	0.02	-0.01	0.05	0.153
Summer														
PedsQL PF	652	90.6	14.3	305	91.2	13.2	0.6	-1.3	2.5	0.541	0.4	-1.8	2.6	0.702
PedsQL EF	652	82.8	20.0	305	85.0	18.4	2.2	-0.4	4.9	0.099	1.5	-1.6	4.6	0.342
PedsQL SF	652	88.7	17.6	305	89.8	16.9	1.1	-1.3	3.4	0.384	0.8	-2.0	3.5	0.574
PedsQL SchF	652	80.8	20.3	305	81.6	18.7	0.8	-1.9	3.5	0.553	-0.3	-3.4	2.8	0.864
PedsQL PHSS	652	84.1	15.9	305	85.5	15.0	1.4	-0.8	3.5	0.207	0.7	-1.8	3.1	0.594
PedsQL Total	652	85.7	14.5	305	86.9	13.5	1.2	-0.8	3.1	0.233	0.6	-1.6	2.8	0.594
EQ-5D VAS	583	76.8	17.0	279	81.7	17.0	4.9	2.5	7.4	0.0001	3.8	1.0	6.6	0.008
EQ-5D Utility	646	0.89	0.21	293	0.91	0.20	0.02	-0.01	0.05	0.163	0.02	-0.03	0.04	0.707

*P-value from two independent samples *t*-test.
#Difference adjusted for age, sex (male/female), ethnicity (white/non-white), free school meals (yes/no), area (NW/SW).
PedsQL PF (Physical Functioning); SF (Social Functioning); EF (Emotional Functioning) SchF (School Functioning); PHSS (Psychosocial Health Summary Score); Total (Total Scale Score).
EQ-5D VAS (Visual analogue scale); Utility (Utility score).
For both the PedsQL and EQ-5D dimensions a higher score indicates better QoL.

Table 5: Mean scores of QoL dimensions by weight status by season

	BMI of pupils grouped by Normal or overweight/obese according to UK cut points													
	Overweight/obese			Normal weight			Mean	95% CI			Adjusted	95% CI		
	N	Mean	SD	N	Mean	SD	Difference	Lower	Upper	P-value*	Difference	Lower	Upper	P-value#
Winter														
PedsQL PF	173	85.6	18.1	517	90.8	14.0	5.2	2.6	7.8	0.001	4.8	2.2	7.4	0.001
PedsQL EF	173	78.6	21.5	517	82.6	20.6	4.0	0.4	7.6	0.031	4.3	0.7	7.8	0.018
PedsQL SF	173	83.8	21.8	517	90.2	16.6	6.3	3.2	9.4	<0.001	5.8	2.7	8.9	<0.001
PedsQL SchF	173	77.7	20.9	517	80.3	20.1	2.6	-0.9	6.1	0.145	2.6	-0.9	6.1	0.150
PedsQL PHSS	173	80.0	18.6	517	84.3	16.2	4.3	1.4	7.2	0.004	4.2	1.4	7.1	0.004
PedsQL Total	173	81.4	17.7	517	85.9	14.7	4.5	1.8	7.2	0.001	4.4	1.7	7.0	0.001
EQ-5D VAS	177	75.5	18.0	522	80.6	16.1	5.1	2.3	8.0	<0.001	5.8	3.1	8.6	0.001
EQ-5D Utility	176	0.89	0.15	526	0.90	0.18	0.01	-0.02	0.04	0.651	0.01	-0.02	0.04	0.557
Summer														
PedsQL PF	89	88.1	15.0	334	91.4	12.8	3.2	0.1	6.4	0.041	3.3	0.1	6.4	0.042
PedsQL EF	89	78.7	23.8	334	83.8	17.8	5.1	0.6	9.6	0.026	5.6	1.1	10.1	0.016
PedsQL SF	89	85.4	20.0	334	90.1	14.9	4.8	1.0	8.5	0.014	4.3	0.4	8.1	0.029
PedsQL SchF	89	79.7	21.2	334	80.8	19.3	1.0	-3.6	5.7	0.657	1.1	-3.5	5.8	0.631
PedsQL PHSS	89	81.3	16.8	334	84.9	13.7	3.6	0.2	7.0	0.035	3.7	0.2	7.1	0.036
PedsQL Total	89	83.0	15.5	334	86.5	12.5	3.5	0.4	6.6	0.025	3.6	0.4	6.7	0.025
EQ-5D VAS	85	74.6	17.4	312	80.0	16.0	5.3	1.4	9.2	0.008	6.3	2.3	10.3	0.002
EQ-5D Utility	90	0.84	0.30	335	0.93	0.14	0.08	0.04	0.13	0.001	0.08	0.04	0.13	0.001

*P-value from two independent samples *t*-test.

#Difference adjusted for age, sex (male/female), ethnicity (white/non-white), free school meals (yes/no), season (winter/summer), area (NW/SW).

PedsQL PF (Physical Functioning); SF (Social Functioning); EF (Emotional Functioning) SchF (School Functioning); PHSS (Psychosocial Health Summary Score); Total (Total Scale Score).

EQ-5D VAS (Visual analogue scale); Utility (Utility score).

For both the PedsQL and EQ-5D dimensions a higher score indicates better QoL.

Table 6: Mean scores of QoL dimensions by fat dietary consumption status by season

	Fat intake grouped by optimal <=35% of calorie intake or not optimal >35% of calorie intake													
	Fat intake too high			Optimal fat intake			Mean	95% CI			Adjusted	95% CI		
	N	Mean	SD	N	Mean	SD	Difference	Lower	Upper	P-value*	Difference	Lower	Upper	P-value#
Winter														
PedsQL PF	624	89.5	14.6	185	91.1	13.2	1.6	-0.8	3.9	0.187	1.7	-0.7	4.0	0.167
PedsQL EF	624	80.9	20.5	185	84.9	19.9	3.9	0.6	7.3	0.021	3.9	0.6	7.2	0.021
PedsQL SF	624	88.4	17.9	185	89.0	17.3	0.6	-2.3	3.5	0.691	0.4	-2.5	3.3	0.774
PedsQL SchF	624	79.7	19.9	185	81.5	19.4	1.9	-1.4	5.1	0.263	1.7	-1.6	4.9	0.313
PedsQL PHSS	624	83.0	16.5	185	85.1	15.9	2.1	-0.6	4.8	0.120	2.0	-0.7	4.6	0.143
PedsQL Total	624	84.6	15.1	185	86.6	14.3	2.0	-0.5	4.4	0.111	1.9	-0.5	4.3	0.125
EQ-5D VAS	639	79.4	16.5	185	77.0	18.1	-2.4	-5.2	0.3	0.084	-2.0	-4.7	0.8	0.159
EQ-5D Utility	646	0.90	0.17	186	0.91	0.15	0.01	-0.02	0.04	0.452	0.01	-0.02	0.04	0.433
Summer														
PedsQL PF	751	90.8	14.1	206	90.8	13.6	0.0	-2.2	2.2	0.998	0.1	-2.1	2.2	0.955
PedsQL EF	751	83.1	19.8	206	85.0	18.4	1.9	-1.2	4.9	0.227	2.1	-0.9	5.1	0.169
PedsQL SF	751	88.8	17.6	206	90.0	16.5	1.1	-1.6	3.8	0.412	1.3	-1.4	4.0	0.361
PedsQL SchF	751	80.5	20.2	206	83.0	18.0	2.6	-0.5	5.6	0.099	2.3	-0.7	5.4	0.133
PedsQL PHSS	751	84.1	15.9	206	86.0	14.3	1.8	-0.6	4.3	0.132	1.9	-0.5	4.3	0.122
PedsQL Total	751	85.8	14.5	206	87.2	12.9	1.4	-0.8	3.6	0.214	1.4	-0.8	3.6	0.198
EQ-5D VAS	671	78.7	16.9	191	77.1	18.0	-1.6	-4.4	1.1	0.252	-1.4	-4.2	1.4	0.318
EQ-5D Utility	737	0.90	0.20	202	0.89	0.24	-0.01	-0.04	0.03	0.747	0.00	-0.03	0.03	0.906

*P-value from two independent samples *t*-test.
#Difference adjusted for age, sex (male/female), ethnicity (white/non-white), free school meals (yes/no), season (winter/summer), area (NW/SW).
PedsQL PF (Physical Functioning); SF (Social Functioning); EF (Emotional Functioning) SchF (School Functioning); PHSS (Psychosocial Health Summary Score); Total (Total Scale Score).
EQ-5D VAS (Visual analogue scale); Utility (Utility score).
For both the PedsQL and EQ-5D dimensions a higher score indicates better QoL.

Table 7: Mean scores of QoL dimensions by fruit and vegetable dietary consumption status and season

	Fruit intake either optimal (5 or more portions of fruit/vegetables per day) or not optimal													
	Not optimal			Yes optimal			Mean	95% CI			Adjusted	95% CI		
	N	Mean	SD	N	Mean	SD	Difference	Lower	Upper	P-value*	Difference	Lower	Upper	P-value#
Winter														
PedsQL PF	403	91.0	12.2	408	88.7	16.0	-2.3	-4.3	-0.3	0.022	-2.4	-4.3	-0.4	0.018
PedsQL EF	403	83.7	19.7	408	80.0	20.8	-3.7	-6.5	-0.9	0.010	-3.7	-6.4	-0.9	0.009
PedsQL SF	403	89.9	16.9	408	87.1	18.4	-2.7	-5.2	-0.3	0.028	-2.8	-5.2	-0.4	0.023
PedsQL SchF	403	80.6	19.8	408	79.6	19.7	-1.1	-3.8	1.7	0.444	-1.2	-3.9	1.5	0.394
PedsQL PHSS	403	84.7	16.0	408	82.3	16.6	-2.5	-4.7	-0.2	0.030	-2.5	-4.8	-0.3	0.024
PedsQL Total	403	86.3	14.3	408	83.9	15.5	-2.4	-4.5	-0.4	0.020	-2.5	-4.5	-0.5	0.016
EQ-5D VAS	411	78.0	18.2	414	79.9	15.5	1.9	-0.4	4.2	0.107	1.9	-0.3	4.2	0.093
EQ-5D Utility	418	0.91	0.17	415	0.90	0.16	-0.01	-0.03	0.01	0.374	-0.01	-0.03	0.01	0.385
Summer														
PedsQL PF	413	91.1	13.6	544	90.6	14.3	-0.5	-2.3	1.3	0.587	-0.7	-2.5	1.1	0.452
PedsQL EF	413	84.8	19.1	544	82.5	19.8	-2.3	-4.8	0.2	0.068	-2.6	-5.1	-0.1	0.044
PedsQL SF	413	90.8	15.1	544	87.7	18.9	-3.1	-5.3	-0.9	0.007	-2.9	-5.2	-0.7	0.011
PedsQL SchF	413	81.1	20.6	544	81.0	19.2	-0.1	-2.6	2.5	0.949	0.0	-2.5	2.6	0.981
PedsQL PHSS	413	85.6	15.0	544	83.7	16.0	-1.8	-3.8	0.2	0.072	-1.8	-3.9	0.2	0.076
PedsQL Total	413	86.9	13.6	544	85.5	14.6	-1.5	-3.3	0.3	0.106	-1.6	-3.4	0.3	0.099
EQ-5D VAS	372	76.3	17.6	490	79.9	16.7	3.6	1.3	5.9	0.002	2.8	0.5	5.2	0.018
EQ-5D Utility	407	0.89	0.21	532	0.90	0.21	0.00	-0.02	0.03	0.729	0.01	-0.02	0.03	0.707

*P-value from two independent samples *t*-test.
#Difference adjusted for age, sex (male/female), ethnicity (white/non-white), free school meals (yes/no), season (winter/summer), area (NW/SW).
PedsQL PF (Physical Functioning); SF (Social Functioning); EF (Emotional Functioning) SchF (School Functioning); PHSS (Psychosocial Health Summary Score); Total (Total Scale Score).
EQ-5D VAS (Visual analogue scale); Utility (Utility score).
For both the PedsQL and EQ-5D dimensions a higher score indicates better QoL.

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