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Abstract

Purpose: This study aimed to identify changes in clusters of lifestyle behaviours (physical activity, screen time and diet) between the ages of 7 and 14 years, and to examine socio-demographic determinants of changes.

Methods: Longitudinal analyses were performed on a sample of 9,339 children from the UK Millennium Cohort Study (MCS) who had complete data on behaviours of interest at age 7 (wave 4) and 14 years (wave 6). Joint Correspondence Analysis (JCA) and k-means cluster analysis were used to identify clusters of lifestyle behaviours at both time waves. Multinomial logistic regressions were used to examine the associations between socioeconomic variables and changes in cluster membership. Analyses were conducted separately for boys and girls.

Results: Clusters of behaviours at age 7 and 14 years were identified as healthy, mixed or unhealthy respectively. Compared to girls, a higher proportion of boys remained in the healthier cluster over time (19.1% vs. 13.1%) or became healthier (26.4% vs. 9.36%). A higher proportion of girls changed to an unhealthier cluster (57.2% vs. 33.9%). Indicators of lower socio-economic status, such as low family income, low parental education, and not living with both parents at age 7 were associated with unhealthier changes in cluster membership.

Conclusion: Lifestyle behaviours cluster in children and are susceptible to change over a 7-year period, with a high proportion of boys becoming healthier and a higher proportion of girls became unhealthier. Indicators of socio-economic status appear to be important in determining changes in clusters.

Keywords: lifestyle behaviours, clusters, longitudinal, children, adolescents, inequalities.

What is known: poor lifestyle behaviours (i.e. unhealthy dietary habits, low physical activity, and sedentary behaviours) tend to cluster in children and adolescents.

What is new: Lifestyle behaviours cluster in children and are susceptible to changes between childhood and adolescence. Changes occur differently in boys and girls. Indicators of low socio-economic status are associated with unhealthier changes in behavioural clusters.

List of abbreviations: HC: Healthy Cluster, IQR: interquartile range, JCA: Joint Correspondence Analysis, OECD: Organisation for Economic Co-operation and Development, MC: Mixed Cluster, MCA: Multiple Correspondence Analysis, MCS: Millenium Cohort Study, MVPA: moderate-to-vigorous physical activity, NVQ: National Vocational Qualification, OR: odds ratio, TV: television, UC: Unhealthy Cluster.

Introduction

Lifestyle behaviours such as diet, physical activity, and sedentary behaviour have a significant impact on the health and wellbeing of children and young people [1, 2]. Previous studies suggest that the transition from childhood to adolescence is a critical period for behaviour formation [3, 4]. Adolescence is often accompanied by increases in screen time, decreases in physical activity, and poorer dietary behaviours, characterised by a low consumption of fruit and vegetables, higher consumption of snacks and sugar-sweetened beverages, and breakfast skipping [3, 5–8]. The acquisition of poor lifestyle behaviours during adolescence can result in higher adiposity and cardiometabolic risk [9–11], lower cardio-respiratory fitness [9, 11], poorer self-rated heath [12], poorer mental and emotional health [9, 11, 13], and lower quality of life [10].

Much of the evidence on health behaviours of adolescents comes from studies looking at individual health behaviours in isolation. However, lifestyle behaviours are likely to co-occur within groups of young people [9, 14]. For example, it has been shown than high screen time and high energy-dense snacks consumption tend to cluster in young people, as does low fruit consumption and low physical activity [9, 14]. The effect of clusters of behaviours on health is likely to be greater than the effect of individual behaviours [15, 16]. A better understanding of how, and in whom lifestyle behaviours cluster, and how clusters of behaviours evolve over critical life periods of childhood is essential for the development of targeted interventions. However, to date, much of the evidence on clustering of health behaviours has come from cross-sectional studies [9, 17] or research that has not examined changes in clusters from childhood to adolescence [9]. Previous research has shown that a high proportion of 5-6 years old children belonged to an unhealthy behavioural cluster (high sedentary and low physical activity, or high TV and high energy-dense snacks consumption) and tended to remain in the same cluster or move to the other unhealthy cluster by age 9 years [18]. Furthermore, in a study of adolescents aged 14-16 years at baseline there was a high stability in clusters of lifestyle behaviours (healthy and unhealthy) over a two-year period [19]. However, it is unknown how clusters of lifestyle behaviours change as children become adolescence. Given the significant social, environmental, and interpersonal changes that go alongside this transition [3, 20], it is imperative to understand in whom and how clusters of behaviours change during this period to help inform public health interventions.

An understanding of the determinants of behavioural clusters is required to underpin public health interventions aimed at promoting positive changes in health behaviours [17]. Given that behaviour change interventions that are theoretically based have been shown to be more effective that those without a theoretical underpinning [21, 22], it is useful to utilise behavioural theories to provide a framework for studying determinants of behavioural clusters. There is support for the use of socio-ecological models for understanding key determinants of health behaviours [23]. The socio-ecological model acknowledges that children are embedded within larger social systems and that characteristics of children interact with environments that underlie health behaviours [24].

Previous research has identified that indicators of socio-economic position, factors from a most pertinent level of the socio-ecological model, are important influences on children's behavioural clusters, partly because they influence children's attitudes, experiences, behaviours and exposures to health risk factors [25]. For example, cross-sectional studies have shown that higher parental education is associated with behavioural clusters including high physical activity in schoolchildren [26], while girls and children from lower educated parents have a higher prevalence of unhealthier clusters (for example, clusters including high consumption of sugar sweetened beverages, high screen time, and low sleep duration) [26, 27]. However, wider socio-economic determinants of changes in clusters of lifestyle behaviours are poorly understood.

The results from this study provide support for intervening on multiple behaviours during childhood and adolescence, and to focus on gender differences and parental characteristics related to socioeconomic disparities. More longitudinal analyses in different countries that help to better understand how young boys and girls from different socioeconomic positions change their lifestyle behaviours over the time may guide research to develop more specific and targeted interventions that better consider the needs of different subgroups of young people.

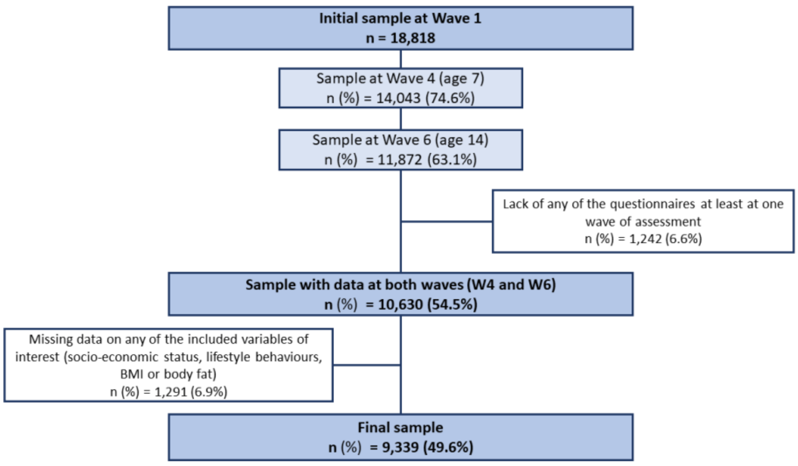
Methods

Study design and participants

Data from the UK Millennium Cohort Study (MCS) (https://cls.ucl.ac.uk/cls-studies/millennium-cohort-study/) were used for the present analyses. Details of the design and sampling of MCS has been published elsewhere [28]. In brief, the MCS is an observational nationally representative longitudinal birth cohort study, which examines socio-economic, and health related circumstances of children born in the UK between September 2000 and January 2002. At baseline (Wave 1) 18,818 children were first assessed when they were 9 months of age. For the present analyses, data when participants were aged 7 years

(MCS4: January-December 2008; n = 14,043) and aged 14 years (MCS6: January 2015-March 2016; n = 11,872) were used (Figure 1).

Figure 1. Sample selection flow-chart



Measures

All assessments of behaviours (physical activity, screen-time, and dietary behaviours) were collected via parent report when participants were aged 7 years, and via self-report when participants were aged 14 years. For the present analyses, variables were dichotomized considering the value which were closer to the guideline recommendations [29, 30] and the sample distribution.

Physical activity

Physical activity was reported as the number of days per week that the cohort member (child participant) took part in moderate-to vigorous physical activity (MVPA). For the present analysis, MVPA was classified as '< 5 days/week' and '≥ 5 days/week'.

Screen time

The number of hours spent watching television (TV) and playing electronic games on a typical weekday was reported. Time spent TV viewing was dichotomized into '< 3 hours/day' and '≥ 3 hours/day', and time spent using electronic games was dichotomized into '< 1 hour/day' and '≥ 1 hour/day'.

Dietary behaviours

Participants reported the servings of fruit eaten per day, and the number of days per week breakfast was eaten. Fruit consumption was dichotomized into '< 2 servings/day' and '≥ 2 servings/day', and the frequency of eating breakfast was dichotomized into 'not every day' and 'everyday'.

Socioeconomic variables at age 7 years

When participants were aged 7 years, parents reported their child's sex, ethnicity, and their weekly household income according to the Organisation for Economic Co-operation and Development (OECD), participants whose OECD was below 60% of the median were considered in situation of poverty. Parents also reported their highest National Vocational Qualification (NVQ) level achieved, and who the child lived with at home.

Statistical analyses

Analyses were conducted using Stata software version 14 (Stata, College Station, TX). Baseline sample characteristics were computed by sex and summarized as median and interquartile range (IQR) for continuous variables, and frequencies and percentages for categorical variables. Kolmogorov Smirnov test and histograms were used to assess the variable distribution. Mann Whitney U tests were used for sex differences in continuous non-parametrical variables, and chi-square tests was used for sex differences in proportions.

At both time points, Joint Correspondence Analysis (JCA), which is an extension of the Multiple Correspondence Analysis (MCA), was conducted to explore the patterns in the categorical lifestyle variables. The analysis included five variables (physical activity, TV viewing, electronic games playing, breakfast eating and fruit consumption). Analyses were carried out for boys and girls separately, as significant sex differences were shown in the lifestyle behaviours at baseline (Table 1). The dimensions revealed from the JCA that contained most of the data variability were used to inform the cluster analysis. The Calinski-Harabasz rule [31] was used to determine the optimal number of clusters solutions. The final number of clusters was decided based on interpretability and Calinski-Harabasz indexes at both time points and for both sexes. So, the number of clusters less or equal to five, with a higher Calinski-Harabasz index at both time points and for both sexes were selected. K-means cluster analysis was used to create 3 clusters of behaviours using the coordinates obtained from the JCA at both waves of assessment independently, and for boys and girls separately. The stability (tracking) of cluster membership between ages 7 years and 14 years was examined using Kappa (K) statistics. The degree of tracking was evaluated using the cut-offs suggested by Landis and Koch [32]: < 0.2, poor; 0.2–0.4, fair; 0.41–0.6, moderate; 0.61–0.8, good; > 0.81, very good. The K value for the stability of cluster membership between 7 and 14 years was 0.254 for girls and 0.265 for boys, which shows fair agreement between baseline and follow-up cluster membership.

As the tracking of clusters was fair, we determined the profile of changes in behavioural clusters. Participants were classified depending on their continuity in the same cluster over time or by their change from one cluster to another. The categories to represent change between age 7 and 14 years were 'remained in healthy cluster', 'remained in mixed cluster', 'remained in unhealthy cluster', 'changed to an unhealthier cluster (i.e. moved from healthy at age 7 to mixed or unhealthy at age 14; or from mixed at age 7 to unhealthy at age 14)', and 'changed to a healthier cluster (i.e. moved from unhealthy at age 7 to mixed or healthy at age 14; or from mixed at age 7 to healthy at age 14)'. Multinomial logistic regressions and the calculation of the corresponding odds ratios (OR) were used to examine the associations between socioeconomic variables at baseline and the changes in cluster membership between ages 7 and 14 years. These models were performed for boys and girls separately and were adjusted for weight status and body fat percentage. Anthropometric covariates were collected by trained researchers during home visits when children were aged 7 years (MCS 4).

Results

From the initial MCS sample of 18,818 children, a final sample analytical sample of 9,339 children (4,660 girls and 4,679 boys; 49.6% of the initial sample) had complete data on all variables of interest and were included in the present analyses (Figure 1).

Characteristics of participants at age 7 years

Parents of boys had a high education level (NVQ above 3) (40.27% vs. 38.65%; p = 0.035) and had higher weekly family income (£405.27 ± 232.47 vs. £397.99 ± 234.50; p = 0.038) compared to girls (Table 1).

At age 7, girls participated in MVPA less frequently and skipped breakfast more frequently than boys. Boys consumed less servings of fruit and spent more time watching TV and playing electronic games than girls (Table 1).

Characteristics of Behavioural Clusters

For boys, the two dimensions (x and y) revealed by the JCA analyses explained 76.1% and 26.1% of the variability in the data at baseline, and the 89.4% and 10.4% variability in the data at follow-up. For girls, the two dimensions revealed by the JCA analyses explained 82.4% and 17.5% of the variability in the data at baseline, and the 86.5% and 13.4% variability in the data at follow-up (SF 1).

Three behavioural clusters solutions were produced: a Healthy Cluster (HC), a Mixed Cluster (MC) and an Unhealthy Cluster (UC) (Table 2). At baseline, 41.6% of boys and 52.6% of girls were in the HC, 36.5% of boys and 31.2% of girls were in the MC, and 21.9% of boys and 16.2% of girls were in the UC.

Among boys and girls at baseline, the HC was characterized by no breakfast skipping, lower TV viewing, higher MVPA, higher fruit consumption, and lower e-games playing than in the MC and UC (Table 2). The UC was characterized by lower MVPA, higher breakfast skipping, lower fruit consumption (especially in boys), higher TV viewing, and higher e-games playing than HC and MC. The MC was characterized by lower MVPA, low breakfast skipping, low TV watching higher, high electronic games playing, and fruit consumption lower than HC, but higher than UC (Table 2).

At follow up, there were differences in the behaviours that characterised each cluster, and clusters differed more between boys and girls than at baseline (Table 2). In boys, the three clusters had a similar percentage of high e-games playing (between 28.8% and 37.4%), while 76% of the girls with high e-games playing were in the UC. In girls, the MC was characterized by high fruit consumption (similar to HC), while in boys the MC was characterized by low fruit consumption (Table 2).

Changes in behavioural clusters between age 7 and 14 years

Almost a fifth of boys (19.1%) who were in the HC at baseline remained in the HC at age 14 compared with 13.1% of girls (Table 3). A similar proportion of boys and girls who were in the MC at age 7 remained in the MC at age 14 years (11.2% and 9.1%), and a higher proportion of boys (7%) who were in the UC at age 7 remained in the UC at age 14 years compared to girls (3.4%). A high percentage of boys (26.4%) became healthier compared to girls (9.4%). A higher proportion of girls became unhealthier compared to boys (57.2% vs. 33.9%).

Associations between indicators of socio-economic and change in behavioural cluster profiles.

After controlling for socio-economic indicators and anthropometric factors, compared to the boys who remained in HC, boys from low-income households were more likely to change to a healthier cluster than those from a higher income household (OR (95%CI) = 1.43 (1.10, 1.84)) (Table 4). Boys with parents of higher education were less likely to remain in the MC, remain in the UC and change to an unhealthier cluster, but also less likely to change to a healthier cluster than those of less educated parents (NVQ below 3 or other qualifications). Boys living with a single parent or other guardian were more likely to remain in MC, remain in UC and change to an unhealthier cluster, but also less likely to change to a healthier cluster compared to those living with both parents.

Compared to the girls who remained in HC, girls from lower income households were more likely to remain in UC and change to an unhealthier cluster (Table 5). Girls with higher educated parents were less likely to remain in MC, remain in UC, and change to an unhealthier cluster, but also less likely to change to a healthier cluster than those with lower parental education. Girls whose parents had other qualifications were two times more likely to remain in UC (OR (95%CI) = 2.25 (1.40, 3.62)), and two times more likely to change to a healthier cluster (OR (95%CI) = 2.14 (1.30, 3.52)) compared to girls who parents have lower education levels. Girls from White ethnic groups were less likely to remain in MC and less likely to change to a healthier cluster compared to girls from other ethnic groups. Girls living with a single parent or other guardian were more likely to remain in UC and change to an unhealthier cluster compared to those living with both parents.

Discussion

The aims of this study were to identify the changes in behavioural clusters from childhood to adolescence and to examine the associations between indicators of socio-economic status and changes in behavioural clusters over the time. To the best of our knowledge these are the first analyses to have examined changes in clusters of health behaviours over 7 years, to have considered the transition from childhood to adolescence, and associated these changes to socio-economic indicators. Findings show low consistency in behavioural clusters over the 7 years age 7 and 14 years with clear sex differences, as girls tend to change to unhealthier clusters, while boys tend to remain in healthier clusters. Indicators of socio-economic status during childhood appear to be important determinants of changes in behavioural clusters over the 7-year period.

The present study found that behavioural clusters are susceptible to changes over a 7-year period. At age 7 years boys and girls had similar cluster prevalences, being in the HC was the most prevalent and in the UC was the least prevalent. This changed in boys to a an almost equal prevalence across the three clusters, whereas among girls, the UC became the most prevalent and the HC the least prevalent at age 14 years. Previous studies have also shown that clusters of health behaviours have low to moderate tracking rates from ages 5-11 and 9-14 years [18]. Within the clusters in the present study, the number of boys with high e-games playing increased over the time and was similarly distributed among the three clusters, and the number of boys and girls with high TV watching increased, especially in the UC. These results are in line with other studies reporting an increase in screen time from childhood to early adolescence, with differences in media used among boys and girls [33], and such increases in screen time could be driving the changes seen in certain clusters.

Results also shown that girls tended to change to unhealthier clusters, while boys tended to remain in HC or change to healthier clusters during the transition from childhood to adolescence. Previous literature has shown evidence of sex differences in lifestyle behavioural patterns over the time. Research has shown that girls are more likely to become unhealthier in terms of lifestyle patterns of physical activity and sedentary behaviour [34, 35], especially when they came from lower socio-economic backgrounds [34]. Furthermore, a study by Daking et al. [36] found that boys were more likely to show unfavourable changes in lifestyle behavioural clusters (including diet, physical activity, and sedentary behaviour) across the transition from middle to late adolescence compared to girls. These findings show that variability in behaviours included in cluster analyses may influence the direction of sex differences regarding lifestyle patterns. Further research is needed examining the same behavioural clusters over critical time periods to be able to compare and unpack the sex differences in changes over time to inform interventions.

In addition to the gender differences seen in changes in clusters over time, indicators of socio-economic status appeared to impact changes in cluster membership. Among both boys and girls, living with a single parent (or other person different from parents) was associated with a higher chance of remaining in UC or changing to unhealthier clusters, while higher parental education was associated with a higher likelihood of remaining in HC. For girls, lower family income was also associated with a higher probability of remaining in UC or changing to unhealthier clusters. Lower socio-economic status has been previously examined in association with lifestyle clusters in young people in cross-sectional studies [9]. For example, low parental education [37–39], low household income [37], and living in a deprived neighbourhood [40] have been associated with unhealthier lifestyle clusters, which may be related to a higher food insecurity/access to healthy foods [41], and/or lower access to a safe built environment that facilitate the physical activity practice. [42, 43]. Contrastingly, we also found that children with low socio-economic status had higher probabilities of transitioning to healthier clusters. These results may be partially explained by our reference group in the multinomial logistic regression analyses which was 'remaining in HC'. Most of the children from high-socio economic environments were in the healthier cluster at baseline (SF 2), therefore these children had less probability of changing to healthier clusters than children from lower socio-economic groups. The results from this study provide support for intervening on multiple behaviours during childhood and adolescence, and to focus on gender differences and parental characteristics related to socioeconomic disparities. More longitudinal analyses in different countries that help to better understand how young boys and girls from different socioeconomic positions change their lifestyle behaviours over the time may guide research to develop more specific and targeted interventions that better consider the needs of different subgroups of young people.

Strengths and limitations

Strengths of the study include the longitudinal study design, which includes a large nationally representative sample of British children, the inclusion of multiple health behaviours, and thorough analysis of clustering. However, conclusions must be made in light of the limitations. Participants (12%) were excluded from the original sample due to missing data (SF 3), potentially limiting the generalisability of our findings. The outcome variables (physical activity, screen time, and dietetic variables) and sociodemographic variables were all assessed via questionnaires, which could lead to errors in the measurement due to socially desirable responses and/or inaccurate recall [44–46]. Furthermore, parents reported during the first wave of data collection and adolescents during the second wave which could change reporting bias [47].

Conclusions

Lifestyle behaviours cluster in children and are susceptible to change over a 7-year period with a high proportion of boys changing to healthier clusters compared to girls, and a higher proportion of girls changing to unhealthier clusters compared to boys. Children from lower socioeconomic status backgrounds including low household income, low parental education or not living with both parents were more likely to change to unhealthier clusters over this period, but also more likely to change to healthier clusters. More longitudinal analyses in different countries are needed for a better understanding of the key drivers of change in clusters among subgroups of children, which is essential for the development of interventions targeting multiple health behaviours.

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Statements and declarations

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Ethics approval: All procedures performed for each MCS wave were carried out in accordance with the Declaration of Helsinki and have received ethical approval from the National Research Ethics Service (NRES) Research Ethics Committee (REC) London – Central (REC ref: 13/LO/1786).

Consent to participate: Parents and participants provided written informed consent prior to completing all assessments.

Data availability: Anonymised data from the MCS are accessible for academic use through the UK Data Service (https://ukdataservice.ac.uk/).

Table 1. ~~Baseline c~~Characteristics of the sample at age 7 by sex expressed as median (IQR) or n (%).

	All	Boys	Girls	*p*
n	9339	4679 (50.1)	4660 (49.9)	
Socio-economic variables				
OECD weekly family income	353.1 (220.2, 530.2)	360.42 (229.5, 533.1)	348.9 (212.5, 527.8)	*0.038*
OECD < 60% median	2540 (27.2)	1219 (26.0)	1321 (28.3)	*0.013*
Parental NVQ				*0.035*
Up to level 3	4468 (47.8)	2240 (47.9)	2228 (47.8)	
Above level 3	3685 (39.5)	1884 (40.3)	1801 (38.6)	
Other qualifications	1186 (12.7)	555 (11.9)	631 (13.5)	
Ethnicity				0.239
White	7810 (83.6)	3934 (84.1)	3876 (83.2)	
Other	1529 (16.4)	745 (15.9)	784 (16.8)	
Household carers				0.231
Both parents	7087 (75.9)	355 (76.0)	3532 (75.8)	
Mother only	1627 (17.4)	794 (17.0)	833 (17.9)	
Father only or other	625 (6.7)	330 (7.0)	295 (6.3)	
Anthropometric variables				

% Body fat	20.0 (17.4, 23.4)	19.0 (16.9, 21.9)	21.2.0 (18.2, 24.7)	*<0.001*
Weight status (IOTF)				*<0.001*
Not overweight	7567 (81.0)	3891 (83.2)	3676 (78.9)	
Overweight	1290 (13.8)	557 (11.9)	733 (15.7)	
Obesity	482 (5.2)	231 (4.9)	251 (5.4)	
Behavioural variables				
MVPA				*0.001*
<5 days per week	9072 (97.1)	4518 (96.6)	4554 (97.7)	
5 or more days per week	267 (2.9)	161 (3.4)	106 (2.3)	
Breakfast frequency				*<0.001*
Not every day	589 (6.3)	239 (5.1)	350 (7.5)	
Every day	8750 (93.7)	4440 (94.9)	4310 (91.5)	
Fruit servings				*<0.001*
< 2 per day	2003 (21.4)	1084 (23.2)	919 (19.7)	
2 or more per day	7336 (78.5)	3595 (76.8)	3741 (80.3)	
TV viewing				*<0.001*
< 3 hours per day	7916 (84.8)	3904 (83.4)	4012 (86.1)	
3 or more hours per day	1423 (15.2)	775 (16.6)	648 (13.9)	
E-games playing				*<0.001*
< 1 hour per day	6079 (65.1)	2677 (57.2)	3402 (73.0)	
1 or more hours per day	3260 (34.9)	2002 (42.8)	1258 (27.0)	

a) Significant differences between sexes ($p < 0.05$) are in italics.
b) BMI: body mass index; IOTF: International Obesity Task Force; MVPA: moderate-to-vigorous physical activity; NVQ: National Vocational Qualification; OECD: Organisation for Economic Co-operation and Development.

465 **Table 2. Cluster characteristics at baseline and follow-up represented as n (%).**

Commented [NP1]: I think this is super useful

		Boys					
		Baseline (7 years)			Follow-up (14 years)		
		Healthy Cluster (n = 1945)	Mixed Cluster (n = 1707)	Unhealthy Cluster (n = 1027)	Healthy Cluster (n = 1804)	Mixed Cluster (n = 1440)	Unhealthy Cluster (n = 1435)
MVPA	< 5 days per week	1816 (40.2)	1679 (37.2)	1023 (22.6)	436 (17.5)	819 (32.9)	1237 (49.6)
	5 or more days per week	129 (80.1)	28 (17.4)	4 (2.5)	1368 (62.5)	621 (28.4)	198 (9.1)
Breakfast frequency	Not every day	0 (0.0)	53 (22.2)	186 (77.8)	217 (12.6)	483 (28.1)	1017 (59.2)
	Every day	1945 (43.8)	1654 (37.2)	841 (18.9)	1587 (53.6)	957 (32.3)	418 (14.1)
Fruit servings	< 2 per day	13 (1.2)	418 (38.6)	653 (60.2)	699 (21.3)	1204 (36.8)	1371 (41.9)
	2 or more per day	1932 (53.7)	1289 (35.9)	374 (10.4)	1105 (78.6)	236 (16.8)	64 (4.6)

TV watching	< 3 hours per day	1945 (49.8)	1503 (38.5)	456 (11.7)	1563 (56.2)	885 (31.8)	333 (12.0)
	3 or more hours per day	0 (0.0)	204 (26.3)	571 (73.7)	241 (12.7)	555 (29.2)	1102 (58.1)
E-games playing	<1 hour per day	1906 (71.2)	654 (24.4)	117 (4.4)	728 (76.9)	181 (19.1)	38 (4.0)
	1 or more hours per day	39 (1.9)	1053 (52.6)	910 (45.5)	1076 (28.8)	1259 (33.7)	1397 (37.4)
Girls							
		Baseline (7 years)			**Follow-up (14 years)**		
		Healthy Cluster (n = 2453)	**Mixed Cluster (n = 1453)**	**Unhealthy Cluster (n = 754)**	**Healthy Cluster (n = 885)**	**Mixed Cluster (n = 1331)**	**Unhealthy Cluster (n = 2444)**
MVPA	< 5 days per week	2351 (51.6)	1449 (31.8)	754 (16.6)	264 (8.0)	924 (28.1)	2095 (63.8)
	5 or more days per	102 (96.2)	4 (3.8)	0 (0.0)	621 (45.1)	407 (29.6)	349 (25.3)

	week						
Breakfast frequency	Not every day	0 (0.0)	129 (36.9)	221 (63.1)	103 (4.1)	560 (22.3)	1848 (73.6)
	Every day	2453 (56.9)	1324 (30.7)	533 (12.4)	782 (36.4)	771 (35.9)	596 (27.7)
Fruit servings	< 2 per day	12 (1.3)	463 (50.4)	444 (48.3)	159 (5.0)	641 (20.2)	2375 (74.8)
	2 or more per day	2441 (65.2)	990 (26.5)	310 (8.3)	726 (48.9)	690 (46.5)	69 (4.6)
TV watching	< 3 hours per day	2450 (61.1)	1244 (31.0)	318 (7.9)	804 (31.6)	861 (33.8)	880 (34.6)
	3 or more hours per day	3 (0.5)	209 (32.2)	436 (67.3)	81 (3.8)	470 (22.2)	1564 (74.0)
E-games playing	<1 hour per day	2429 (71.4)	797 (23.4)	176 (5.2)	849 (27.0)	1009 (32.1)	1283 (40.9)
	1 or more hours per day	24 (1.91)	656 (52.2)	578 (45.9)	36 (2.4)	322 (21.2)	1161 (76.4)

a) Percentages are presented by row.
b) MVPA: moderate-to-vigorous physical activity; TV: television.

Table 3. Changes in behavioural clusters from baseline to follow-up represented as n (%)

	Clusters at 14 y					
	Boys (n = 4679)			Girls (n = 4660)		
Clusters at 7 y	Healthy	Mixed	Unhealthy	Healthy	Mixed	Unhealthy
Healthy	893 (19.1)	589 (12.6)	463 (9.9)	609 (13.1)	746 (16.1)	1098 (23.6)
Mixed	649 (13.9)	525 (11.2)	533 (11.4)	207 (4.4)	425 (9.1)	821 (17.6)
Unhealthy	262 (5.6)	326 (7.0)	439 (9.4)	69 (1.5)	160 (3.4)	525 (11.3)

a) Percentages have been calculated over the total number of boys and the total number of girls, respectively.

Table 4. Boys' ~~relative risk~~odds ratios (~~RRR~~ORs) and 95% confidence intervals (CI) for being in the different longitudinal cluster profiles according to socio economic status and at age 7 (n = 4679).

	Boys							
	Model 1				Model 2			
	Remained in Mixed Cluster	Remained in Unhealthy Cluster	Change to an unhealthier cluster	Change to a healthier cluster	Remained in Mixed Cluster	Remained in Unhealthy Cluster	Change to an unhealthier cluster	Change to a healthier cluster
OECD < 60% median	1.83*** (1.41, 2.39)	3.04*** (2.33, 3.95)	1.78*** (1.44, 2.20)	2.30*** (1.85, 2.85)	1.21 (0.88, 1.65)	1.26 (0.92, 1.73)	1.19 (0.93, 1.53)	1.43** (1.10, 1.84)
NVQ								
Above level 3	0.52*** (0.42, 0.66)	0.24 *** (0.18, 0.32)	0.53*** (0.44, 0.63)	0.48*** (0.44, 0.63)	0.58*** (0.46, 0.74)	0.29*** (0.22, 0.38)	0.58*** (0.49, 0.70)	0.54*** (0.45, 0.65)
Other qualifications	1.27 (0.85, 1.91)	2.10*** (1.44, 3.05)	1.29 (0.929, 1.80)	1.87*** (0.40, 0.57)	1.12 (0.72, 1.72)	1.95** (1.30, 2.91)	1.17 (0.82, 1.66)	1.51* (1.63, 2.13)
Ethnicity								
White	0.79 (0.58, 1.07)	0.87 (0.62, 1.20)	0.84 (0.66, 1.06)	0.64*** (0.50,	0.90 (0.65, 1.25)	1.24 (0.87, 1.77)	0.97 (0.75, 1.25)	0.84 (0.65, 1.09)

				0.81)				
Household carers								
Mother only	1.96*** (1.44, 2.67)	3.61*** (2.67, 4.88)	1.87*** (1.46, 2.40)	1.74*** (1.34, 2.26)	1.64** (1.18, 2.29)	2.55*** (1.84, 3.55)	1.57** (1.20, 2.05)	1.33* (1.00, 1.76)
Father only or other	2.23** (1.40, 3.55)	3.86*** (2.45, 6.06)	2.06*** (1.40, 3.03)	1.97** (1.32, 2.94)	1.95** (1.22, 3.12)	2.79*** (1.75, 4.43)	1.79** (1.21, 2.64)	1.64* (1.09, 2.47)

a) * $p < 0.05$; ** $p < 0.01$; ***$p < 0.001$
b) Base values for multinomial logistic regressions were ‘remained in healthy cluster’ (cluster profile), ‘not in poverty: OECD income above 60% of the median’ (poverty situation), ‘up to level 3’ (NVQ), ‘other different from white’ (ethnicity), and ‘both parents’ (household carers).
c) Model 1: unadjusted; Model 2: adjusted by weight status, % body fat, and the other socio-demographic variables.
d) NVQ: National Vocational Qualification.

Table 5. Girls' ~~relative risk~~odds ratios (~~RRR~~ORs) and 95% confidence intervals (CI) for being in the different longitudinal cluster profiles according to socio economic status at age 7 (n = 4660).

	Girls							
	Model 1				**Model 2**			
	Remained in Mixed Cluster	**Remained in Unhealthy Cluster**	**Change to an unhealthier cluster**	**Change to a healthier cluster**	**Remained in Mixed Cluster**	**Remained in Unhealthy Cluster**	**Change to an unhealthier cluster**	**Change to a healthier cluster**
OECD < 60% median	2.45*** (1.78, 3.36)	4.74*** (3.54, 6.34)	2.65*** (2.07, 3.40)	2.86 (2.10, 3.90)	1.07 (0.74, 1.54)	1.82** (1.29, 2.56)	1.38* (1.04, 1.85)	1.32 (0.91, 1.91)
NVQ								
Above level 3	0.29*** (0.22, 0.38)	0.21*** (0.16, 0.28)	0.39*** (0.33, 0.48)	0.41*** (0.31, 0.53)	0.31*** (0.23, 0.41)	0.27*** (0.20- 0.35)	0.46*** (0.38, 0.56)	0.44*** (0.33, 0.58)
Other qualifications	2.10** (1.30, 3.39)	3.00*** (1.92, 4.70)	1.76** (1.16, 2.66)	2.96*** (1.85, 4.75)	1.62 (0.98, 2.69)	2.25** (1.40, 3.62)	1.40 (0.91, 2.16)	2.14** (1.30, 3.52)
Ethnicity								
White	0.41*** (0.29, 0.57)	0.52*** (0.37, 7.26)	0.60*** (0.46, 0.80)	0.37*** (0.26, 0.52)	0.51*** (0.35, 0.74)	0.88 (0.61, 1.28)	0.77 (0.57, 1.03)	0.54** (0.37, 0.78)

Household carers								
Mother only	1.93** (1.31, 2.84)	3.69*** (2.62, 5.20)	2.60*** (1.94, 3.50)	1.90** (1.30, 2.78)	1.48 (0.98, 2.23)	2.16*** (1.49, 3.15)	1.93*** (1.41, 2.65)	1.37 (0.91, 2.06)
Father only or other	2.08* (1.14, 3.79)	2.62** (1.49, 4.61)	2.76*** (1.72, 4.41)	0.98 (0.48, 1.99)	1.69 (0.92, 3.10)	1.82* (1.02, 3.25)	2.25** (1.38, 3.58)	0.82 (0.40, 1.68)

a) * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

b) Base values for the multinomial logistic regressions were 'remained in healthy cluster' (cluster profile), 'not in poverty: OECD income above 60% of the median' (poverty situation), 'up to level 3' (NVQ), 'other different from white' (ethnicity), and 'both parents' (household carers).

c) Model 1: unadjusted; Model 2: adjusted by weight status, % body fat, and the other socio-demographic variables.

d) NVQ: National Vocational Qualification.