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Longitudinal associations of energy balance-related behaviours and cross-sectional associations of clusters and body mass index in Norwegian adolescents

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Abstract

Background: Insight into the role of energy balance-related behaviours (EBRB) is of great importance when it comes to prevention of weight gain and design of interventions tailored to target these behaviours.

Objectives: First, the present study examines the longitudinal association of four EBRB in Norwegian adolescents. Second, it aims to examine whether clusters of EBRB are cross-sectionally associated with being overweight.

Design: The present study is part of the 'Fruits and Vegetables Make the Marks' project. The study sample consists of twenty control schools in two Norwegian counties.

Methods: Survey questionnaires were completed by 884 pupils with an average age at baseline, September 2001, of 11·8 years. In the follow-up surveys in May 2002 and May 2005, a total of 809 and 724 adolescents participated, respectively. Four EBRB were measured: habitual fruit and vegetable intake, snacking and soda consumption, television and computer use and physical activity.

Results: Results of the associations between EBRB were similar for boys and girls. The odds, ranging from 1·14 to 12·06, were mostly significant. One out of four clusters, the unhealthy cluster, was significantly and cross-sectionally associated with overweight and obesity.

Conclusions: Longitudinal associations of EBRB show that it is important to start early with interventions that aim to prevent unhealthy behaviours becoming habitual. These behaviours should be targeted at the same time as they tend to co-occur. More research, preferably longitudinal and more objective, is needed to investigate associations between health behaviours and body weight among adolescents.

Keywords
Adolescent
Overweight
Longitudinal
Clustering

In order to prevent overweight, insight into the role of energy balance-related behaviours (EBRB) is important, as it supports the design of interventions targeting these behaviours. Multiple Health Behaviour Research (MHBR) seems to be of great importance when interventions are developed and evaluated[1]. The rationale for this is that health behaviours tend to co-occur, although controversies about their co-occurrence as well as in their association with adolescent overweight exist. Sedentary behaviour is found to be associated with snacking behaviour, lower fruit and vegetable intake or lower physical activity (PA) levels[2–6]. Other researchers found low correlations between sedentariness and PA, and between fruit and vegetable intake and PA[7,8]. Regarding associations between being overweight and health behaviours, no clear relation is found for fruit and vegetable intake[9–11]. Several cross-sectional studies show that the combination of high sedentary behaviour and low levels of PA results in the highest odds for being overweight[2,12–15]. In a large cohort of the Health Behaviour in School-aged Children (HBSC) study, an inverse relation was found between the intake of sweets and being overweight[10].

Until now, most of the studies have investigated associations of health behaviours by cross-sectional design. The present study is longitudinal and has two aims. First, it examines the existence of longitudinal associations between four EBRB in Norwegian adolescents (in order to improve the understanding of obesogenic behavioural patterns). Second, the aim is to examine whether clusters of EBRB are cross-sectionally associated with BMI.

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Methods

Study sample

The present study is part of the 'Fruits and Vegetables Make the Marks' (FVMM) project. FVMM is an intervention project including thirty-eight out of forty-eight randomly selected elementary schools in two Norwegian counties[16]. The study sample of the present study consists of sixth and seventh graders from the twenty control schools. All schools were public schools, as are most schools in Norway. Prior to the study, informed consent was obtained from the children and their parents. Ethical approval and research clearance were obtained from the National Committees for Research Ethics in Norway and from the Norwegian Social Science Data Services. Out of 1065 eligible adolescents, 884 completed the baseline questionnaire. The average age of the sample at baseline (September 2001) was 11·8 years: 11·3 for the sixth graders and 12·3 for the seventh graders. A total of 809 and 724 adolescents participated in the follow-up surveys in May 2002 and May 2005, respectively. Besides the adolescents, parents also completed a questionnaire. At baseline, a total of 738 parents participated.

Questionnaire

A survey questionnaire was completed by the pupils in the classroom in the presence of a trained project worker. One school lesson (45 min) was used to complete the questionnaire. Habitual fruit and vegetable (FV) intake was measured by four frequency questions: 'How often do you eat vegetables for dinner?' 'How often do you eat other vegetables (e.g. carrot for school lunch)?' 'How often do you eat an apple, orange, pear or banana?' 'How often do you eat other fruits or berries?' All four questions had ten response alternatives, ranging from never (0) to several times every day (10), which resulted in a score ranging from 0 to 40. A test–retest correlation of this scale in a sample of 114 sixth graders was 0·75. A validation study among eighty-six sixth grade pupils showed a correlation of 0·32 between this scale and a 7 d food diary, which is similar to results found in other studies of the same age group[17].

A sum score of snacking and soda (SS) consumption was created from the following three items: 'How often do you drink soda (including sugar)?' 'How often do you eat candy (e.g. chocolate, mixed candy)?' 'How often do you eat potato chips?' The same response alternatives were used as applied for habitual fruit and vegetable intake, giving the SS consumption a scale range from 0 to 30. The reliability coefficient of the SS consumption scale in a sample of 114 sixth grade pupils was 0·81.

Habitual FV intake and SS consumption were split into quartiles. For FV, the lowest quartile served as a risk category, whereas the highest three quartiles were used as the category of reference. For SS, the lowest three quartiles served as the reference category. Gender-specific quartiles were created for both FV and SS because for each measurement significant differences in the distribution of those two EBRB between boys and girls were found.

Sedentary behaviour (watching television (TV)) was measured by the question: 'Outside school time, how many hours a day do you watch TV or sit behind the computer?'. The cut-off point for TV was set at 2 h/d, in concordance with the recommendations of the American Academy of Pediatrics[18]. Less than 2 h/d served as the reference category.

PA was measured by the question: 'Outside school time: how many times a week do you have exercise that makes you sweat and/or out of breath?'. The cut-off point for PA was set at three times a week. More than three times a week served as the category of reference. The rationale for this is that the question refers to activities outside school hours and thereby excludes exercise during school time.

BMI was calculated by self-reported height and weight at follow-up 3. Parental education level (Low: no college or university education, High: having attended college or university) was also included in the analysis, which was measured in the parental questionnaire at baseline.

Statistical analyses

Gender differences in the distribution of the EBRB were statistically tested with χ^2 tests. Attrition bias was investigated with logistic regression analysis to compare baseline characteristics of participants at follow-up 3 with the dropouts at that time point. Both analyses were performed in the Statistical Package for Social Sciences statistical software package version 15·0 (SPSS Inc., Chicago, IL, USA).

To investigate the associations between EBRB, longitudinal multi-level mixed model logistic regression analyses were performed[19], for which the EBRB were dichotomized into high-risk *v.* low-risk behaviour. The dichotomized EBRB served both as dependent as well as independent variables. In a mixed model analysis, all repeated measurements are analysed simultaneously, taking into account the dependency of the observations within one individual. The resulting OR can be interpreted as a sort of average OR over time. For each individual, the EBRB were measured three times. In the longitudinal analyses, cases with missing data at one or more time points were included. All models were adjusted for school and time. Interactions with time were analysed for each association to evaluate whether the association remained stable over time. For the interactions, a P value $<0·10$ was used.

To investigate the cross-sectional relationship between the EBRB and BMI, clusters were created by applying K-means cluster analysis and a linear regression was performed. As BMI is measured at the third follow-up only, EBRB of the third follow-up are included in the present analysis. The independent variables were now not dichotomized but inserted as the original continuous or categorical variable.

Table 1 Characteristics of participating Norwegian adolescents in the FVMM cohort from September 2001 to May 2005

	Baseline				Follow-up 1				Follow-up 3			
Characteristics	Boys (*n* 433)		Girls (*n* 441)		Boys (*n* 399)		Girls (*n* 400)		Boys (*n* 335)		Girls (*n* 378)	
Habitual FV intake (0–40/week)												
Mean	12·7		15·4		12·0		14·4		11·9		14·7	
SD	7·3		6·9		7·3		6·9		6·9		7·2	
25th percentile	7·5		10·0		7·0		9·0		6·5		9·5	
SS consumption (0–30/week)												
Mean	7·6		6·5		7·9		6·6		8·0		5·9	
SD	4·8		4·4		5·6		4·2		5·2		4·2	
75th percentile	10·0		8·0		10·0		8·0		11·0		8·0	
	n	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%
Sedentary behaviour (watching TV/computer use)												
<2 h/d	173	40·0*	221	50·2	166	41·6	172	43·5	56	16·7**	85	22·5
≥2 h/d	260	60·0	219	49·8	233	58·4	233	56·5	279	83·3	292	77·5
Physical activity												
<3 times/week	89	20·6	114	25·9	74	18·5	88	22·0	78	23·3	94	24·9
≥3 times/week	344	79·4	327	74·1	325	81·5	312	78·0	257	76·7	284	75·1
Parental education level												
Low	201	59·1	231	62·4	192	59·6	211	62·8	163	58·8	203	62·1
High	139	40·9	139	37·6	130	40·4	125	37·2	114	41·2	124	37·9
Overweight/obese****									51	17·4***	23	7·.2
BMI (kg/m^2)												
Mean									21·2		20·3	
SD									3·6		3·2	

FVMM, Fruits and Vegetables Make the Marks; FV, fruit and vegetables; SS, snacking and soda; TV, television; IOTF, International Obesity Task Force.
*$P \leq 0{\cdot}01$, χ^2 test.
**$P \leq 0{\cdot}05$, χ^2 test.
***$P \leq 0{\cdot}001$, χ^2 test.
****Based on IOTF criteria.

Table 2 Longitudinal association of risk categories of Norwegian adolescents in the FVMM cohort, from September 2002 to May 2005

	High SS		High TV		Low PA	
Variable	OR	95 % CI	OR	95 % CI	OR	95 % CI
Low FV						
Boys	1·75*	1·02, 2·31	1·77*	1·18, 2·17	4·70*	2·87, 6·04
Girls	1·89	1·19, 2·39	1·45*	1·02, 1·73	2·79*	1·87, 3·41
High SS						
Boys	–	–	12·06*	4·24, 20·55	1·42	0·89, 1·89
Girls	–	–	5·27*	3·24, 6·75	1·42	0·94, 1·75
High TV						
Boys	–	–	–	–	1·14	0·72, 1·44
Girls	–	–	–	–	1·14	0·76, 1·41

FVMM, Fruits and Vegetables Make the Marks; FV, fruit and vegetables; SS, snacking and soda consumption; TV, television; PA, physical activity.
*Significant $P \leq 0{\cdot}05$.

In all analyses, gender and parental education were considered as possible effect modifiers ($P = <0{\cdot}10$) and confounders. All multi-level analyses were performed with MLwiN, version 1·1[20] and the P value was set at 0·05. Three levels were recognized: repeated measures, individuals and schools.

Results

Table 1 shows characteristics of the participating adolescents. For sedentary behaviour, there were significant gender differences in the two surveys ($P = <0{\cdot}01$ and $P = <0{\cdot}05$). There was a significant difference in prevalence of overweight and obesity between boys and girls, respectively, 17·4 % and 7·2 % ($P = <0{\cdot}001$) based on cut-off points of the International Obesity Task Force (IOTF; 23·29 and 23·92 for 15-year-old boys and girls, 23·90 and 24·37 for 16-year-old boys and girls)[21].

Dropout analysis shows that there were significantly more adolescents with high-risk behaviours at baseline for FV (OR 1·57, 95 % CI 1·08, 2·29), SS (OR 1·49, 95 % CI 1·01, 2·18) and PA (OR 2·56, 95 % CI 1·74, 3·76) who did not participate at the last follow-up.

Table 2 presents the results of the longitudinal multi-level logistic regression to investigate the associations

Table 3 Clusters of energy balance-related behaviours of Norwegian adolescents in the FVMM cohort, from September 2002 to May 2005

Cluster variable	FV intake	SS consumption	Sedentary behaviour	PA
Cluster 1: Healthy (*n* 88)	High	Low	Low	High
Cluster 2: Quite healthy (*n* 255)	Medium	Low	Medium	High
Cluster 3: Quite unhealthy (*n* 270)	Low	Low	High	Medium
Cluster 4: Unhealthy (*n* 89)	Low	High	High	Low

FV, fruit and vegetables; SS, snacking and soda; TV, television; PA, physical activity.

Table 4 Association between clusters and BMI in the FVMM cohort among Norwegian adolescents

Cluster variable	β†	*P* value	β‡	*P* value
Cluster 1: Healthy (reference) (*n* 88)	–	–	–	–
Cluster 2: Quite healthy (*n* 255)	−0·20	0·68	−0·28	0·56
Cluster 3: Quite unhealthy (*n* 270)	0·32	0·50	−0·13	0·79
Cluster 4: Unhealthy (*n* 89)	−0·62	0·28	−1·27	0·04*

FVMM, Fruits and Vegetables Make the Marks.
*Significant $P \leq 0{\cdot}05$.
†Crude analysis.
‡Adjusted for gender and parental education level.

between EBRB. In general, for both boys and girls associations of high-risk EBRB exist, except for TV and PA, and for SS and PA. For example, boys with low FV intake (low FV) show a 1·75 odds for performing high-risk behaviour for SS consumption (high SS). Time interaction was not significant for any of the four associations.

K-means cluster analysis results in four clusters (Table 3). A healthy cluster (*n* 88) consists of a high FV intake, low SS consumption, the lowest time spent on sedentary behaviour and the highest amount of PA. The 'quite healthy' cluster consists of a medium FV consumption, low SS consumption, medium sedentary behaviour and a relatively high amount of PA. The 'quite unhealthy' cluster consists of low consumption of FV, SS, high sedentary behaviour and a medium amount of PA. An 'unhealthy' cluster is defined by a low intake of FV, high SS consumption, high sedentary behaviour and a low amount of PA.

Table 4 shows the results of the cross-sectional linear regression analyses to investigate the relationship between clusters of EBRB and BMI. The 'unhealthy cluster' is significantly negatively related to BMI (β −1·27, $P = 0{\cdot}048$). None of the other clusters is significantly associated with BMI.

Discussion

The present study was carried out to investigate whether longitudinal associations exist among four EBRB in Norwegian adolescents. Second, cross-sectional analyses were performed to investigate how clusters of health-related behaviours were associated with BMI of these adolescents. The present study showed that most of the risk behaviours are longitudinally associated. The presence of associated EBRB confirms the statement that health behaviours tend to co-occur, the rationale of MHBR[1]. Furthermore, one cluster was found to be cross-sectionally associated with BMI, in an unexpected direction.

Similar results in associations of EBRB were shown in the cross-sectional study of Lowry *et al.*[3] who found that sedentary behaviour was associated with eating insufficient FV among high-school students in the USA. Utter *et al.*[5] found an association between high level of TV viewing and high SS intake in a cross-sectional study among New Zealand children and young adolescents. A national sample of Iranian adolescents showed that youth, being in the lowest tertile of PA, had significantly lower FV intake[22]. Two reviews also found no association between sedentariness and low PA[7,23]. Besides the fact that the association between EBRB exists, the results of the present study also show that this association remains stable over time. This indicates the seemingly great importance of starting interventions aimed at influencing these health behaviours at an early phase in life, before unhealthy behaviours start becoming habitual. Second, it suggests the importance of targeting multiple health behaviours at the same time to possibly gain more health benefits from interventions aimed at reducing health risk behaviours. Most of the interventions that were included in the two reviews that are effective in skin-folds and/or BMI reduction have a dietary as well as a PA focus[24,25].

Adolescents in the unhealthy cluster (Table 4) show a significantly lower BMI than adolescents in the healthy cluster. However, owing to the lack of a baseline measurement of height and weight, there is no possibility interpreting this as a causal association. The HBSC cohort similarly found an inverse relation between adolescents with high sweets intake and being overweight[10]. Several explanations for the lower BMI in adolescents with unhealthy patterns can be mentioned. One could be restrictions in SS consumption of the overweight/obese adolescents to control their weight. Another possibility is that under-reporting of snacks and sweets intake by adolescents with a higher BMI might have occurred, because overweight and obese adolescents tend to under-report their dietary intake more often than adolescents with normal weight do[26,27]. Furthermore, the questions assessing SS consumption do not measure portion size. Since BMI is used as an indicator for a healthy or unhealthy weight, it could also be that adolescents in the healthy cluster have a higher muscle mass[28].

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There are several other limitations of the present study that have to be mentioned. First of all, weight and height are self-reported. As many studies show that self-reported height and weight in adolescents lead to under-classification of overweight and obesity, there is a chance that this has occurred in the present study as well[29–32]. Second, a significant difference between boys and girls in the prevalence of overweight and obesity was found (17·4 % boys, 7·2 % girls, $P = <0·001$). Objective measurements in Norway show a lower prevalence rate for boys (14·6 %) and a considerably higher rate for girls (17·7 %)[33]. Since this prevalence rate is a mean percentage of 4–15-year-old children and adolescents, a better comparison could possibly be made with data from the HBSC study. They found a prevalence of overweight and obesity of 14·6 % and 9·5 % for 15–year-old Norwegian boys and girls, respectively[34]. It could either mean that the girls with overweight or obesity who participated in the third follow-up are an underestimation of the actual overweight and obesity prevalence or that the prevalence is low due to loss to follow-up. Third, the question concerning PA does not measure the duration of the activity, which can cause bias in measurement. Furthermore, the questions do not separately address behaviours during weekdays and weekends, while the literature shows that there are differences in weekday and weekend patterns of sedentary behaviour and PA[35–37].There are no significant differences found either in the level of PA between boys and girls or between the three-time measurements. A study among Swedish 15- and 16-year-olds shows comparable activity patterns between genders[38]. In contrast, there are other studies showing differences in activity patterns, with boys being more active than girls, and a decrease in PA over time[39–41]. Fourth, dropout analysis shows that an attrition bias had occurred during the last follow-up. This negatively affects the results because it seems that pupils participating at the last measurements are, on average, performing more healthy behaviour than pupils participating at baseline. Owing to lesser variation in behaviours, it might have become more difficult to show an association with BMI.

Despite the limitations mentioned, a strength of the present study is that the EBRB are longitudinally associated, while most previous research that investigated associations of these behaviours was performed cross-sectionally. Furthermore, multi-level analyses were performed, which takes the dependency of repeated measures of the adolescents and going to the same school into account.

Conclusion

Longitudinal associations of EBRB show that it is important to start at an early phase in life to prevent unhealthy behaviours becoming habitual. Besides this, it underlines the importance of targeting multiple behaviours at the same time to possibly obtain more health benefits than when these behaviours are targeted separately. An association between clusters of these EBRB and BMI was only found for SS consumption, in an unexpected direction. More research is needed to investigate associations between health behaviours and body weight among adolescents, preferably using longitudinal and more objective data measuring body weight.

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