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# Health behaviour and academic achievement in Icelandic school children

Inga Dóra Sigfúsdóttir[1]*, Álfgeir Logi Kristjánsson[1] and John P. Allegrante[2]

## Abstract

**Interest in the relationship between health behaviours and academic achievement has recently intensified in the face of an epidemic of childhood and adolescent obesity and converging school reforms in the United States and other nations with advanced economies. Epidemiologic research has demonstrated that poor diet and lack of adequate physical activity place children at risk for being overweight and obese and thus influence future health status. Additional research has also shown that children and adolescents whose diets are nutritious and whose participation in physical activity is high tend to perform better on various measures of cognitive performance and academic achievement. We analysed cross-sectional survey data from 5810 Icelandic school children to explore the relationship between selected health behaviours and academic achievement. Body mass index, diet and physical activity explained up to 24% ($P < 0.01$) of the variance in academic achievement when controlling for gender, parental education, family structure and absenteeism. Variance explained increases to 27% when depressed mood ($P < 0.05$) and self-esteem ($P < 0.01$) are added to the model, but confounds the role of physical activity. Although not robust, these findings are consistent with previous work and affirm the complexity of the relationship of health to academic achievement.**

## Introduction

There is converging interest among public health scientists and school policy makers in the health status of children and adolescents and its impact on their academic achievement. This interest has been catalysed by a series of recent reviews of the research evidence regarding the impact on cognitive performance and academic achievement of nutrition and exercise [1], asthma [2], obesity [3], sleep [4] and chronic medical conditions [5]. Generally, these reviews have identified research studies whose results point collectively to a positive relationship between good health status and good health habits and the academic performance of students. The two areas of greatest interest in studies that have attempted to link school performance and health are diet and physical activity.

Although the impact of diet and nutrition on school performance in developing countries is difficult to assess and can be confounded by socioeconomic status, school factors and other variables [6], there is growing and convincing evidence for a link between diet and academic performance in countries with advanced economies. Research has shown that malnourished children or children who eat unhealthy diets, for example, manifest a number of behaviours that can interfere with learning and

[1]Icelandic Centre for Social Research and Analysis, School of Health and Education, Reykjavik University, Ofanleiti 2, 103 Reykjavík, Iceland and [2]Department of Health and Behavior Studies and Center for Health Promotion, Teachers College, and Department of Sociomedical Sciences, Mailman School of Public Health, Columbia University, New York, NY 10027 USA
*Correspondence to: I. D. Sigfúsdóttir.
E-mail: ingadora@ru.is

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academic performance [7, 8]. These include irritability, apathy and lower self-esteem. However, it is the consequences of overweight and obesity among growing numbers of children and adolescents that are of most concern. An obesity epidemic has emerged over the past 20 years in both the United States and in Iceland. During this period of time, the United States has seen a 4-fold increase in obesity among children and adolescents between the ages of 6 and 18 [9]. In Iceland, a similar trend has been observed; the Icelandic Public Health Institute has estimated that the rate of obesity among 9-year-old children has increased from 1.8% to 4.8% among boys and 1.0% to 4.8% among girls from 1978 to 1998 [10].

A number of reports in both the United States and Europe have revealed the negative effect of obesity among children and adolescents [11, 12]. In the most recent review of research articles published between 1994 and 2004, Taras and Potts-Datema [3] identified and reviewed 10 studies from around the world that examined the relationship between obesity and outcomes related to school performance, including measures of student academic achievement, cognitive ability or school attendance. Taras and Potts-Datema concluded that while the body of published work was small and methodologically limited, the preponderance of evidence from these studies showed that overweight and obese children and adolescents generally do not perform as well, or attend school as much, as their healthy counterparts. Such findings are difficult to interpret, however, due to the fact that school performance is confounded by school attendance and other factors, such as mental health, low self-esteem, or depression [3].

In addition to the findings on diet and academic achievement, a strong connection has been established between physical activity and positive academic outcomes. Several papers have asserted that school-based physical activity increases concentration, boosts self-discipline and improves academic skills, including reading and writing abilities [13, 14, 15]. Physical activity has also been shown to be positively related with higher levels of self-esteem [16].

Well-designed empirical studies of the relationship between obesity, physical activity and other health behaviours and academic achievement, however, are scarce. While most studies of the effect of obesity on student performance have been conducted with US school children [17, 18, 19], studies of obesity and student performance have been reported for fairly diverse population samples of children in Brazil [20], Chile [21, 22], China [23], Finland [24, 25], Thailand [26] and the United Kingdom [27]. Although the hypothesized relationship has been largely supported by this work, not all of the published research has consistently reported that obesity is inversely correlated with academic performance. Moreover, a wide range of methodologic approaches to the measurement of health-related behaviours and student performance, population samples and age ranges can be found across these studies, which may explain some of the inconsistency in findings. No such studies have been conducted among Icelandic children and adolescents, a comparatively homogeneous population.

The purpose of this study was to examine the relationship of selected health behaviours and academic achievement in Icelandic school children. Specifically, we sought to identify the relative contribution of body mass index (BMI), diet and physical activity as correlates of academic performance in the study sample. We hypothesized that increased BMI, poor diet and lack of physical activity would be associated with poor academic achievement.

## Methods

### Study sample

We utilized nationally representative data from the 2000 Icelandic study, Youth in Iceland, for this analysis. The Youth in Iceland sample consists of 14- and 15-year old students who attended the 9th and 10th grades in all Icelandic secondary schools during March 2000. This represents ~78% of the population of Iceland in these age groups. The Icelandic Centre for Social Research and Analysis at Reykjavik University supervised the

data collection process. Anonymous questionnaires and envelopes for returning completed questionnaires were distributed to all secondary schools in Iceland. Teachers supervised the participation of the students in the study and administered the survey questionnaire at individual school sites. All students who attended school on the day that the questionnaire was scheduled to be administered completed the questionnaire inside their classrooms. Once students had finished answering all questions, they were asked to place their completed questionnaire in the envelope and carefully close it before returning it to the supervisor. The students were asked and reminded not to write their names or social security numbers, or any other identifying information, anywhere on the questionnaire. In addition, students were asked to complete the entire questionnaire and ask for help if they had any problems with any questions.

A total of 6346 students (51.4% girls, 48.6% boys) completed the questionnaire, which constituted ~82% of all students in these age groups who were enrolled in schools throughout Iceland during the survey. Because BMI was an independent variable in the study and needed to be calculated from self-reports of height and weight, those students who had not answered the questions on height and weight or either one, or those who answered them incorrectly or without foundation, were screened from the initial sample. So, those who reported being either 30 kg or less in weight, or 145 kg or more in weight, were omitted from the sample; those who reported to be 130 cm in height or less or 230 cm in height or more were also omitted. This left a final sample of 5810 individuals (51.7% girls, 48.3% boys) for the study. Thus, of the 536 cases we lost, 307 were lost due to the failure of students to answer question about either height or weight and the remaining 229 were lost due to filtering.

## Measures

### *Academic achievement*

Academic achievement was the main dependent variable in this study. In order to estimate the level of academic achievement, students were asked to self-report their average grades in the core subjects of Icelandic, Mathematics, English and Danish (alternatively Swedish or Norwegian). In Iceland, these are the so-called 'unitary' subjects which every student in the 9th and 10th grades must undertake in order to complete secondary school. Furthermore, the grade range in Iceland is 0–10; a score of <5 results in a fail grade and >5 a pass grade. The response format was 0 = 'under 4', 1 = 'about 4', 2 = 'about 5', 3 = 'about 6', 4 = 'about 7', 5 = 'about 8', 6 = 'about 9' and 7 = 'about 10'. These 4 items were then combined into a scale ranging from 0 to 28 (Cronbach's $\alpha = 0.83$).

### *Body mass index*

To measure BMI, respondents were asked to self-report their weight and height. BMI was calculated from these self-reports with the following formula: weight in kilograms/(height in metres $\times$ height in metres). Because BMI values are sensitive to changes in fat distribution and the development of muscle during puberty, we calculated and used a BMI *z*-score for each student's age within the 2-year spread in age of our study population.

### *Poor diet*

To measure if respondents consumed a poor diet, we constructed the variable 'bad diet'. This was done by asking respondents to self-report how often they ate (i) sweets, (ii) crisps, (iii) French fries, (iv) hamburger or a hot dog or (v) pizza. The response format was 1 = 'almost never', 2 = 'less than once a week', 3 = 'every week', 4 = 'once a day' and 5 = 'more than once a day'. These items were then combined into a scale with a range from 0 to 20 (Cronbach's $\alpha = 0.74$).

### *Fruits and vegetables*

To measure if respondents had positive eating habits, we constructed the variable 'fruits and vegetables'. This was done by asking respondents to self-report how often they ate either fruits or vegetables or both. The response format was 1 = 'almost never', 2 = 'less than once a week', 3 = 'every week', 4 = 'once a day' and 5 = 'more than once a day'. These items

were then combined into a scale with a range from 0 to 8 (Cronbach's $\alpha = 0.67$).

### *Physical activity*

Physical education is compulsory in the Icelandic national curriculum for secondary schools and is usually taught as one lesson a week per pupil. To measure physical activity, respondents were asked four self-report questions all of which account for different levels of physical activity: 'How often do you participate in sports or physical activity apart from the compulsory classes in school', 'How often do you participate in sports with a sports club or a team', 'How often do you participate or train in sports that are neither organized by your school nor a sports club/team' and 'How often do you physically test yourself so you wind yourself significantly or sweat'. The response format was 1 = 'almost never', 2 = 'less than once a week', 3 = 'once a week', 4 = '2–3 times a week', 5 = '4–5 times a week' and 6 = 'almost every day'. Moreover, these four items where combined into a scale with a range from 0 to 20 (Cronbach's $\alpha = 0.73$).

### *Control variables*

In Iceland, the largest proportion of the population is of Norse and Celtic origin and 86% belong to the Lutheran Church [28]. Because of this homogeneity, demographic factors such as race, ethnicity and religion, often used in research elsewhere, were considered irrelevant and thus not examined. However, four other factors were used as control variables in this study: absenteeism, level of parental education as a proxy measure of socioeconomic status, family structure and gender. Prior studies [29, 30, 31] have shown that these variables do matter when studying the relationship of health behaviours and academic achievement.

Absenteeism was obtained by asking students to self-report how frequently they skipped classes. The response format was 1 = 'almost never', 2 = 'less than once a month', 3 = 'every month', 4 = 'every week' and 5 = 'almost daily'.

Parental education was obtained by asking students separate questions about their fathers' and mothers' educational attainment. The response format was 1 = 'finished elementary school or less', 2 = 'started a school on the secondary level', 3 = 'finished secondary level', 4 = 'started university level' and 5 = 'has a university degree'. These two items were then combined into a scale with a range from 0 to 8.

Family structure was measured by asking 'who lives with you in your home'. The response format was 1 = 'both parents', 2 = 'mother and not father', 3 = 'father and not mother', 4 = 'mother and partner', 5 = 'father and partner', 6 = 'I live on my own' and 7 = 'other arrangement'. This variable was then collapsed and dichotomized with 0 = 'lives with both parents' (73%) and 1 = 'other arrangements' (27%). Gender was also dichotomized, with 0 = boys and 1 = girls.

### *Other confounding influences*

Based on previous work [3, 32], we believed that mental health factors might constitute potential confounding influences on the health-related variables under study. Thus, we included two additional measures in our analysis: depressed mood and self-esteem.

Depressed mood was assessed by asking respondents 10 questions that were drawn from the Symptom Distress Checklist developed by Derogatis *et al.* [33]. These were: 'I was sad or had little interest in doing things', 'I had little appetite', 'I felt lonely', 'I had sleeping problems', 'I cried easily or wanted to cry', 'I felt sad or blue', 'I was not excited in doing things', 'I was slow or had little energy', 'The future seemed hopeless' and 'I thought of committing suicide'. The response format was 0 = 'never', 1 = 'seldom', 2 = 'sometimes' and 3 = 'often' to indicate the severity of depressed mood symptoms. These items were then combined into a scale with a range from 0 to 30 (Cronbach's $\alpha = 0.87$).

Self-esteem was measured by the Rosenberg Self-Esteem Scale [34]. This 10-item scale consists of positive and negative self-appraisal statements: 'On the whole, I am satisfied with myself', 'At times, I think I am no good at all', 'I feel that I have a number of good qualities', 'I am able to do things

as well as most other people', 'I feel I do not have much to be proud of', 'I certainly feel useless at times', 'I feel that I'm a person of worth, at least on an equal plane with others', 'I wish I could have more respect for myself', 'All in all, I am inclined to feel that I am a failure' and 'I take a positive attitude toward myself'. The response format was 0 = 'strongly disagree', 1 = 'disagree', 2 = 'agree' and 3 = 'strongly agree'. Scores range from 0 to 30 with higher scores reflecting high self-esteem (Cronbach's $\alpha = 0.89$).

### Data analyses

We used Pearson's $r$ correlation matrix to first examine the bivariate relationship between all variables included in the study. Furthermore, in order to estimate the probable descriptive differences on key variables between students who were overweight and students of normal weight in these age groups, we ran a series of Student's $t$-tests for independent samples between the top 85th percentile on BMI and the remaining participants. We then used a series of ordinary least squares (OLS) regression analyses [35] to examine how BMI, healthy and unhealthy eating habits and physical activity varied in relation to academic achievement while controlling for gender, parental education, family structure and absenteeism and any potential interaction effects between these items. We treated our data as normative because we had over 5000 cases, essentially the entire population of the school-based children and adolescents of the country in the grades and age groups under study. In addition, academic achievement, our dependent variable, follows a normal distribution.

## Results

Table I shows the descriptive statistics for each of the variables included in the study. The four measures about academic achievement have a combined mean of 16.60 [standard deviation (SD) = 5.73, Cronbach's $\alpha = 0.83$]. The four physical activity measures combined have a mean of 8.80 (SD = 5.11, Cronbach's $\alpha = 0.73$). The mean score for the two questions that comprised our composite measure of healthy nutrition (eating fruits and vegetables) was 3.64 (SD = 1.74, Cronbach's $\alpha = 0.67$); the mean score for poor eating habits, which was composed of five questions about bad food consumption, was 7.07 (SD = 2.58, Cronbach's $\alpha = 0.74$). Finally, the average weight for the participants in the study was 61.37 kg (SD = 11.88) and the average height was 170.43 cm (SD = 8.50); average BMI for the entire study sample was 21.05 (SD = 3.33).

BMI values for the total study population ($n = 5810$) ranged from 9.42 to 57.08. Table II contains the results of the Student's $t$-tests for independent samples and shows the differences between students who were in the 85th percentile or above on BMI and those below the 85th percentile for all study variables. Students who have BMIs in the 85th percentile or above differ from those with less BMI on self-esteem, grades and depressive mood ($P < 0.01$), with higher BMI students having lower self-esteem, poorer grades and higher depressive mood. Students with higher BMIs also have parents with lower education, report less physical activity and eat less nutritiously than those with lower BMIs ($P < 0.01$).

Table III shows the bivariate correlations between the key variables in the study. As shown, the correlation between physical activity and grades is positive ($r = 0.09$) and significant ($P < 0.01$) but only of modest strength. The correlation between BMI and grades is of modest strength ($r = -0.12$, $P < 0.01$) and consistent with the hypothesized direction of the influence of BMI. The bivariate relationship between poor diet and grades is slightly stronger and negative ($r = -0.14$, $P < 0.01$) but still modest, while the correlation between eating fruits and vegetables and grades is positive and moderately strong ($r = 0.23$, $P < 0.01$).

The results of our regression analyses show that the variables we selected predicted academic achievement when controlling for gender, parental education, family structure and absenteeism and any interaction effects they might have had on the dependent variable (Table IV). Physical activity is a weak but significant ($P < 0.01$) predictor of

**Table I.** *Descriptive statistics for all study variables*

| Variable | *n* | Range | Mean | SD | Cronbach's α |
|---|---|---|---|---|---|
| Gender | 5803 | 0–1 | 0.52 | 0.50 | n/a |
| Parental education | 4484 | 0–8 | 3.97 | 2.40 | n/a |
| Family structure | 5794 | 0–1 | 0.73 | 0.44 | n/a |
| Absenteeism | 5786 | 1–5 | 1.44 | 0.89 | n/a |
| Grades in Icelandic | 5752 | 1–8 | 5.20 | 1.52 | n/a |
| Grades in English | 5707 | 1–8 | 5.51 | 1.70 | n/a |
| Grades in Danish | 5669 | 1–8 | 5.00 | 1.84 | n/a |
| Grades in Mathematics | 5720 | 1–8 | 4.85 | 1.94 | n/a |
| Grades combined | 5590 | 0–28 | 16.60 | 5.73 | 0.83 |
| Participation in sports or physical training apart from compulsory classes | 5660 | 1–6 | 2.90 | 1.77 | n/a |
| Participation in sports with a club or a team | 5662 | 1–6 | 2.85 | 1.96 | n/a |
| Participate or train in sports that are neither organized by the school nor a sports club/team | 5651 | 1–6 | 2.90 | 1.65 | n/a |
| How often physically tests oneself so winded significantly or sweat | 5661 | 1–6 | 4.16 | 1.48 | n/a |
| Physical activity combined | 5589 | 0–20 | 8.80 | 5.11 | 0.73 |
| How often eats fruits | 5769 | 1–5 | 2.91 | 1.00 | n/a |
| How often eats vegetables | 5724 | 1–5 | 2.72 | 1.00 | n/a |
| Fruits and vegetables combined | 5703 | 0–8 | 3.64 | 1.74 | 0.67 |
| How often eats sweets | 5737 | 1–5 | 3.05 | 0.89 | n/a |
| How often eats crisps | 5772 | 1–5 | 2.18 | 0.76 | n/a |
| How often eats French fries | 5760 | 1–5 | 2.20 | 0.710 | n/a |
| How often eats hamburger or a hot dog | 5758 | 1–5 | 2.26 | 0.68 | n/a |
| How often eats pizza | 5759 | 1–5 | 2.38 | 0.64 | n/a |
| Bad food combined | 5654 | 0–20 | 7.07 | 2.58 | 0.74 |
| Weight in kilograms | 5810 | 33–126 | 61.37 | 11.88 | n/a |
| Height in centimetres | 5810 | 130–200 | 170.43 | 8.50 | n/a |
| BMI | 5810 | 9.42–57.07 | 21.05 | 3.33 | n/a |
| I was sad or had little interest in doing things | 5759 | 1–4 | 1.97 | 0.98 | n/a |
| I had little appetite | 5778 | 1–4 | 1.82 | 0.99 | n/a |
| I felt lonely | 5748 | 1–4 | 1.61 | 0.92 | n/a |
| I had sleeping problems | 5785 | 1–4 | 1.62 | 0.93 | n/a |
| I cried easily or wanted to cry | 5764 | 1–4 | 1.55 | 0.95 | n/a |
| I felt sad or blue | 5780 | 1–4 | 1.63 | 0.92 | n/a |
| I was not excited in doing things | 5770 | 1–4 | 1.60 | 0.85 | n/a |
| I was slow or had little energy | 5766 | 1–4 | 1.44 | 0.77 | n/a |
| The future seemed hopeless | 5779 | 1–4 | 1.40 | 0.80 | n/a |
| I thought of committing suicide | 5779 | 1–4 | 1.28 | 0.73 | n/a |
| Depressed mood | 5594 | 0–30 | 5.83 | 5.95 | 0.87 |
| On the whole, I am satisfied with myself | 5781 | 1–4 | 1.56 | 0.73 | n/a |
| At times, I think I am no good at all | 5776 | 1–4 | 1.78 | 0.78 | n/a |
| I feel that I have a number of good qualities (reversed) | 5734 | 1–4 | 1.97 | 0.89 | n/a |
| I am able to do things as well as most other people | 5758 | 1–4 | 1.81 | 0.76 | n/a |
| I feel I do not have much to be proud of (reversed) | 5726 | 1–4 | 2.15 | 0.91 | n/a |
| I certainly feel useless at times | 5749 | 1–4 | 1.91 | 0.82 | n/a |
| I feel that I'm a person of worth, at least on an equal plane with others | 5747 | 1–4 | 1.90 | 0.87 | n/a |
| I wish I could have more respect for myself (reversed) | 5748 | 1–4 | 2.49 | 1.01 | n/a |
| All in all, I am inclined to feel that I am a failure (reversed) | 5756 | 1–4 | 1.99 | 0.98 | n/a |
| I take a positive attitude toward myself (reversed) | 5758 | 1–4 | 1.85 | 1.00 | n/a |
| Self-esteem | 5533 | 0–30 | 9.37 | 6.21 | 0.89 |

**Table II.** *Independent sample t-tests for differences between the top 85th percentile on BMI and others for all study variables*

| Variables | *n* | | Mean | | SD | | Difference |
|---|---|---|---|---|---|---|---|
| | BMI > 85th percentile | BMI ⩽ 85th percentile | BMI > 85th percentile | BMI ⩽ 85th percentile | BMI > 85th percentile | BMI ⩽ 85th percentile | |
| Grades | 846 | 4744 | 15.16 | 16.86 | 5.69 | 5.70 | −1.70** |
| Gender | 876 | 4927 | 0.48 | 0.52 | 0.50 | 0.50 | −0.04** |
| Parental education | 868 | 4858 | 2.48 | 3.08 | 2.79 | 2.94 | −0.60** |
| Family structure | 872 | 4922 | 0.74 | 0.73 | 0.44 | 0.44 | 0.01 |
| Absenteeism | 873 | 4913 | 1.43 | 1.44 | 0.88 | 0.90 | −0.01 |
| BMI (*z*-score) | 877 | 4933 | 1.75 | −0.31 | 1.03 | 0.59 | 2.06** |
| Physical activity | 848 | 4741 | 7.97 | 8.95 | 4.98 | 5.12 | −0.98** |
| Bad food | 859 | 4795 | 6.73 | 7.13 | 2.63 | 2.57 | −0.40** |
| Fruits and vegetables | 862 | 4841 | 3.35 | 3.69 | 1.72 | 1.74 | −0.34** |
| Depressed mood | 840 | 4754 | 6.69 | 5.68 | 6.35 | 5.86 | 1.01** |
| Self-esteem | 841 | 4692 | 10.68 | 9.13 | 6.62 | 6.10 | 1.55** |

**$P < 0.01$.

**Table III.** *Bivariate correlations between key variables*

| | Gender | Parental education | Family structure | Absenteeism | Grades | BMI | Physical activity | Bad food | Fruits and vegetables | Depressed mood | Self-esteem |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Gender | 1 | | | | | | | | | | |
| Parental education | −0.01 | 1 | | | | | | | | | |
| Family structure | −0.00 | 0.05* | 1 | | | | | | | | |
| Absenteeism | −0.10** | −0.08** | −0.09** | 1 | | | | | | | |
| Grades | 0.19** | 0.35** | 0.12** | −0.26** | 1 | | | | | | |
| BMI | −0.08** | −0.08** | −0.01 | 0.016 | −0.12** | 1 | | | | | |
| Physical activity | −0.22** | 0.07** | 0.10** | −0.11** | 0.09** | −0.02 | 1 | | | | |
| Bad food | −0.25** | −0.01 | 0.02 | 0.19** | −0.14** | −0.07** | 0.01 | 1 | | | |
| Fruits and vegetables | 0.15** | 0.17** | 0.07** | −0.14** | 0.23** | −0.06** | 0.23** | −0.05** | 1 | | |
| Depressed mood | 0.19** | −0.07** | −0.09** | 0.14** | −0.11** | −0.07** | −0.17** | 0.01 | −0.07** | 1 | |
| Self-esteem | 0.23** | −0.15** | −0.07** | 0.11** | −0.21** | 0.07** | −0.20** | −0.01 | −0.14** | 0.57** | 1 |

*$P < 0.05$, **$P < 0.01$.

academic achievement when controlling for other variables. The effect is relatively constant between Models 2 through 4 (β = 0.06, 0.04 and 0.03, respectively), but the β for physical activity falls to 0.02 and is non-significant in Model 5 when depressed mood and self-esteem are added to the model. BMI is a consistently significant predictor of academic achievement in models 2 through 5 and is slightly more powerful than physical activity in each of the models (β = −0.08, $P < 0.01$, models 2 through 4; β = −0.07, $P < 0.01$, Model 5). The diet variables, eating bad food and eating fruits and vegetables, are also significant predictors of academic achievement in the fifth and final OLS model. Eating more bad food (β = −0.05) and more fruits and vegetables (β = 0.09) predict

academic achievement, when controlling for other variables; however, the impact of these variables on academic achievement is relatively weak. When the mental health variable of self-esteem is added to the fifth model, negative self-esteem is a moderately strong and inversely related predictor of academic achievement ($\beta = -0.18$, $P < 0.01$)

A schematic representation of the most parsimonious model is shown in Fig. 1. The arrows indicate the hypothesized relationship of the variables. Together, the β weights for the variables in Model 5 account for 27% of the variance ($R^2 = .27$) in academic achievement. Between models, each independent variable increases the explained variance significantly when gender, parental education, family structure and absenteeism are treated as control variables. All variables shown in the figure (with the exception of physical activity in Model 5) are statistically significant ($P < 0.05$).

**Table IV.** *Standardized beta coefficients from OLS regressions (n = 4820 for all models)*

| | Model 1 | Model 2 | Model 3 | Model 4 | Model 5 |
|---|---|---|---|---|---|
| Gender | 0.15** | 0.16** | 0.12** | 0.14** | 0.16** |
| Parental education | 0.34** | 0.33** | 0.32** | 0.32** | 0.30** |
| Family structure | 0.06** | 0.05** | 0.05** | 0.05** | 0.05** |
| Absenteeism | −0.21** | −0.20** | −0.18** | −0.18** | −0.17** |
| BMI (*z*-score) | | −0.08** | −0.08** | −0.08** | −0.07** |
| Physical activity | | 0.06** | 0.04** | 0.03* | 0.02 |
| Bad food | | | −0.06** | −0.06** | −0.05** |
| Fruits and vegetables | | | 0.11** | 0.11** | 0.09** |
| Depressed mood | | | | −0.06** | 0.03* |
| Self-esteem | | | | | −0.18** |
| $R^2$ | 0.22 | 0.23 | 0.24 | 0.24 | 0.27 |

The dependent variable is for grades from four core subjects: Icelandic, Mathematics, English and Danish.
*$P < 0.05$, **$P < 0.01$.

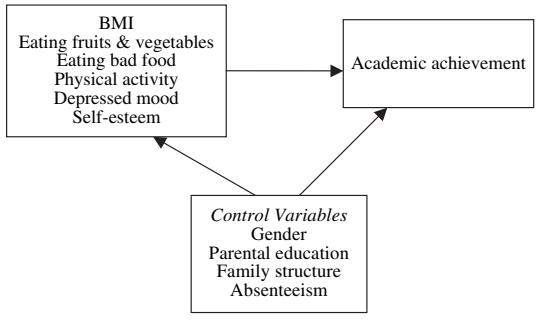


**Fig. 1.** Hypothesized relationship of BMI, diet, physical activity and mental health to academic achievement.

## Discussion

This is the first study of health-related behaviour and academic achievement to be conducted in Icelandic school children. Specifically, we explored whether BMI, diet and physical activity are related to school performance. When control and potential confounding variables are included in the predictive model, BMI was most strongly associated with academic achievement, followed by diet and physical activity as weaker but significant correlates. But BMI and health behaviour variables are overshadowed by parental education, absenteeism and self-esteem. The finding that each of these variables together explains up to 24% of the variance in academic achievement (27% when self-esteem is added), while not robust, is consistent with previous reports that have found evidence of a relationship between health behaviour and academic performance.

Our study was based on data from a large population and the response rate to our survey was high; however, several limitations of our data are worth noting. First, we used cross-sectional data for our correlational analyses, which does not provide definitive causal evidence. Second, our data collection measures relied on self-reports from adolescents. Our measure of academic achievement was a self-reported composite measure and may not be reliable because of the possibility that students did not accurately report their grades. Due to confidentiality restrictions, we were unable to match individual questionnaires with school transcripts to test this possibility. However, methodologic studies suggest that validity and reliability of self-reported

grades are similar to actual school transcripts. For example, in the United States, Schiller [36] has compared student self-reports with official school transcripts in the National Education Longitudinal Survey and found that although students do generally overestimate their math grades by about one-third of a letter grade, self-reported grades provide a reasonably reliable ($r = 0.72$) measure of students' overall position in the grade distribution.

Similarly, our independent measures of height, weight and dietary intake are all self-reported, and could not be corroborated. Several studies of adolescent [37, 38] and adult [39] populations have examined the validity of self-reports of height and weight and have found significant under-reporting of weight and significant over-reporting of height. Hence, self-reported weight of adolescents needs to be viewed with caution. However, there are two reasons why we are reasonably confident in the self-reported data we obtained. First, we were not establishing rates or prevalence of obesity; we used self-reported height and weight as ordinal correlates of academic achievement. Second, our sample size is very large—over 5000 adolescents—which gives us confidence that the responses are much more reliable than if we had studied a small sample. A large segment of the respondents would have had to over- or underestimate their height and weight in order to have biased the results. Furthermore, we minimized the likelihood of such bias by filtering out those reporting exceptionally high or low responses on height and weight.

There are several implications of our findings. First, although there is growing and convincing evidence that nutritionally poor dietary choices and lack of physical activity can place children at risk for being overweight and obese and thus influence future health status, the relationship of health behaviours to academic achievement is complex and not as well established. The nature and strength of the relationship of health behaviours and academic achievement is of increasing importance in the context of school reform efforts such as those that have been stimulated in the United States by the No Child Left Behind Act [13]. For example, a recent study [40] of several hundreds of thousands of fifth, seventh and ninth grade students conducted in 2002 by the California Department of Education showed that physically fit youngsters earned significantly higher scores on math and reading tests than those who were less physically fit. In addition, students who met minimum fitness levels in three or more areas showed the greatest gains in academic achievement. The relationship between fitness and achievement was stronger for females and those students with higher socio-economic status than for males and students of lower socio-economic status. Our study found evidence that is consistent with these findings, but the signal is of moderate strength. Moreover, when confounders such as mental health factors are considered, the impact of physical activity becomes less important. Clearly, many other variables need to be taken into account if we are to paint a complete picture of how health status, health behaviours and other factors contribute to school performance.

Second, schools in the United States and in Iceland and other European countries face enormous pressure to improve the academic skills and performance of their students. There have been a number of calls to action to better utilize schools to improve health status and academic achievement through a broad range of services as part of the comprehensive school health programme [41–43]. Given that our results are consistent with prior work, the implications of our findings suggest the need for schools in Iceland to enhance physical education and make available more nutritious food choices, inside and outside the classroom. Our data also suggest that mental health may be an important, but often overlooked, variable when considering mechanisms underlying school performance. Unlike schools in other advanced economies, school differences in Iceland are not as pronounced; this is due to the fact that universal schooling is obligatory for grades 1–10. All Icelandic schools are funded by the municipalities and supervised by the Ministry of Education, which publishes a uniform national curriculum. This system has strengths: all children receive a similar education irrespective of socio-economic status, and, in theory, changes in school policy that are politically mandated can be easily implemented.

But such a system also has weaknesses: the fact that all schools are uniformly similar and that there is practically no variation in teaching methods across schools diminishes school choice. In this context, there is a need to strengthen the capacity of Icelandic schools to address the individual preferences and abilities of young people in physical education, especially early, at the elementary school level. For example, by providing opportunities for individual success, physical education teachers can help create positive gym class experiences among their students and by doing so activate more students.

Finally, why some children and adolescents engage in healthy behaviour and why others do not, however, is still unclear. Although good nutrition and being physically active may help children and adolescents to maintain desirable weight and perform better at school, it is possible that such proactive health behaviour may be deemed socially undesirable by peers. For example, one recent study has reported that pre-teenage students who engage in higher levels of exercise, good nutrition and prosocial recreation were at greater risk for being bullied or victimized by other (presumably less health conscious) students [44]. In Iceland, prior work [45] has shown that Icelandic schools are among the most important and powerful agents of socialization into physical activity among adolescents, along with the family and sport organizations. Thus, efforts aimed at mobilizing adolescents to engage in healthy behaviour, such as selecting more nutritious diets or being more physically active, should not only focus on individual student attitudes and behaviour, but may also need to address the school culture and broader social environment. Moreover, mental health variables such as depressive mood and self-esteem may mediate the impact of physical activity on academic achievement and thus should be examined more closely in future research.

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## Conflict of interest statement

None declared.

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