University of Utrecht
Child and Adolescent Psychology

Intelligence and self-control in relation to eating pattern, physical activity and bodyweight in adolescents

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CONTENTS

SUMMARY

Research shows that intelligence is related to health. The exact reason for this relation is still unclear. A possibility is that self-control is related to intelligence and explains the relation between intelligence and health. This study investigated whether intelligence is related to healthy eating pattern, physical activity and appropriate bodyweight. Also the relation between self-control and the different kinds of health behaviour is investigated. Moreover, it is investigated whether self-control can explain the relation between intelligence and health.

In total 201 high-school students aged between 15 and 20 participated in the study. They were asked to do three cognitive tests and completed a self-control questionnaire and health questionnaire. The cognitive tests measured reaction time, memory span and fluid intelligence. The health questionnaire contained questions about eating pattern and physical activity.

The results show that intelligence is positively related to healthy eating pattern and physical activity, but not related to bodyweight. Adolescents with a higher score on the intelligence test eat more healthy and less unhealthy foods and engage more in physical activity than less intelligent adolescents. Self-control is also positively related to healthy eating pattern, physical activity and healthy bodyweight. Self-control is not related to intelligence and therefore can not explain the relation between intelligence and health. Results can contribute to develop more effective dietary behaviour change interventions in adolescents.

SAMENVATTING

Uit onderzoek is gebleken dat intelligentie samenhangt met gezondheid. Er is nog geen duidelijke verklaring voor deze relatie. Het is mogelijk dat zelfcontrole samenhangt met intelligentie en hiermee de relatie tussen intelligentie en gezondheid verklaart. Deze studie heeft onderzocht of intelligent samenhangt met een gezond eetpatroon, beweging en gezond lichaamsgewicht. Ook is de relatie tussen zelfcontrole en de verschillende gezondheidsgedragingen onderzocht. Tevens is onderzocht of zelfcontrole de relatie tussen intelligentie en gezondheid kan verklaren.

In totaal deden 201 scholieren tussen de 15 en 20 jaar mee aan het onderzoek. Zij werden gevraagd drie verschillende cognitieve tests te doen en vulden een zelfcontrolevragenlijst en een gezondheidsvragenlijst in. De cognitieve tests maten reactietijd, geheugenspanne en intelligentie. De gezondheidsvragenlijst bestond uit vragen over eetpatroon en beweging.

De resultaten laten zien dat intelligentie positief gerelateerd is aan gezond eetpatroon en beweging, maar niet gerelateerd aan lichaamsgewicht. Adolescenten met een hogere score op de intelligentietest eten meer gezond en minder ongezond voedsel en bewegen meer dan minder intelligente adolescenten. Zelfcontrole blijkt ook positief samen te hangen met een gezond eetpatroon, hoeveelheid beweging en gezond lichaamsgewicht. Zelfcontrole is niet gerelateerd aan intelligentie en kan daarom de relatie tussen intelligentie en gezondheid niet verklaren. Resultaten kunnen bijdragen aan de ontwikkeling van effectievere interventies voor de verandering van eetgewoonten in adolescenten.

INTRODUCTION

Nutrition and physical activity in adolescents

Having a healthy lifestyle as a child and adolescent is very important. Healthy nutrition is an important part of a healthy lifestyle. Unhealthy eating habits can have short term negative effects, such as dental carries, but also a lot of negative health implications in the long term. Unhealthy nutrition in adolescents can have heart diseases and cancer as a result. Overweight in adolescence even is a more powerful predictor of some long-term health risk factors than is overweight in adulthood (Must, Jacques, Dallal, Bajema & Dietz, 1992).

Despite the importance of healthy food consumption, different studies have shown that adolescents often have unhealthy eating and drinking habits. Research done to examine the health of Dutch adolescents showed that a lot of high-school students do not eat and drink as healthy as they should (Van Kooten, De Ridder, Vollebergh, & Van Dorsselaer, 2007). Many skip breakfast and do not eat enough fruit and vegetables, while consuming a high amount of sweets and soft drinks. According to Croll, Neumark-Sztainer and Story (2001) adolescents do have a significant amount of knowledge regarding healthy foods and their importance, but healthy food intake is hindered by a lack of time, limited availability of healthy food in schools and a lack of concern.

Physical activity also contributes to good health. Diet and physical activity both have different and similar characteristics and complement each other in the health process (Baranowski, 2004). Hillman et al. (2006) studied the amount of physical activity in relation to cognition. Participants had to report their physical activity behaviour and were tested for reaction time. The study showed that physical activity was associated with faster reaction times. This could be an indication of a relation between physical activity and cognitive functions.

Intelligence

Cognitive functions are functions that deal with how people perceive, learn, remember and think about information. They play a role in every aspect of our lives. Intelligence could be described as a total of all cognitive capacities. The general opinion is that it is possible to take all different cognitive capacities together and describe the overall cognitive capacity as

intelligence (Gottfredson, 1998). Mental tests often measure different aspects of cognition, such as memory, verbal skills or mathematical skills, but in many tests the same pattern seemed to emerge: people who performed well on a test of one domain of cognition showed good results on tests of the other domains as well. Also, people who showed poor results on one test tend to show poor results on the other tests. Thus, there appeared to be a strong correlation between different aspects of cognitive capacity. This was proof for the existence of overall intelligence (Gottfredson, 1998). The next step was the origin of intelligence. Research that focused on the heritability of intelligence concluded that intelligence for a great part is genetic and thereby highly heritable (Wright et al., 2001).

Intelligence and health

Intelligence has great influence on daily life. For example it is the most important predictor of personal performance in school or on the job. But it can also predict other factors of well being, such as the likelihood of divorcing, school drop out and unemployment (Gottfredson, 1998).

Recent studies also reported a relation between intelligence and health. People with high intelligence tend to be healthier than people with low intelligence. According to longitudinal research done by Deary, Whalley and Starr (2003) on the Scottish Mental Survey of 1932 (SMS1932) higher intelligent people are more likely to live up to age 76. IQ was measured at age 11 and the research showed that participants with a disadvantage of 1 standard deviation (15 points) in IQ-score relative to others were only 79% as likely to live up to age 76. They also found a negative relation between IQ and cancer deaths, when IQ decreases the number of cancer deaths increases.

The exact reason for the relation between intelligence and health is still unclear. Gottfredson and Deary (2004) name several possible explanations for this correlation. The first possible explanation is that intelligence is related to body integrity. This theory states that intelligent people are born with a strong and healthy body that will stay healthier during life than that of people with lower intelligence. Secondly, it is possible that intelligence and risk of illnesses are both related to foetal and child development and insults during childhood. A third possible explanation is that intelligence is related to prosperity and socio-economic status. The basic assumption is that wealthier people live in a healthier environment and can afford better health care which results in better health. But contrary of what would be expected according to this hypothesis, health inequalities tend to increase when health

resources become more available for a wider public. People with high education and good incomes benefit more from the increased health resources than do people with poor education and lower incomes. People in low socio-economic status (SES) groups appear to seek less appropriate care, adhere less often to treatment regimens and know less about how to prevent diseases. Even when health and preventive care is free, people in lower SES groups make less use of it. So it seems that not material resources, but mental resources are the explanation for differences in health.

The last explanation enters into these mental resources. According to this explanation people with higher intelligence have more mental resources, which are described as cognitive demands of preventing illness and accidents. Intelligence is manifested in thinking skills, such as learning, reasoning and problem solving, which is even more important in complex situations. Health self-care is a changing and complex task in which one has to protect oneself of accidents and diseases. In doing this, thinking skills play an important role. It is important to learn, generalize and understand ways of preventing accidents and illness. When to seek help and how to control a disease are examples of problems in which mental resources can play an important role. In support of this hypothesis, intelligent people indeed tend to know and understand health self-care better and are more able to solve health involving problems (Godfrettson & Deary, 2004). Also, intelligent people tend to prevent diseases better by having a healthy lifestyle. They involve less in health risk behaviour. Research shows that more intelligent people tend to smoke less and are more likely to give up smoking. Also they less often have overweight and problems with obesity (Batty, Deary, Schoon & Gale, 2007).

O'tool (1990) studied intelligence in relation with deathly accidents. In support of the hypothesis, he found that intelligence was the major predictor of motor vehicle accidents. He found that the accident rate was three times as high in the lower levels of IQ (below 85) than in the higher ones (above 115). Moreover, in 1992 O'Toole and Stankov studied the relation between intelligence and non-combat deaths at age 40 in Australian veterans. After controlling for other variables, such as health, behavioural, demographic and other psychological variables, the addition of each IQ-point meant a 1% decrease in risk of death.

According to Tangney, Baumeister and Boone (2004) self-control is the explanation for the relation between health risk behaviour and intelligence. Self-control is regarded as one of the mental resources that can help to prevent oneself of illness and accidents.

Self-control

Self-control is regarded as the capacity to change and adapt the self to provide a better fit between the self and the environment (Rothbaum, Weisz & Snyder, 1982). Through self-control people are able to inhibit or change their inner responses and refrain from acting out undesirable behaviours. This way better adaptation to the environment is possible with positive outcomes as a result.

Various outcomes have been related to self-control. Tangney, Baumeister and Boone (2004) found that self-control is positively related to task performance, the quality of relationships and interpersonal skills, secure attachment and emotional responses. They also investigated the relation between self-control and impulse regulation, with the hypothesis being that people with low self-control show more dysfunctional, impulsive behaviours. They found that participants that scored low on self-control indeed reported more impulsive behaviours.

A lot of these impulsive behaviours, such as binge eating and alcohol abuse, are risk factors for different kinds of diseases. Young adolescents with low self-control tend to show more health risk behaviour than do adolescents with high self-control (Wills et al., 2001). Therefore adolescents with high self-control may be more able to prevent themselves from illness and are healthier on average than adolescents with low self-control.

Reaction time and memory

Reaction time and memory are often found to be related to intelligence and therefore can play a role in the relation between intelligence and health as well. Several studies found a relation between reaction time and general intelligence (Deary, Der & Ford, 2001; Jensen & Munro, 1979). Reaction time has found to have some relations with health as well. Shipley, Der, Taylor and Deary (2006) conclude in their study that slower reaction time is related to higher mortality risk. According to Deary and Der (2005) reaction time can explain the relation between intelligence and death. Moreover, slower reaction times were related to a higher amount of exercise (Hillman et al., 2006).

Some studies also found a relation between working memory and intelligence (Kyllonen & Christal, 1990). Moreover, Shipley, Der, Taylor and Deary (2006) found a relation between memory and risk of dying for young adults. Thus, according to several studies working

memory and reaction time are related to general intelligence and can play a role in the relation between intelligence and health.

Adolescents and health

In the period between childhood and adulthood, adolescents experience stress, injustice and sometimes fear in their relations with peers, parents and teachers (Olsson, Fahlén & Janson, 2008). Adolescents are emancipating from their parents and are consequently showing some risk behaviour (Olsson, Fahlén & Janson, 2008). Because adolescents are getting more independent from their parents, they more often decide about their food intake. Research shows that in this specific period consequently dietary patterns tend to decline in quality (Larson, 2008). Moreover, the consolidation of health behaviours such as food intake and the amount of exercise starts in childhood and early adolescence after which the behaviours do not change much (Kelder, Perry, Klepp & Lytle, 1994). Therefore, it is very important to obtain and maintain a healthy diet in adolescence.

In the presents study the importance of intelligence and self-control as factors in health behaviour in adolescents is investigated. This study enters into the relation between intelligence and healthy diet and physical activity. Also it is investigated whether self-control explains the relation between intelligence and healthy diet and physical activity.

METHOD

Hypotheses

The present study investigates if intelligence and self-control are related to bodyweight, physical activity and eating habits in adolescents. Intelligence is tested with an intelligent test, a reaction times test and a memory test. Bodyweight, physical activity, eating habits and self-control are tested by the use of surveys. It is investigated whether self-control explains the relation between intelligence and healthy diet and physical activity.

Hypotheses:

1. Intelligence is positively related to healthy eating pattern, physical activity and appropriate bodyweight.
2. Self-control is positively related to healthy eating pattern, physical activity and appropriate bodyweight.
3. Self-control is a mediator between intelligence and the different kinds of health behaviour.

Participants

For the research 201 participants (105 women) were tested. Participants were high school students aged between 15 and 20 with mean age 16.8 (*SD* = 0.98). This age group was chosen because this is a period in which adolescents are getting more independent and are making their own decisions concerning their diet. To maximize variance in IQ, the adolescents that participated in the study are attending different kinds of high schools. Around one third of the participants is attending a Mavo high school or MBO school, one third a Havo high school and one third is attending a VWO high school. Schools were situated in different cities throughout The Netherlands, so that the sample would be representative for adolescents in The Netherlands. Cities were Utrecht, Huizen, Oosterhout, Eindhoven, Culemborg, Arnhem and Sleeuwijk. The aim was to have a representation of gender and age as well. For participating in the study participants received something to eat and drink: a chocolate bar or a small bag of crisps and a soft drink.

Materials

To measure intelligence, a simple reaction times test, the Raven Standard Progressive Matrices and Corsi block-tapping task were used. Moreover, the Self-Control Scale and a health questionnaire were administered. All tests and questionnaires were completed on a computer.

Simple Reaction Times test

A simple reaction times test (SRT) measures the time between a stimulus and the response. In this test, participants had to push the space button as fast as they could when a circle turned green. The circle each time appeared at a different place on the screen and the time before it turned green was variable, between 500 and 2000 milliseconds. First, participants had 10 trials to practice. After the practice trials, two blocks each consisting of 24 trials were administered. For every trial, reaction time was measured and the mean and median reaction time were calculated for every block.

Raven Standard Progressive Matrices

The Raven Standard Progressive Matrices (RSPM; Raven, 1958) measures fluid intelligence, the ability to solve problems and understand the relationship of various concepts (Cattell, 1971). The test demands analytic reasoning on abstract visuospatial material (Carpenter, Just & Shell, 1990). The RSPM consists of 60 problems in which participants had to find the correct item that is missing in the pattern out of 6 or 8 possible items. Figure 1 is an example of an item of the RSPM. During the test problems became more difficult and abstract. A computerized version of the RSPM was used. The computerized version is found to be equivalent to the standard version (Williams & McCord, 2006). Problems appeared on the computer screen and participants had to click on one of the items before the next problem appeared. First, participants received 5 problems to practice after which all 60 problems were administered. The answering time was not limited. For every correct item one point was given with a maximum score of 60. The RSPM is a valid and reliable measure for intelligence.

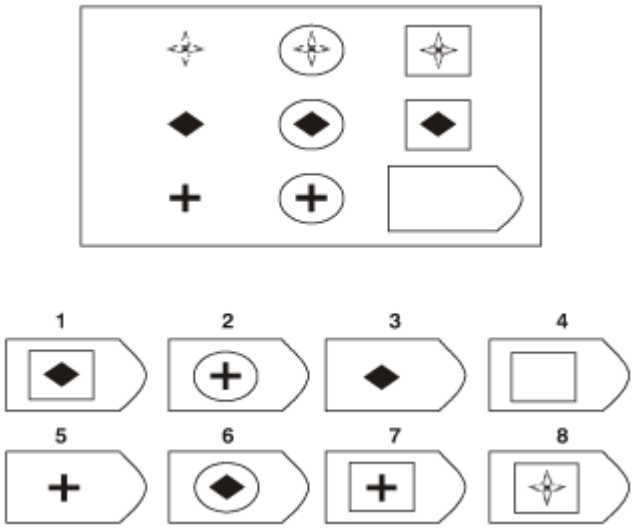

Figure 1. Item of the Raven Standard Progressive Matrices

Corsi block-tapping task

To measure memory span, the Corsi block-tapping task (Milner, 1971) was used. In the Corsi block-tapping task participants had to remember a sequence of blocks. Nine green squares appeared one the screen in asymmetrical order (figure 2). Every trial few squares turned blue in a certain sequence. In the first part of the test, participants were asked to recall the sequence and click on the squares that had turned blue in the same order as the squares had done. In the second part, participants had to click on the blocks in the contrary order, starting with the block that had turned blue last and finishing with the one that turned blue first. The answering time was not limited. In both parts, the number of squares was increased by one square after every two sequences. Two trials of each sequence length were presented. The shortest sequences included two squares and the longest ones nine squares. The task was ended if both trials of each sequence length were incorrect. To calculate the score, the block span was multiplied by the number of correct trials. The maximum score was 162.

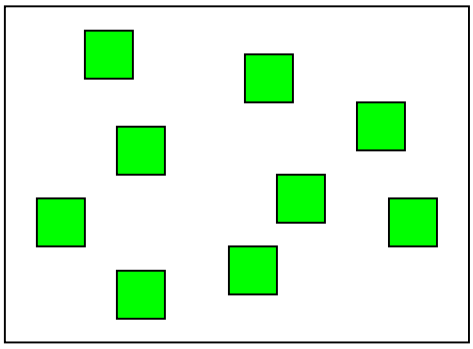

Figure 2. Computer screen of the Corsi-block tapping task

Self-control

To measure self-control the Self-Control Scale (Tangney, Baumeister, Boone, 2004) was used. The Self-Control Scale (Cronbach's *alpha* = 0.89) consists of 36 questions about self control (e.g. "I am good at resisting temptation"). Participants rated their self control on 5-point Likert-scales (anchors 1 = not at all like me, 5 = very much like me).

After administration answers on three items were removed from the data. Those were the items: "I engage in healthy practices", "I eat healthy foods", "I sometimes drink or use drugs to excess". Because the relation between self-control and health is examined, the health related items in the Self-Control Scale had to be removed. Negatively formulated items were reverse scored. A higher score means a greater ability to control oneself. Because all participants were Dutch, a Dutch version of the Self-Control Scale was used (Kuijer, De Ridder, Ouwehand, Houx & Van den Bos, 2008). Appendix 1 contains all questions of the Self-Control Scale.

Nutrition and physical activity

To measure eating habits and physical activity, a health survey was administered. The survey contained questions about length, bodyweight, physical activity and eating habits. The questions about eating were extracted from the questionnaire used in the Dutch Health Behaviour in School-aged Children (HBSC)-study on adolescent health, well-being and health-behaviour (Ter Bogt, Van Dorsselaer & Vollebergh, 2003). A question about how much money participants spend on snacks and soft drinks was added.

Physical activity was assessed using the 60 min Moderate-to-Vigorous Physical Activity (MVPA) measure (Prochaska, Sallis, & Long, 2001). The MVPA is found to be a valid and reliable measure of physical activity. It consists of two questions: 'Over the past 7 days, how many days were you physically active for a total of at least 60 min per day?' and 'Over a typical or usual week, how many days were you physically active for a total of at least 60 min per day?' The average number of days of the past and a typical week was an index for engaging in physical activity.

To find out if a person's bodyweight is appropriate for his/her length the Body Mass Index (BMI) was used. It is an index of weight-for-height and it is computed by dividing the weight in kilograms by the square of the height in metres (kg/m^2). According to the World Health Organisation a person is supposed to have a BMI between 18.5 and 25 to have a healthy bodyweight. Appendix 2 contains all questions of the health survey.

Design and procedure

In total 10 third and fourth year students of University of Utrecht were responsible for administering the tests. The order of the tests for all participants was as follows: reaction times test, Raven's Standard Progressive Matrices, Corsi block-tapping task, self-control survey and the health control survey as last. The Mental Information processing and Neuropsychological Diagnostic System (MINDS; Brand & Houx, 1992) was used for display of the tests. A test battery was made in which the tests automatically appeared in the given order. Several computers were used to complete the tests on.

Participants could sign up or were personally asked by the experimenters or high school teachers to participate in the study. Participants were tested in small groups ranging from 2 to 6 pupils. They were tested in a separate room or quiet part of the library on their high school in the presence of at least one of the experimenters. All participants received the following instruction: "You are going to do a few tests and complete some surveys on the computer in front of you. After you completed a test, the next one will automatically follow. Instructions for every test will appear on the screen." Total duration of the administration was between 30 and 50 minutes for all participants, with one exception of 20 minutes.

Statistical analysis

Pearson's correlations and hierarchal regression analyses were used to examine whether intelligence is correlated with healthy diet, physical activity and bodyweight. To be sure that gender, age and family income were not responsible for correlative outcomes they were controlled for in the hierarchal regression analyses.

Before conducting the regression analyses, normal distribution of the predictor and outcome variables was examined. Few variables had no normal distribution and for those logistic transformation was conducted. Because logistic transformation did not have an effect on the correlations for those variables, no logistic transformations were used in the analyses. Predictor variables were reaction time, intelligence, memory span and self-control. Dependant variables were breakfast consumption during the week and during the weekend, intake of fruits, vegetables, candy, crisps, snacks and soft drinks, money spend on unhealthy foods and drinks, BMI and the amount of physical activity. For the hierarchal regression analyses, intake of candy, crisps, snacks and soft drinks were included in the scale "unhealthy food" (Cronbach's *Alpha* = 0.65). Control variables were gender, age and family income. Family income is divided into the yearly income of participant's parents, what kind of house they live in and if participant's parents rent or own the house.

RESULTS

Eating pattern

Table 1 presents correlations, means, standard deviations and minima and maxima for control variables, intelligence, reaction time, memory span, self-control, eating habits, physical activity and BMI. Scores on the eating habits were recoded, so that for intelligence and memory span a positive correlation with eating habits means that participants with a higher score have a healthier eating pattern for all variables. For reaction time, a lower score justifies better cognitive functioning. Thus, for reaction time a negative correlation with eating variables means that people with better cognitive functioning have a healthier eating pattern.

As expected the three cognitive tests correlate with each other. Correlations with eating habits were only found for intelligence. Participants that scored higher on the intelligence test more often have breakfast during the weekend, eat more vegetables and have a lower consumption of soft drinks, crisps and snacks than participants with a low score. Also participants with a higher score tend to spend less money on unhealthy foods and drinks than participants with a low score on the intelligent test. No significant correlations were found between reaction time and eating habits. For memory span, only a weak correlation with soft drinks was found.

Self-control did not correlate with intelligence, reaction time or memory span, but self-control does correlate with different eating habits. Participants with more self-control more often have breakfast during the week and weekend, eat less crisps and snacks and spend less money on sweets, snacks or soft drinks.

Because of the lack of correlations between reaction time, memory span and eating pattern, only intelligence and self-control were used in the hierarchal regression analyses. Table 2 summarizes the results of self-control and intelligence predicting the different health behaviours in the hierarchal regression analyses. The control variables entered in the first step were significantly related to some eating behaviours [Step 1: $R^2 = .07$, $F(5,190) = 2.71$, $p < .05$ for breakfast during the weekend; $R^2 = .06$, $F(5,190) = 2.60$, $p < .05$ for fruit intake; $R^2 = .12$, $F(5,190) = 5.16$, $p < .001$ for unhealthy food intake; $R^2 = .11$, $F(5,190) = 4.88$, $p < .001$ for money spend on unhealthy foods and drinks].

Table 1: Control variables, predictor variables and eating pattern, physical activity and BMI: correlations and descriptive statistics

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1. Age	-																						
2. Gender	.07	-																					
3. Own house	-.02	.13	-																				
4. Family income	-.01	.13	.39**	-																			
5. Kind of house	-.03	.11	.30**	.23**	-																		
6. Intelligence	-.03	-.01	.16*	.13	.03	-																	
7. Reaction time	-.11	-.17*	-.06	-.18*	-.15*	-.31**	-																
8. Memory Span Forward	-.09	.12	.11	.11	-.06	.17*	-.03	-															
9. Memory Score Forward	-.13	.09	.09	.10	-.05	.23**	-.11	.94**	-														
10. Memory Span Backward	-.09	.01	.03	-.01	-.03	.27**	-.13	-.02	-.02	-													
11. Memory Score Backward	-.07	.07	.05	.02	-.01	.27**	-.18**	.10	.12	.93**	-												
12. Self-control	-.01	-.04	-.07	.03	-.09	.05	-.08	-.12	-.09	-.08	-.06	-											
13. Breakfast week	-.06	.02	.08	.13	-.03	.02	.03	-.03	-.00	-.10	-.09	.24**	-										
14. Breakfast weekend	-.15*	-.15*	.07	.08	-.10	.18*	.03	.11	.13	-.04	-.06	.21**	.40**	-									
15. Fruit	-.11	-.18**	.03	.10	-.03	.06	.01	-.05	-.04	-.10	-.12	.11	.18*	.28**	-								
16. Vegetables	-.05	-.11	.01	.00	.05	.21**	.04	-.05	-.06	.07	.06	.11	-.01	.17*	.33**	-							
17. Candy	.15*	.01	-.24**	-.15*	-.17*	-.11	.06	.08	.09	-.05	-.05	.00	-.09	-.13	-.11	-.03	-						
18. Soft drinks	.16*	-.26**	-.12	-.05	-.07	.17*	-.09	.15*	.17*	-.15*	-.16*	.12	.10	.20**	.19**	.20**	.27**	-					
19. Crisps	.14*	-.21**	-.10	-.09	.01	.16*	-.07	.04	.06	.03	.01	.18**	.05	.02	.16*	.11	.37**	.44**	-				
20. Snacks	.03	.24**	-.04	.04	-.04	.23**	-.10	.01	.06	.02	.01	.14*	.13	.20**	.24**	.32**	.23**	.33**	.39**	-			
21. Money	.11	.30**	.05	.11	.16*	-.18*	-.04	-.03	-.08	.04	.06	-.25**	-.22**	-.38**	-.17*	-.25**	-.13	-.29**	-.36**	-.47**	-		
22. Physical activity	-.07	.19**	.09	.09	.16*	.16*	-.13	.03	.06	-.05	.00	.15*	.16*	.11	.21**	.21**	-.15*	-.04	.04	.01	-.01	-	
23. BMI	.15*	.14*	-.00	.03	-.08	-.09	.11	.11	.09	-.10	-.08	-.19**	-.16*	-.17*	.04	.02	.20**	.01	.05	.06	.06	.01	-

*$p < 0.05$; **$p < 0.01$.

Table 1: continued

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
M	16.78	.48	1.89	2.65	2.31	46.37	275.89	5.55	49.33	4.94	37.29	105.25	5.39	2.76	4.41	5.12	3.38	3.32	4.49	5.17	2.05	3.94	21.12
SD	.98	.50	.32	.60	.96	7.01	43.51	1.82	26.58	1.72	21.19	15.52	1.36	.53	1.52	.93	1.40	1.80	1.19	.90	2.49	2.03	2.42
Minimum	15	0	1	1	1	20	214	1	2	1	1	61	1	1	1	2	1	1	1	1	0	0	16.60
Maximum	20	1	2	3	4	60	659	9	126	8	88	139	6	3	7	7	7	7	7	7	15	7	30.67

Table 2: Hierarchal regression for control-variables, self-control and intelligence predicting different health behaviours.

	Breakfast week			Breakfast weekend			Fruit			Vegetables			Unhealthy foods			Money		
Variables	*B*	*SE B*	*β*	*B*	*SE B*	*β*	*B*	*SE B*	*β*	*B*	*SE B*	*β*	*B*	*SE B*	*β*	*B*	*SE B*	*β*
Step 1: Control variables added																		
Age	-.09	.10	-.06	-.07	.04	-.14	-.15	.11	-.10	-.04	.07	-.05	.19	.07	.19**	.24	.17	.10
Gender	.03	.20	.01	-.15	.08	-.15*	-.61	.22	-.20**	-.24	.14	-.13	-.43	.13	-.23***	1.30	.35	.26***
Own or rent the house	.21	.34	.05	.15	.13	.09	.05	.37	.01	.03	.23	.01	-.42	.23	-.14	-.39	.59	-.05
Family income	.29	.18	.13	.07	.07	.08	.34	.19	.14	.00	.12	.00	-.01	.12	-.01	.26	.31	.06
Kind of house	-.10	.11	-.07	-.08	.04	-.14	-.06	.12	-.04	.06	.07	.06	-.04	.07	-.04	.37	.19	.14*
Step 2: Self-control added																		
Age	-.08	.10	-.06	-.07	.04	-.13	-.15	.11	-.10	-.04	.07	-.05	.19	.07	.20**	.24	.17	.09
Gender	.04	.19	.01	-.15	.07	-.14*	-.60	.22	-.20**	-.24	.14	-.13	-.43	.13	-.22***	1.29	.34	.26***
Own or rent house	.29	.33	.07	.18	.13	.11	.09	.37	.02	.05	.23	.02	-.39	.22	-.13	-.52	.58	-.07
Family income	.25	.17	.11	.06	.07	.07	.32	.19	.13	-.01	.12	-.01	-.03	.12	-.02	.32	.30	.08
Kind of house	-.07	.11	-.05	-.07	.04	-.12	-.04	.12	-.02	.07	.07	.07	-.02	.07	-.02	.32	.18	.12
Self-control	.02	.01	.24***	.01	.00	.19**	.01	.01	.13	.01	.00	.12	.01	.00	.12	-.04	.01	-.21**
Step 3: Intelligence added																		
Age	-.08	.10	-.06	-.07	.04	-.13	-.15	.11	-.10	-.04	.07	-.04	.19	.06	.20**	.23	.17	.09
Gender	.03	.20	.01	-.15	.07	-.14*	-.60	.22	-.20**	-.23	.13	-.12	-.42	.13	-.22***	1.26	.33	.25***
Own or rent the house	.30	.34	.07	.14	.13	.09	.08	.37	.02	-.03	.23	-.01	-.46	.22	-.16*	-.34	.57	-.04
Family income	.25	.18	.11	.05	.07	.06	.31	.20	.12	-.04	.12	-.03	-.05	.12	-.03	.38	.30	.09
Kind of house	-.07	.11	-.05	-.06	.04	-.12	-.04	.12	-.02	.07	.07	.08	-.02	.07	-.02	.31	.18	.12
Self-control	.02	.01	.24***	.01	.00	.18**	.01	.01	.13	.01	.00	.11	.01	.00	.11	-.03	.01	-.20**
Intelligence	-.00	.01	-.02	.01	.01	.15*	.01	.02	.03	.03	.01	.20**	.02	.01	.17*	-.06	.02	-.17*

For breakfast during the week, R^2 = .03 (p > .05) for step 1; ΔR^2 = .06 (p < .001) for step 2; ΔR^2 = .00 (p > .05) for step 3. For breakfast during the weekend, R^2 = .07 (p < .05) for step 1; ΔR^2 = .04 (p < .001) for step 2; ΔR^2 = .02 (p < .05) for step 3. For fruit, R^2 = .06 (p < .05) for step 1; ΔR^2 = .02 (p > .05) for step 2; ΔR^2 = .00 (p > .05) for step 3. For vegetables, R^2 = .02 (p > .05) for step 1; ΔR^2 = .02 (p > .05) for step 2; ΔR^2 = .04 (p < .01) for step 3. For unhealthy foods, R^2 = .12 (p < .001) for step 1; ΔR^2 = .01 (p > .05) for step 2; ΔR^2 = .03 (p < .05) for step 3.

For money, R^2 = .11 (p < .001) for step 1; ΔR^2 = .05 (p < .01) for step 2; ΔR^2 = .03 (p < .05) for step 3. *p < .05; **p < .01; ***p < .001

Table 2: continued

	Physical activity			BMI		
Variables	*B*	*SE B*	*β*	*B*	*SE B*	*β*
Step 1: Control variables added						
Age	-.15	.14	-.08	.35	.17	.15*
Gender	.69	.29	.17*	.61	.35	.13
Own house	.11	.49	.02	.00	.59	.00
Family income	.14	.26	.04	.20	.31	.05
Kind of house	.28	.16	.13	-.24	.19	-.10
Step 2: Self-control added						
Age	-.15	.14	-.07	.35	.17	.14*
Gender	.69	.28	.17*	.61	.34	.13
Own house	.22	.48	.03	-.10	.58	-.01
Family income	.09	.25	.03	.24	.31	.06
Kind of house	.32	.15	.15	-.29	.19	-.11
Self-control	.03	.01	.21**	-.03	.01	-.17*
Step 3: Intelligence added						
Age	-.14	.14	-.07	.34	.17	.14*
Gender	.71	.28	.18*	.59	.34	.12
Own house	.09	.48	.02	-.02	.59	-.00
Family income	.05	.25	.01	.27	.31	.07
Kind of house	.33	.15	.16	-.29	.19	-.12
Self-control	.03	.01	.20**	-.03	.01	-.17*
Intelligence	.04	.02	.14*	-.03	.02	-.08

For physical activity, R^2 = .06 (p < .05) for step 1; ΔR^2 = .04 (p < .01) for step 2; ΔR^2 = .02 (p < .05) for step 3. For BMI, R^2 = .05 (p > .05) for step 1; ΔR^2 = .03 (p < .05) for step 2; ΔR^2 = .01 (p > .05) for step 3.

*p < .05; **p < .01.

Entering self-control as a second step resulted in a significant increment in R^2 for breakfast during the week and weekend and money spend on unhealthy foods and drinks [Step 2: ΔR^2 = .06, $F(1,189)$ =11.93, $p < .001$; β = .24, $p < .001$ for breakfast during the week; ΔR^2 = .04, $F(1,189)$ = 7.47, $p < .01$; β = .19, $p < .01$ for breakfast during the weekend; ΔR^2 = .05, $F(1,189)$ = 10.08, $p < .01$; β = -.21$p < .01$ for money spend on unhealthy foods and drinks]. This indicates that self-control adds to predicting breakfast during the week and weekend and the amount of money spend on unhealthy foods above the other predictors. The increase in explained variance for fruit, vegetables and intake of unhealthy foods were borderline significant [Step 2: ΔR^2 = .02, $F(1,189)$ = 3.31, p = .07; β = .13, p = .07 for fruit; ΔR^2 = .02, $F(1,189)$ = 2.90, p = .09; β = .12, p = .09 for vegetables; ΔR^2 = .01, $F(1,189)$ = 3.08, p = .08; β = .12, p = .08 for unhealthy foods].

Entering intelligence as a third step resulted in a significant increment in R^2 for breakfast during the weekend, vegetable intake, unhealthy food intake and money spend on unhealthy foods and drinks [Step 3: ΔR^2 = .02, $F(1,188)$ = 4.61, $p < .05$; β = .15, $p < .05$ for breakfast during the weekend; ΔR^2 = .04, $F(1,188)$ = 7.83, $p < .01$; β = .20, $p < .01$ for vegetable intake; ΔR^2 = .03, $F(1,188)$ = 6.14, $p < .05$; β = .17, $p < .05$ for unhealthy food intake; ΔR^2 = .03, $F(1,188)$ = 6.23, $p < .05$; β = -.17, $p < .05$ for money spend on unhealthy foods and drinks]. Thus, intelligence adds to predicting breakfast during the weekend, vegetable intake, unhealthy food intake and money spend on unhealthy foods and drinks above the other predictors.

Physical activity

Table 1 shows the correlations between the different cognitive tests and physical activity. Intelligence correlates with physical activity, so that participants with higher scores engage more in physical activity than participants with lower scores. Reaction time and memory span did not correlate with physical activity. Self-control does correlate with physical activity, in that participants with more self-control engage more in physical activity.

In the hierarchal analyses, the control variables were significantly related to physical activity [Step 1: R^2 = .06, $F(5,190)$ = 2.62, $p < .05$], but entering self-control in the second step also significantly contributes to predicting physical activity [Step 2: ΔR^2 = .04, $F(1,189)$ = 9.34, $p < .01$; β = .21, $p < .01$]. Intelligence did also significantly increase the explained

variance in step 3 [Step 3: $\Delta R^2 = .02$, $F(1,188) = 4.26$, $p < .05$; $\beta = .14$, $p < .05$]. Thus, self-control and intelligence both add to predicting physical activity.

Bodyweight

No significant correlations were found between BMI-scores and intelligence, reaction time or memory span (table 1). A possibility is that the correlation is a non-linear correlation. Therefore RSPM-scores were divided into groups. The different groups were: scores between mean and mean+*SD*, scores between mean+*SD* and mean+2*SD*, scores between mean and mean-*SD*, scores between mean-*SD* and mean-2*SD* and scores lower than mean-2*SD*. The BMI-scores of the five groups were compared using between group one-way Analysis of Variance (ANOVA). No significant differences were found between the groups [$F(4,195) < 1.0$]. For self-control a negative correlation was found with BMI, so adolescents with more self-control have a lower BMI-score.

Control variables were not significantly related to BMI [Step 1: $R^2 = .05$, $F(5, 190) = 1.97$, $p > .05$]. Entering self-control in the second step resulted in a significant increment in R^2 [Step 2: $\Delta R^2 = .03$, $F(1,189) = 6.03$, $p < .05$; $\beta = -.17$, $p < .05$]. Intelligence did not add in predicting BMI [Step 3: $\Delta R^2 = .01$, $F(1,188) = 1.30$, $p > .05$]. This indicates that only self-control adds to predicting BMI.

Self-control as a mediator

Self-control did not correlate with intelligence, reaction time or memory span (Table 1). Because self-control did not correlate with scores on the intelligence test, reaction time test and Corsi-block tapping task, self-control can not be a mediator for intelligence and health behaviour.

DISCUSSION

The aim of this study was to determine whether intelligence and self-control can be related to eating habits, physical activity and bodyweight in adolescents. Main findings in the study were in agreement with the first hypotheses. Intelligence correlates with healthy eating patterns and physical activity, in that more intelligent adolescents have a healthier diet and engage more in physical activity. Intelligent adolescents more often have breakfast during the week, eat more vegetables and less unhealthy foods, such as crisps, snacks and soft drinks, than less intelligent adolescents. They also spend less money on unhealthy foods and drinks. Despite these findings, no correlations were found between intelligence and BMI.

Results also confirm the second hypothesis. Self-control was a predictor of healthy food intake, physical activity and BMI. Adolescents with high self-control more often have breakfast during the week and weekend, eat less crisps and snacks and spend less money on unhealthy foods. Moreover, they engage more in physical activity and have a lower BMI-score.

For the third hypothesis, no relation was found between self-control and intelligence. Therefore, self-control does not explain the relation between intelligence and the different kinds of health behaviour.

Controlling for the variables age, gender and family income made no difference for the significance of the results. Interestingly, when controlled for family income the amount of money spend on unhealthy foods is still related to intelligence and self-control. That is, less intelligent adolescents and adolescents with less self-control spend more money on unhealthy foods and drinks independent of family income.

The three tests that measure cognitive functions correlate with each other as expected, but only the scores on the intelligence test correlate with health behaviour. Reaction time was expected to also have a relation with health behaviour, because of the relation between reaction time and intelligence found in the present study and former studies (Deary, Der & Ford, 2001; Jensen & Munro, 1979) and the relation between reaction time and health (Deary and Der, 2005; Shipley, Der, Taylor and Deary, 2006). Some studies also found relations between working memory and intelligence and risk of dying for young adults (Kyllonen & Christal, 1990; Shipley, Der, Taylor and Deary, 2006). No correlations between reaction time or memory and health behaviours were found in this study. An explanation could be that reaction time and memory are related to general health and mortality, but not to

the specific health behaviours investigated in this study. A possibility is that reaction time and memory are related to some health risk factors, but not to eating pattern, physical activity or bodyweight.

Several studies found a relationship between intelligence and bodyweight, in that more intelligent people less often have overweight and problems with obesity (Batty, Deary & Macintyre, 2007; Batty, Deary, Schoon, & Gale, 2007). No such relation was found in the present study. Explanation for this refers to the age of the participants. In the present study bodyweight was investigated in adolescents, whereas former studies concerning this subject tested adults. The Body Mass Index is developed for adults and is therefore less representative for adolescents. Adolescents in the age group of the present study may still be growing, which indeed could make the BMI index less representative. Moreover, data of bodyweight and length in this study were based on self-reports. Thinkable is that the adolescents did not always report their correct weight or length.

Contrary of what was expected, no relation between self-control and intelligence was found. Possible is that there indeed is no relation between intelligence and self-control. Another possibility refers to selection bias. In some of the schools participants were chosen randomly, but in other high schools participants could sign up for participating in the study. Maybe participants who signed up have different qualities and characteristics than students that did not sign up. Thinkable is that participants that did sign up, have more self-control than the other students resulting in a lack of a relation between self-control and intelligence. Self-efficacy is also a possible mediator between intelligence and health behaviour. Researchers have found a relation between self-efficacy and physical activity. Adolescents with low self-efficacy tend to engage les in vigorous and moderate physical activity, toning exercises and playing on sport teams (Valois, Umstattd, Zullig & Paxton, 2008). In future studies on this subject self-efficacy should be considered as a possible mediator between intelligence and health as well.

This study was subjected to some other limitations. First, data on self-control and health behaviours were based on self-reports which are not always reliable. The second limitation refers to group size. In total 201 participants were tested, which is minimal. It would be interesting to test a lot more participants which may result in stronger correlations between intelligence, self-control, eating pattern and physical activity. Furthermore, in this study only Dutch adolescents were tested, but testing participants from other cultures would be interesting and would enable a better generalization.

In sum, we can conclude that intelligence as well as self-control is positively related to healthy eating pattern and physical activity, but self-control does not act as a mediator for intelligence and health. Bodyweight is also related to self-control, but results must be interpreted with caution, because the BMI-index is not totally representative for adolescents. Findings in this study could be considered in prevention of overweight and diseases. Unhealthy eating habits and overweight in children and adolescents are a worldwide issue and the percentage of overweight children and adolescents is still increasing (Hossain, Kawar & El Nahas, 2007). Overweight in adolescents is a more powerful predictor of some health risk factors than is overweight in adulthood and could have dangerous health problems as a result (Must, Jacques, Dallal, Bajema & Dietz, 1992). Initiatives that enhance self-control in adolescents and encourage them to eat healthier and engage in physical activity are recommended. Knowing that less intelligent adolescents have an unhealthier diet and engage less in physical activity than intelligent adolescents, extra support and information about the importance of healthy nutrition and exercise could be given at lower levelled high-schools. This way, dietary behaviour change interventions can become more effective.

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APPENDIX 1

Self-control items

Antwoordmogelijkheden*:*

1 Helemaal niet op mij van toepassing

2 Niet echt op mij van toepassing

3 Een beetje op mij van toepassing

4 Redelijk op mij van toepassing

5 Heel erg op mij van toepassing

1	Ik kan verleidingen goed weerstaan	1	2	3	4	5
2	Ik vind het moeilijk om slechte gewoontes te stoppen	1	2	3	4	5
3	Ik ben lui	1	2	3	4	5
4	Ik zeg ongepaste dingen	1	2	3	4	5
5	Ik sta mezelf wel eens toe om controle te verliezen	1	2	3	4	5
6	Ik doe wel eens dingen die slecht voor me zijn als ze leuk zijn	1	2	3	4	5
7	Mensen kunnen erop rekenen dat ik me aan afspraken houd	1	2	3	4	5
8	`s Ochtends kom ik moeilijk uit bed	1	2	3	4	5
9	Ik vind het moeilijk om ‘nee’ te zeggen	1	2	3	4	5
10	Ik verander nogal vaak van mening	1	2	3	4	5
11	Ik ben een flapuit	1	2	3	4	5
12	Mensen noemen me impulsief	1	2	3	4	5
13	Ik weiger dingen die slecht voor me zijn	1	2	3	4	5
14	Ik geef te veel geld uit	1	2	3	4	5
15	Ik houd alles netjes	1	2	3	4	5
16	Soms geef ik toe aan mijn verlangens	1	2	3	4	5

17	Ik ben betrouwbaar	1	2	3	4	5
18	Ik laat me meeslepen door mijn gevoelens	1	2	3	4	5
19	Ik doe veel dingen in een opwelling	1	2	3	4	5
20	Ik kan goed een geheim bewaren	1	2	3	4	5
21	Mensen zeggen dat ik een ijzeren zelfdiscipline heb	1	2	3	4	5
22	Als ik iets af moet hebben, doe ik het vaak op het allerlaatste moment	1	2	3	4	5
23	Ik word gemakkelijk ontmoedigd	1	2	3	4	5
24	Ik zou beter moeten nadenken voordat ik iets doe	1	2	3	4	5
25	Ik doe dingen die goed zijn voor mijn gezondheid	1	2	3	4	5
26	Ik eet gezond	1	2	3	4	5
27	Pleziertjes weerhouden me er soms van mijn (huis)werk af te krijgen	1	2	3	4	5
28	Ik heb moeite met concentreren	1	2	3	4	5
29	Ik kan goed werken aan lange termijn doelen	1	2	3	4	5
30	Soms kan ik mezelf er niet van weerhouden iets te doen, zelfs als ik weet dat het verkeerd is	1	2	3	4	5
31	Ik doe vaak dingen zonder goed na te denken over mogelijke alternatieven	1	2	3	4	5
32	Ik verlies gemakkelijk mijn geduld	1	2	3	4	5
33	Ik val mensen vaak in de rede	1	2	3	4	5
34	Soms ben ik onmatig met alcohol of drugs	1	2	3	4	5
35	Ik ben altijd op tijd	1	2	3	4	5
36	Ik zou willen dat ik meer zelfdiscipline had	1	2	3	4	5

APPENDIX 2

Health questions

1. Hoe vaak ontbijt je (meer dan een glas melk of vruchtensap, of een kop thee) door de week?

1 = Ik ontbijt nooit door de week

2 = 1 dag

3 = 2 dagen

4 = 3 dagen

5 = 4 dagen

6 = 5 dagen

2. Hoe vaak ontbijt je (meer dan een glas melk of vruchtensap, of een kop thee) in het weekend?

1 = Ik ontbijt nooit in het weekend

2 = Ik ontbijt meestal op één van de dagen van het weekend (zaterdag OF zondag)

3 = Ik ontbijt meestal op allebei de dagen van het weekend (zaterdag EN zondag)

3. Hoe vaak eet je fruit?

1 = Nooit

2 = Minder dan 1 keer per week

3 = 1 keer per week

4 = 2-4 dagen per week

5 = 5-6 dagen per week

6 = Iedere dag, 1 keer per dag

7 = Iedere dag, meer dan 1 keer per dag

4. Hoe vaak eet je groente?

1 = Nooit

2 = Minder dan 1 keer per week

3 = 1 keer per week

4 = 2-4 dagen per week

5 = 5-6 dagen per week

6 = Iedere dag, 1 keer per dag

7 = Iedere dag, meer dan 1 keer per dag

5. Hoe vaak eet je snoep of chocolade?

1 = Nooit

2 = Minder dan 1 keer per week

3 = 1 keer per week

4 = 2-4 dagen per week

5 = 5-6 dagen per week

6 = Iedere dag, 1 keer per dag

7 = Iedere dag, meer dan 1 keer per dag

6. Hoe vaak drink je frisdrank met suiker?

1 = Nooit

2 = Minder dan 1 keer per week

3 = 1 keer per week

4 = 2-4 dagen per week

5 = 5-6 dagen per week

6 = Iedere dag, 1 keer per dag

7 = Iedere dag, meer dan 1 keer per dag

7. Hoe vaak eet je chips of nootjes?

1 = Nooit

2 = Minder dan 1 keer per week

3 = 1 keer per week

4 = 2-4 dagen per week

5 = 5-6 dagen per week

6 = Iedere dag, 1 keer per dag

7 = Iedere dag, meer dan 1 keer per dag

8. Hoe vaak eet je snacks (zoals patat, kroket, frikadel etc.)?

1 = Nooit

2 = Minder dan 1 keer per week

3 = 1 keer per week

4 = 2-4 dagen per week

5 = 5-6 dagen per week

6 = Iedere dag, 1 keer per dag

7 = Iedere dag, meer dan 1 keer per dag

9. Hoeveel euro besteed je gemiddeld aan snoep, snacks en/of frisdrank per dag? Geef het aantal euro hieronder aan.

10. Hoeveel dagen was je in de afgelopen 7 dagen minimaal 60 minuten per dag lichamelijk actief?

0 = 0 dagen

1 = 1 dag

2 = 2 dagen

3 = 3 dagen

4 = 4 dagen

5 = 5 dagen

6 = 6 dagen

7 = 7 dagen

11. Hoeveel dagen ben je in een gemiddelde week minimaal 60 minuten per dag lichamelijk actief?

0 = 0 dagen

1 = 1 dag

2 = 2 dagen

3 = 3 dagen

4 = 4 dagen

5 = 5 dagen

6 = 6 dagen

7 = 7 dagen