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MASTER OF SCIENCE in human nutrition

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Fruit and Vegetable intake in 7 - 9-year-old children

Effect of a school-based intervention
on fruit and vegetable intake at school and at home

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TABLE OF CONTENTS

INDEX OF TABLES

INDEX OF FIGURES

ABSTRACT IN ICELANDIC

Markmið: Rannsökuð voru áhrif íhlutandi aðgerða til að bæta fæðuvenjur og auka hreyfingu meðal 7 - 9 ára grunnskólabarna í verkefninu „Lífstíll 7 - 9 á barna“. Í verkefninu „Næring 7 - 9 ára íslenskra barna“ var næringarinntaka 7 ára barna rannsökuð haustið 2006 og næring sömu barna aftur rannsökuð tveimur árum síðar þegar þau voru 9 ára, haustið 2008, í kjölfar margþættra aðgerða til að bæta fæðuvenjur. Niðurstöðurnar sýndu aukna ávaxta- og grænmetisneyslu hjá rannsóknarhópi en minnkaða neyslu hjá viðmiðunarhópi. Markmið þessa meistaraverkefnis var að greina nánar hvar og hvenær „Næring 7 - 9 ára íslenskra barna“ var áhrifaríkust.

Rannsóknarsnið: Margþætt skólaíhlutun sem miðaði að því að auka ávaxta- og grænmetisneyslu 7 - 9 - ára barna, bæði í skólanum og heima. Neyslan var könnuð með þriggja daga veginni skráningu neysluskráningu. Við úrvinnslu þessarar rannsóknar var dögunum skipt í tímabil í eða utan skóla.

Vettvangur: Sex skólar í Reykjavík, valdir af handahófi. Þrír íhlutunarskólar og þrír viðmiðunarskólar.

Viðfang: 7 – 9 - ára skólabörn. 163 börn voru skoðuð með tilliti til upphafsgilda varðandi ávaxta- og grænmetisneyslu haustið 2006. Upphafsgildi og lokagildi ávaxta- og grænmetisneyslu 105 barna haustið 2008 voru borin saman til að rannsaka áhrif íhlutunarinnar.

Niðurstöður: Hlutfallslega mest aukning í ávaxtaneyslu miðað við upphafsgildi, eða 65% (P=0.047), var í morgunnestinu en aukning í grænmetisneyslu dreifðist jafnar yfir daginn. Drengir í íhlutunarhópnum juku ávaxtaneyslu sína um 61 grömm (P=0.001) í morgunnestinu og stúlkurnar í viðmiðunarhópnum lækkuðu meðalneyslu sína um 72 g (P<0.001) í morgunnestinu. Lægsti þriðjungur íhlutunarhópsins jók meðalneyslu sína á ávöxtum og grænmeti á skóladögum um 109 g/dag (<0.001)og sá þriðjungur viðmiðunarhópsins sem neytti mest af ávöxtum og grænmeti við upphaf rannsóknar minnkaði meðalneyslu sína um 256 g/dag.

Ályktun: Aðgerðir í grunnskólum hafa mikil áhrif til aukningar í neyslu og sporna við minnkandi neyslu ávaxta- og grænmetis meðal grunnskólabarna. Mestar breytingar urðu í morgunnestinu við þessa íhlutun.

ABSTRACT

Objective: Multi component school-based dietary interventions have shown considerable effectiveness in increasing fruit and vegetable intake in children. The aim of this study was to further explore when and where the school-based intervention "Nutrition in Icelandic 7 - 9-year-old children" was most effective.

Design: School-based dietary intervention study on fruit and vegetable intake in 7 - 9-year-old children.

Setting: Six randomly selected schools in Reykjavik, Iceland. Three intervention schools and three control schools.

Subjects: 7 - 9-year-old school children. 163 children were studied for baseline values, and 105 for comparison of baseline and follow-up fruit and vegetable intake.

Results: The highest proportional increase, 65% (P=0.047), in fruit intake was in the midmorning-snack but increase in vegetable intake was more evenly distributed. Boys in the intervention group increased their fruit intake by 61 g/day (P=0.001) in the midmorning-snack and the girls in the control group decreased their fruit intake by 72 g/day (P<0.001) in the midmorning-snack. The lowest tertile in the intervention group increased its school-day fruit and vegetable intake by 109 g/day (P<0.001) and the highest tertile in the control group decreased its intake by 256 g/day (P=0.028).

Conclusion: Intervention and/or multi component nutritional education in schools are very effective in sustaining and improving to sustain and improve fruit and vegetable intake in school-children. Most changes in intake from the present intervention are seen in the midmorning-snack.

ACKNOWLEDGEMENTS

1. INTRODUCTION

In childhood, people develop eating habits that influence their choice of food throughout life. People consuming fair amount of fruit and vegetables in childhood are more likely to have healthy eating habits as adults (de Sa & Lock, 2008; Rasmussen et al., 2006; Lytle, Seifert, Greenstein, & McGovern, 2000; Birch & Fisher, 1998). Interventions aimed at children may therefore have a lifelong impact on health behaviour, e.g. eating habits (Klepp et al., 2005; Lien, Lytle, & Klepp, 2001). Children in Iceland consume far too little of fruits and vegetables and actions are needed to increase the general intake of fruits and vegetables (Yngve et al., 2005). Several studies are available on fruit and vegetable intake in the Icelandic population (Kristjansdottir & Thorsdottir, 2009; Gunnarsdottir, Eysteinsdottir, & Thorsdottir, 2008; Thorsdottir & Gunnarsdottir, 2006; Thorsdottir, Gunnarsdottir, Ingolfsdottir, & Palsson, 2006; Yngve et al., 2005; Steingrímsdóttir, Thorgeirsdottir, & Olafsdottir, 2002). In 2006 the intervention study "Lifestyle of 7-9-year-old children" was implemented with the nutritional component "Nutrition in 7-9-year-old school children". The aim of the study was to evaluate the diet of 7-year-old school children and compare it to the food-based dietary guidelines (FBDG) at baseline. Intervention effects were evaluated after two years of intervention. The nutrition intervention was successful in increasing fruit and vegetable intake (Kristjansdottir & Thorsdottir, 2010).

The purpose of this thesis is to further analyse where the intervention had the most impact, whether it was at home, at midmorning-snack at school or lunch at school. It analysed gender disparity and difference in intake according to baseline level of intake.

2. NUTRITIONAL EPIDEMIOLOGY

The best possible scientific evidence in nutrition is obtained with nutritional epidemiological research, especially randomised controlled experimental interventions of sufficient duration in time. These studies support an understanding of the role of nutrition in risk prevention and increased risk of ill health and diseases. Epidemiological studies can be divided into observational or experimental investigations (Margetts & Nelson, 1997).

2.1. Nutritional studies

In observational studies the investigator can exploit difference between persons or groups investigated. He studies the differences between outcome and exposure of groups without interfering with the exposure. The main differences in study design of observational studies are the time when exposure and outcome are measured. In cross-sectional studies, the exposure and outcome are both measured in the present and at the same point in time. Samples in cross-sectional studies should reflect the population characteristics for both exposure and outcome. In case-control studies outcome is measured, or case group selected, by certain outcome of interest and past exposure is ascertained. In cohort studies outcome is ascertained in the future but exposure is measured in the present from groups of people with different levels of exposure (Margetts & Nelson, 1997). Correlation studies look at correlation of mean food intake in large population and prevalence of one or many diseases. It can give strong correlation and point to the causality of diseases. The problem with such correlation studies is that potential determinants of the disease other than the dietary factors can alter the food intake effect. Case-Control and Cohort Studies are often more precise and can avoid many of the weaknesses of correlation studies (W. Willett, 1998).

The strongest evidence for the effect of an exposure on an outcome is, in general, provided with experimental studies. The exposure is assigned to subjects by investigators, but ethical issues of harmful exposure must be considered and that limits the field where experimental studies can be applied. Experimental studies are e.g. clinical trials, field trials and field intervention studies (Margetts & Nelson, 1997). The present study is a school-based intervention study, aiming at increasing fruit and vegetable intake in 7 - 9-year-old children.

2.2. Dietary assessment methods

With clearly defined study aim and the type of study considered it is important to choose the right methods to assess individual diet or diet of a group. Information on dietary habits and intake can be obtained at three levels, food-supply data, data on the household level and individual intake data (Willett, 1998). Selection of method depends on the objectives of each study. Every method has its own strengths and weaknesses and no method is the single ideal one (Biró, Hulshof, Ovesen, & Amorim Cruz, 2002). Food supply data and data on household budget give valuable information on the food available within a country and information on patterns of consumption in subgroups of the population can be obtained. It is not precise on nutritients content of the diet and does not give information on individual level (Margetts & Nelson, 1997). Data on the individual level on the other hand provide information on average food and nutrient intake and their distribution in well-defined group of individuals (Biró et al., 2002). It facilitates estimation of the adequacy of dietary intake and investigates the relationship of diet and health (Willett, 1998). Information on individual dietary intake is mainly obtained in three ways, food frequency questionnaire (FFQ), 24-hours recall, and dietary records (Margetts & Nelson, 1997).

The food frequency questionnaire gives information about the subjects usual frequency of consumption on food items listed in a questionnaire. Quantities of foods eaten and/or nutrient intakes can be estimated with questions regarding portion sizes. FFQ is a useful tool to estimate particular foods or food-items usually eaten and can be used to rank individuals into low or high consumers. The respondents' customary eating pattern is not affected by the questionnaire and the respondent burden is small. The disadvantages of FFQ are that memory of food pattern in the past is required and reporting of intake in the past may be influenced by actual intake. The quality of the data depends partly on the time span the questionnaire refers to. Quantifications of food intake can be inaccurate (Biró et al., 2002).

The 24-hour recall can be written or information obtained by interviews on the previous day's intake. The actual food consumed is described and portion sizes are obtained (Margetts & Nelson, 1997). An interview can be carried out face-to-face or by phone. The method is dependent on well-trained interviewers (Biró et al., 2002). One 24-hour recall per person can characterize the average intake of a group or population but to obtain individual intake a repeated 24-hour recall is needed (Margetts & Nelson, 1997). The advantages of 24 hour recall are that with interviewing, the personal contact contributes to the reliability of the

collected data. The interview is open-ended and the procedure does not alter food intake pattern. The respondent data is relatively small. The disadvantages are that the recall depends on the respondents' memory. It can be difficult to estimate portion sizes accurately and it is important to train the interviewer (Biró et al., 2002).

In the dietary record method, the respondent records all foods and beverages that he consumes, and in addition records the amount by weighing it or estimating it with household utensils. Before data collection, the persons investigated must be trained to adequately describe their diet. The reporting must be done at the time of consumption and a record of 3 days must be randomized in a group to cover weekday and seasonal variations (Biró et al., 2002). The advances of dietary record are that the amount and type of food consumed is fairly accurate and the weighing method is regarded as the "golden standard". It does not rely on memory and it is open ended. The disadvantages are that it requires good cooperation of the respondents to agree to recording and to record intake correctly at the time of consumption, so there is a high participation burden. Habitual eating pattern may change or be influenced by the recording process. The reliability of records decrease over time if diet is recorded for too many days (Biró et al., 2002). In the present study, a three day weighed dietary record was used to assess the children's diet at baseline and follow up.

2.3. Evidence based, best scientific knowledge

It is preferable that the relationship between nutrition and increases or decreases in risk of diseases is established by multiple randomized controlled trials of interventions, and implemented on group that is representative for the population in question. That type of evidence is though not often available (Willett, 1998). The recommended practice in dietary/nutrition aspect should modify the attributable risk of the undesirable exposure in that population. Table 1 gives an example on how evidence can be weighed according to study design. The following criteria were used by the World Health Organisation in their report: Diet, Nutrition and Prevention of chronic diseases, and are based on the criteria used by the World Cancer Research fund.

The study "Lifestyle of 7-9-years-old children" is a school-based intervention study providing important information on how to improve dietary habits in school children. The results will contribute to strengthening the evidence of effectiveness of school-based dietary interventions.

Table 1 - Criteria used to describe the strength of evidence according to WHO (WHO, 2003)

Convincing evidence. Evidence based on epidemiological studies showing consistent associations between exposure and disease, with little or no evidence to the contrary. The available evidence is based on a substantial number of studies including prospective observational studies and where relevant, randomized controlled trials of sufficient size, duration and quality showing consistent effects. The association should be biologically plausible.

Probable evidence. Evidence based on epidemiological studies showing fairly consistent associations between exposure and disease, but where there are perceived shortcomings in the available evidence or some evidence to the contrary, which precludes a more definite judgement. Shortcomings in the evidence may be any of the following: insufficient duration of trials (or studies); insufficient trials (or studies) available; inadequate sample sizes; incomplete follow-up. Laboratory evidence is usually supportive. Again, the association should be biologically plausible.

Possible evidence. Evidence based mainly on findings from case-control and cross-sectional studies. Insufficient randomized controlled trials, observational studies or non-randomized controlled trials are available. Evidence based on non-epidemiological studies, such as clinical and laboratory investigations, is supportive. More trials are required to support the tentative associations, which should also be biologically plausible.

Insufficient evidence. Evidence based on findings of a few studies which are suggestive, but are insufficient to establish an association between exposure and disease. Limited or no evidence is available from randomized controlled trials. More well designed research is required to support the tentative associations.

In the following text these criteria are referred to when strength of evidence is addressed.

3. NUTRITION RECOMMENDATIONS

Before vitamins and minerals were discovered as vital components of the diet, nutrient deficiency diseases were common. In the early days of nutrition recommendations, their main objective was to prevent these deficiency disorders. Classical deficiency symptoms caused by too low intake are now rare in the Nordic countries (Nordic Council of Ministers, 2004). There was a shift in the main focus, in the 1970's, from prevention of deficiency disorders to maintenance of good health and preventing major chronic diseases. The Nordic countries have collaborated for several decades in setting guidelines for recommended intakes of nutrients and dietary composition. The first official Nordic Nutrition Recommendations (NNR) was issued in 1980. In 2004 the 4th edition was issued, and it gives the important basis for various uses in the area of food, nutrition and health policy, for formulation of food-based dietary guidelines and for diet and health-related campaigns (Nordic Council of Ministers, 2004). In Iceland, a Nutrition policy was agreed upon in the Parliament and nutritional goals developed in 1989 (Ministry of Health and Social Security Affairs, 1989). The goals and later the general nutrition advise indicates how healthy diet is composed and a special focus is on the issues where the Icelandic food habits can be improved (The Public Health Institute of Iceland, 2006).

3.1. Nutrient's reference value

The main objectives on nutrient's reference values or recommended daily intake for nutrients is to ensure a diet providing the amount of every essential nutrient in the amount necessary for optimal growth, function, development and health during life. In this context health is defined by low prevalence of diet-related diseases in the population (Nordic Council of Ministers, 2004; WHO, 2003). The reference values are based on evaluation of the average requirement of the population. Considerations of clinical and biochemical deficiency symptoms, body stores, body pool turn-over and tissue levels are included in the establishment of the values along with biological factors e.g. age, sex, height, weight, pregnancy and lactation. Safety margins are also established, which cover individual variation and potential negative effects of high intakes. The recommendations constitute the scientific background for development of food-based dietary guidelines in the Nordic countries (Nordic Council of Ministers, 2004).

3.2. Food based dietary guidelines

The concept "food based dietary guidelines" (FBDG) represents the general nutrition advises expressed at the food level aimed at the general population or specific population groups (FAO/WHO, 1998). The Nordic Nutrition Recommendations (NNR) say that if a diet fulfills the recommendations, the requirement for practically all nutrients will be covered (Nordic Council of Ministers, 2004). The Public Health Institute of Iceland published food-based dietary guidelines, for adults and children from 2 years of age, in the year 2006 (The Public Health Institute of Iceland, 2006). The guidelines are based on the best scientific knowledge and studies on the nutrition of the Icelandic population. By complying to the recommendations people can prevent lack of essential nutrients and keep balance between the nutrients (The Public Health Institute of Iceland, 2006).

3.2.1. Fruits and vegetables

The guidelines for fruit and vegetable intake are "5 portions of fruit and vegetables, corresponding to 500 g per day for adults; children younger than ten years require smaller portions". In the present study this was defined as 400 g of fruit and vegetables or more per day, 200 g fruit and 200 g vegetables. To obtain this amount per day, it is recommended to distribute the intake over various meals and snacks in the day (The Public Health Institute of Iceland, 2006).

4. FRUITS AND VEGETABLES FOR HEALTH

The definition of fruits and vegetables generally include the edible parts of plants. Fruit and vegetable have different nutrient content as groups and differ in the manner they are eaten. Fruit juices are sometimes included in the classification of fruits and vegetables but are clearly different as they lack much of the fibre of the whole fruit and are often sweetened, and thus add to energy density without adding to any protective role (Bazzano, 2005). The nutrient density of fruits and vegetables is in general high while the energy density is low. Fruits and vegetables are a good source of many vitamins and minerals such as folic acid, vitamin C, vitamin E, magnesium and potassium (Lampe, 1999; Nordic Council of Ministers, 2004). Fruits and vegetables are also a good source of dietary fibres, carotenoids and flavonoids as well as other bioacative compounds such as plant-sterols (Lampe, 1999; Nordic Council of Ministers, 2004).

Antioxidants found in various berries, fruits and vegetables, inactivate reactive oxygen and by that, delay or prevent oxidative damage in the body (Bazzano, 2005). Stimulation of the immune system, even antibacterial and antiviral activity, modulation of detoxifying enzymes, antioxidant activity, decrease in platelet aggregation, alteration in cholesterol metabolism, modulation of steroid hormone metabolism and blood pressure reduction have been hypothesized as mechanisms of various intake of fruits and vegetables (Lampe, 1999; Nordic Council of Ministers, 2004). Some of the health effects such as antioxidant activity is still present in many fruit juices though consumption of whole fruits gives much better nutrition (Bazzano, 2005).

Controlled trials with micronutrient supplementation have failed to show an effect on chronic disease risk but whole foods, rich in micronutrients e.g. fruits and vegetables show evidence of decreased risk and reduction of chronic diseases (Woodside, McCall, McGartland, & Young, 2005). These compounds can have complementary and overlapping mechanisms of action and a whole variety of mechanisms have been postulated as potential disease-preventive mechanisms (Lampe, 1999). With higher amount eaten and more variability in fruit and vegetable intake, the health benefits are increased (The Public Health Institute of Iceland, 2006).

5. FRUITS AND VEGETABLES TO PREVENT DESEASES

Ample intake of fruit and vegetables seems to reduce risk of several non-communicable chronic diseases. That includes obesity, diabetes mellitus type 2, some types of cancers, cardiovascular diseases (CVD), (The Public Health Institute of Iceland, 2006; WHO, 2003) and even bone diseases (Tucker, 2009; Hunter, Skinner, & Lister, 2008).

5.1. Overweight and obesity

Fibre increases satiety reduces hunger and can thus decrease energy intake (Bazzano, 2005). High intakes of fibres induce weight loss and fruits and vegetables are good source of fibres (WHO, 2003). A diet rich in fruits and vegetables is likely to be generally healthier than one with low amounts of fruits and vegetables. Unhealthy dietary practices include high consumption of saturated fat, salt and refined carbohydrates, as well as low consumption of fruits and vegetables, and these tend to cluster together (WHO, 2003). Low fruit and vegetable diet is more likely to be energy dense and micronutrient poor and contribute to weight gain.

5.2. Diabetes mellitus – type 2

Overweight and obesity are associated with an increased risk of type 2 diabetes in all societies (WHO, 2003). Dietary fibres seems to have protective effect against type 2 diabetes mellitus, independent of age, BMI, smoking and physical activity (WHO, 2003). Controlled experimental studies with high dietary fibre intake show reduced blood glucose and insulin levels (Mann, 2001). Two randomized controlled trials showed reduced risk of impaired glucose tolerance with diets where intake of wholegrain cereals, vegetables and fruits was the main feature (Knowler et al., 2002; Tuomilehto et al., 2001). Diets rich in fruits and vegetables have direct and indirect protective effect against development of type 2 diabetes mellitus.

Fruits and vegetables e.g. bananas, avocados, spinach and green leafy lettuce are good sources of magnesium (Matís, 2003). Several studies have shown the association of magnesium and diabetes. A meta-analysis showed relationship between low magnesium intake and increased risk of type 2 diabetes (Larsson & Wolk, 2007). It is possible that lack of magnesium is part of the insulin resistant mechanism and therefore alters the amount of glucose the human cell

can take up (Takaya, Higashino, & Kobayashi, 2004). A recent study on critically ill patients with type 2 diabetes admitted at hospitals showed that hypomagnesemia at the time of admission seems to be associated with high mortality (Curiel-Garcia, Rodriguez-Moran, & Guerrero-Romero, 2008).

5.3. Cardiovascular diseases

Fruits and vegetables have been found to reduce the risk of cardiovascular diseases (CVD) through variety of phytonutrients, fibre, potassium, magnesium and folate (Bazzano, Serdula, & Liu, 2003; Lampe, 1999). Plant sterols also help in reducing cholesterol by inhibiting cholesterol absorption (Lampe, 1999).

Antioxidants found in fruits and vegetables can reduce plaque formation in atherosclerosis (Bazzano, 2005). Dietary supplementation with specific antioxidants, when tested with randomized controlled trials, did however not show significant benefit in secondary prevention (Bloom, McDiarmid, & Scoville, 2002).

High levels of dietary fibre intake can significantly lower the prevalence of CVD. Fibres reduce plasma total and LDL cholesterol and there are indications that they can lower blood pressure (J. W. Anderson et al., 2009; Lampe, 1999; WHO, 2003). Water-soluble dietary fibres can help in lowering total and LDL cholesterol. Even though this lowering effect is modest it might help in reducing the risk of CVD. Fibre can decrease the insulinemic response to dietary carbohydrates. Experimental studies have revealed that higher levels of insulin might promote dyslipidemia, hypertension, abnormalities in blood-clotting factors, and atherosclerosis (Bazzano, 2005). Observational studies have shown that diet rich in fibre may have moderate lowering effect on blood pressure (He, Streiffer, Muntner, Krousel-Wood, & Whelton, 2004).

The potassium content in various fresh fruits and vegetables e.g. avocado, bananas, prunes, bell peppers and tomatoes (Matís, 2003) may play an important role in lowering the incidence and mortality of CVD (Bazzano, 2005). Dietary intake of potassium is protective against stroke and cardiac arrhythmias (Bazzano, 2005; Lampe, 1999). Inverse association between dietary intake of potassium and blood pressure within and across populations have been found in epidemiological studies and randomized controlled trials have shown that supplementation

with potassium lowers blood pressure. Elevated blood pressure has also been observed when dietary potassium intake was low (Bazzano, 2005).

Dietary and serum concentration of folate has shown an inverse association with mortality from CVD. Folic acid along with vitamin B12 is important for the metabolism of homocystein (Bazzano, 2005). Homocystein concentration has been related to increased CVD risk but intake of dietary folate has shown inverse association with plasma homocysteine (Selhub, 1999). Vegetables rich in folate are e.g. lentils and black eyed peas, spinach and other dark green lettuce, asparagus and broccoli (Insel, Turner, & Ross, 2007).

Even though each component in fruit and vegetable discussed above has its role to prevent CVD it is probably their combined effects that give the best result in risk decrease. It is therefore important to consume whole fruits and vegetables rather than specific nutrients or supplements. A study where the same population was examined for fruit and vegetable intake, cancer and CVD, the incidence of coronary heart diseases and stroke was 30% lower for those who consumed five or more servings per day compared to those who ate less than 1.5 servings per day, but no association was seen for cancer (Hung et al., 2004). So the value of fruits and vegetables in disease prevention lies more with CVD than cancer, but still contributes to both at the same time.

5.4. Cancer

Fruits and vegetables have shown probable evidence in decreased risk of cancer development in oral cavity, oesophagus, stomach and colorectum (Wold Health Organisation (WHO)/ AICR, 2007).

Folate-containing foods probably protect against pancreatic cancer and limited evidence suggests that they also protect against oesophageal and colorectal cancer. Foods containing carotenoids have probable protecting effects against cancers in the mouth, pharynx and larynx and also lung cancer (WHO/AICR, 2007). Thereof, beta-carotene probably protects against oesophageal cancer and lycopene containing foods probably protect against prostate cancer. C-vitamin containing food probably protect against oesophageal cancer (WHO, 2003; WHO/American Institute for Cancer Research *(*AICR), 2007). These compounds can also have overlapping and complementary mechanisms of action (Lampe, 1999).

Non starchy vegetables can probably decrease the risk of cancer in mouth, pharynx and larynx, oesophagus and stomach. There is also limited suggestive evidence of decreased risk of cancer in nasopharynx, lung, colorectum, ovary and endometrium with intake of non-starchy vegetables (WHO/AICR, 2007). Allium vegetables have probably protective effects against stomach cancer and garlic probably protects against colorectal cancer. Mouth, pharynx and larynx may probably be protected with general fruit consumption as well as cancer in the oesophagus, lung and stomach. Limited evidence suggests that fruit consumption protect against cancers of the nasopharynx, pancreas, liver and colorectum (WHO/AICR, 2007).

New publication from the European Prospective Investigation Into Cancer and Nutrition (EPIC) shows less effect of fruit and vegetable intake on cancer risk than described in former studies (Boffetta et al., 2010). The reason might be that older studies where often case-control studies which showed strong correlation of fruit intake and reduced cancer risk. Prospective studies have stronger research value (Willett, 2010). But even though the reduced risk of all cancers, adjusted for co-variants, is only 4%, it is still contributing to preventing measures. It could be questioned if it is correct to evaluate the effect on all cancers, as it was previously known that fruits and vegetables have protective effect against specific cancer types. It might also be discussed if an indirect effect on f. ex. body mass index should be added to the independent association.

5.5. Bone health

Intake of fruits and vegetables is important for bone health trough their good source of several nutrients including magnesium, potassium, vitamin C, vitamin K, several B vitamins and carotenoids. These nutrients have been shown to be more important to bone health than was previously known (Tucker, 2009).

6. FRUIT AND VEGETABLE INTAKE IN EUROPEAN AND ICELANDIC CHILDREN

A pan-European cross-sectional study performed in 9 countries showed that 11-year-old children consume far less than the recommended amount of fruit and vegetables. The mean intake of fruits and vegetables was according to 24-hour recall 141 g/day and 86 g/day respectively over the 9 countries and the intake was lowest among Icelandic children, i.e. 90 g/day and 54 g/day respectively (Yngve et al., 2005). Several studies are available on fruit and vegetable intake in the Icelandic population (Kristjansdottir & Thorsdottir, 2009; Gunnarsdottir et al., 2008; Thorsdottir & Gunnarsdottir, 2006; Thorsdottir et al., 2006; Yngve et al., 2005; Steingrimsdottir et al., 2002). The average intake of fruit is shown in Figure 1 and intake of vegetables in Figure 2. In all these studies, fruit and vegetable intake was far from reaching the recommended intake of 200 g fruits and 200 g vegetables per day. Fruit intake was in all studies less than 150 g/day and vegetable intake most often below 50 g/day. Actions to increase fruit and vegetable intake are needed.
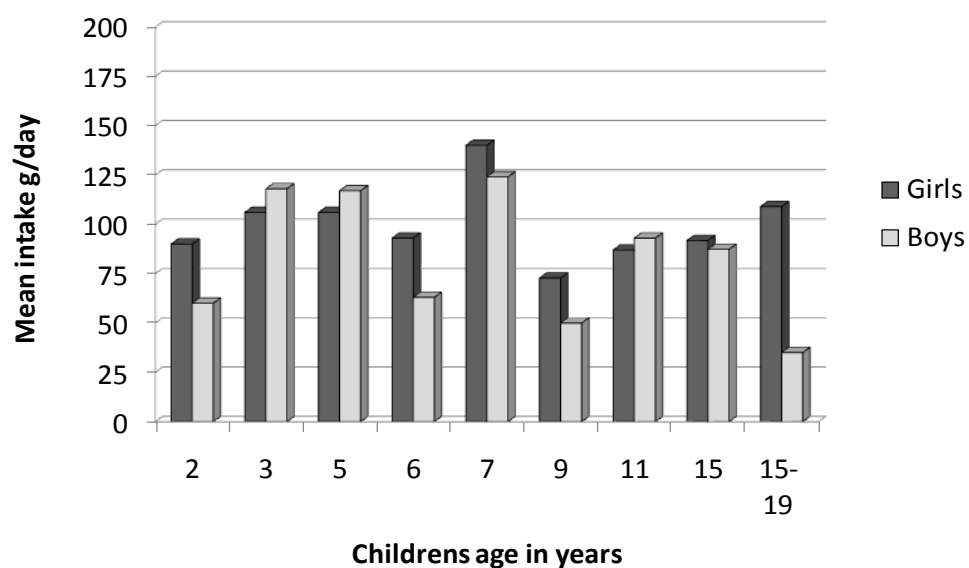
Figure 1 - Fruit intake in Icelandic children and adolescents
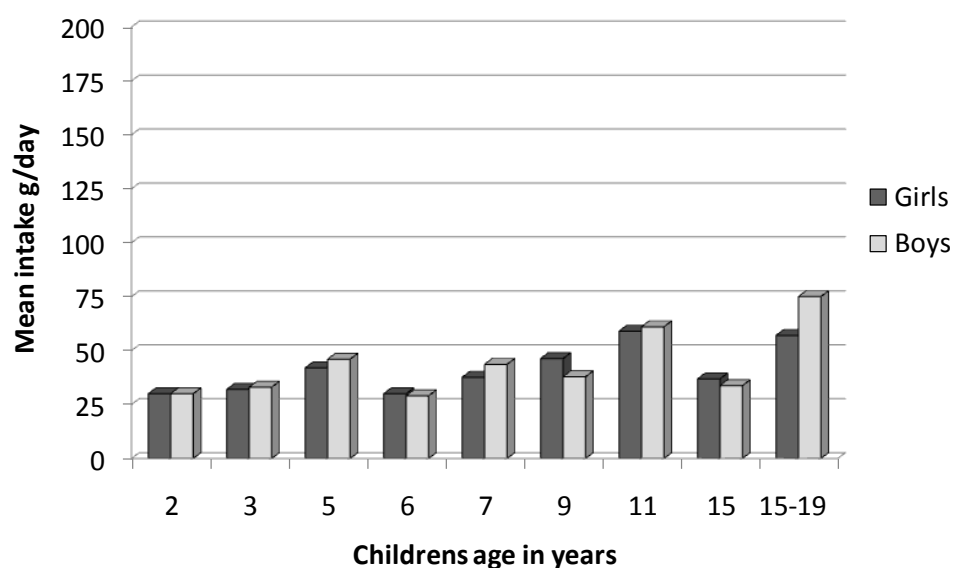
Figure 2 - Vegetable intake in Icelandic children and adolescents

Age	Study	Assessment method
2	(Gunnarsson, 2000)	3 day weighed dietary records
3 and 5	(Gunnarsdottir, Eysteinsdottir, & Thorsdottir, 2008)	3 day assessed dietary records
6	(Thorsdottir, Gunnarsdottir, Ingolfsdottir, & Palsson, 2006)	3 day weighed dietary records, FFQ
7	(Kristjansdottir & Thorsdottir, 2009)	3 day weighed dietary records
11	(Yngve et al., 2005)	1 x 24 hour recall questionary, (FFQ)
9 and 15	(Thorsdottir & Gunnarsdottir, 2006)	2 x 24 hour recall interview
15-19	(Steingrímsdóttir, Thorgeirsdottir, & Olafsdottir, 2002)	1 x 24 hour real, FFQ

7. SCHOOL-BASED FRUIT AND VEGETABLE INTERVENTIONS

In Table 2 an overview is given on different dietary intervention to improve dietary habits among children. It is mainly based on a review by de Sa (2008), with added information from other relevant reviews and studies (Van Cauwenberghe, 2010; de Sa, 2008; Knai, 2006)

The main findings from 31 school-based dietary intervention studies, 16 from Europe, 14 from USA and one from New Zealand, are presented in Table 2. The studies are different in intervention components and results. Van Cauwenberghe (2010) reviewed studies on school-based interventions in Europe to promote healthy nutrition, not only fruit and vegetables. The review assesses intervention success and appraises the methodological rigour of the studies. Non-successful intervention include internet-based studies providing educational material (Haerens, 2007; Mangunkusumo, 2007) and increased availability of fruits and vegetables as a sole intervention component that did not prove to be successful in the long term (Fogarty et al., 2007; Ransley et al., 2007). The most successful school-based interventions in Europe have been multi-component (Van Cauwenberghe et al., 2010; Knai, Pomerleau, Lock, & McKee, 2006), that is using several methods at once to get children to eat more fruits and vegetables. One of these interventions is the Pro Children study which has strong study quality (Van Cauwenberghe et al., 2010) and has shown good and sustained effect on increasing fruit and vegetable intake among school children (Te Velde et al., 2008; Wind et al., 2008; Perez-Rodrigo et al., 2005). At first, a cross-European study aiming at assessing fruit and vegetable consumption among 11-year old school children and their parents was conducted (Wolf et al., 2005; Yngve et al., 2005) and potential determinants at the individual, social and environmental level were assessed (Rasmussen et al., 2006 Klepp et al., 2005). Iceland was one of the nine European countries participating in this part of the study (Kristjansdottir, De Bourdeaudhuij, Klepp, & Thorsdottir, 2009) but did not participate in the intervention at that time.

8. THE PRO CHILDREN INTERVENTION

An Intervention Mapping protocol was used to develop the Pro Children intervention. Promotion of fruit- and vegetable intake was split into performance objectives and related personal, social and environmental determinants (Perez-Rodrigo et al., 2005). Awareness of one's own intake and recommended intake levels, skills and self-efficacy for asking for, keeping and preparing fruit and vegetable, attitude, outcome expectation, self evaluation and fruit and vegetable taste preferences are personal determinants. Peer influence, parental influence and social support are considered determinants on the social level and availability and accessibility at home and at school in addition to social support are determinants considered on environmental level (Rasmussen et al., 2006; Perez-Rodrigo et al., 2005; Wind, Bobelijn, De Bourdeaudhuij, Klepp, & Brug, 2005).

Individual and environmental factors predict fruit and vegetable consumption in children, with taste preferences and availability as possibly the most important determinants. Preparation-skills, ability to ask for fruit and vegetables and awareness of own consumption are also relevant (Perez-Rodrigo et al., 2005). Parents are in many ways important mediators in their children's diet. They are for example in charge of what is bought and prepared for the kids. They also play an important part in the children's lives as role models in influencing eating behaviour. Parents can effectively be reached through their children (Klepp et al., 2005; Perez-Rodrigo et al., 2005).

Multi component interventions should include school-based education aimed at the determinant of children's behaviour, changes in the school environment and parental involvement (Wind et al., 2008). Effective components of nutrition interventions are according to Sahay et al. (2006) theoretical based, involve the family, have clear messages and provide adequate support and training for those implementing the intervention. Schools provide optimal settings for implementing health promotion intervention such as promoting healthy eating habits and fruit and vegetable consumption (Krolner et al., 2009; Perez-Rodrigo et al., 2005).

When the development of the Pro Children project was starting, no intervention aiming at increasing fruit and vegetable intake in the Icelandic population had been done. The project "Everything affects us, especially ourselves!", which is a community based intervention, was started in the year 2004 (Heimisdottir & Gylfason, 2008).

9. NUTRITION IN ICELANDIC 7-9-YEAR-OLD SCHOOL CHILDREN

The study "Nutrition in Icelandic 7-9-year-old school children" was developed following the Pro Children study. It was based on the Pro Children project and was the first school-based intervention in Iceland aiming at improving the childrens diet and increasing fruit and vegetable intake. It was a part of the intervention study "Lifestyle of 7-9-year-old Icelanders" (Kristjansdottir, 2009).

The aim of the "Lifestyle of 7-9-year-old Icelanders" study was to further integrate physical activity into the school routine and to find ways to promote healthy food habits. The main focus of the dietary part of the intervention was on increasing fruit and vegetable intake (Kristjansdottir & Thorsdottir, 2010).

The intervention component was based on determinants of food intake, especially determinants of fruit and vegetable intake (Brug, Tak, te Velde, Bere, & de Bourdeaudhuij, 2008; De Bourdeaudhuij et al., 2008; Kristjansdottir et al., 2006; Rasmussen et al., 2006; Perez-Rodrigo et al., 2005; Bere & Klepp, 2004; Wardle, Herrera, Cooke, & Gibson, 2003; Wind et al., 2005) and on former findings of effective school based interventions (Knai et al., 2006; Sahay et al., 2006; Bere & Klepp, 2005; Perez-Rodrigo et al., 2005).

Table 2 - Selected educational strategies related to learning objective and determinants of fruit and vegetable intake used in the present intervention (Kristjansdottir, 2010)

Learning objective	Activity	Determinants						skills	
		availability	knowledge	awareness	preference/taste	peer influence	parental influence	prepare	ask/obtain
Children are aware of the importance of fruit and vegetable intake for health and well-being	Education workbook-guided activities		x						
Children know recommendation s	Education workbook-guided activities		x						
Children are aware of their own intake and recommendations	Home worksheet- The recommendation children marked on a graph how often they ate fruits and vegetable each day for one week.		x	x			x		
Children eat fruits together at school and are exposed to different fruits and vegetables	Children brought fruits and vegetables to school and ate in class					x	x		x
	School meals	x				x			
Children taste "new" fruits and vegetables	Home worksheet-children listed which fruits and vegetables they had tasted and tested something "new"				x		x		
Children know how to prepare fruits and vegetables	Home worksheet-children prepared fruit and vegetable salad at home and brought the recipe of their favourite salad to school; the recipes were then put on the homepage of the study						x	x	
	In school, home economics -children prepared a dinner party, with different kinds of fruits and vegetables, for their parents (one school) -children prepared fruit and vegetable in school for their classmate (one school)					x	x	x	
Parents know recommendations	Letters to parents with information on the recommendations and the determinants of fruit and vegetable intake, such as availability, eating fruits and vegetables together and family rules.	x					x		

Children in second grade in six randomly selected schools in Reykjavík participated in the baseline study in the autumn of 2006. Baseline data were collected from September to November 2006 and follow-up data collected in the autumn 2008. Data were collected at each school for two weeks and in the same sequence of schools in both years. Written consent of both parent and child was secured before measurements at baseline and follow-up.

Autumn 2006   Autumn 2008

Baseline   Follow-up
measurements   measurements
                         School-based intervention
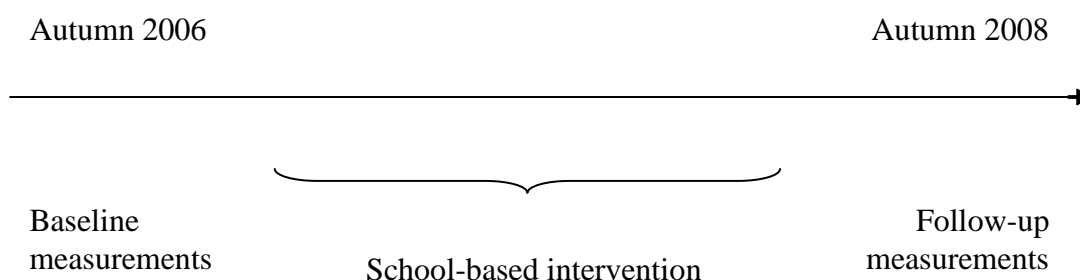
Figure 3 - Design of the study. Baseline measurements were performed in the autumn of 2006, when the children were starting in second grade. The intervention started in the middle of second grade and the follow-up measurements were performed in the end of the intervention in autumn 2008 (Kristjansdottir & Thorsdottir, 2010).

The diet was assessed with 3-day weighed dietary record, including two weekdays and one weekend day. After exclusion of incomplete records and underreports, the diet of 165 children were studied at baseline and 130 children were studied at follow-up. Thereof 106 children were included in the data analysis at both times and were used for analysis of the intervention study (Kristjansdottir & Thorsdottir, 2010). In the present study, the criteria that the child had to attend school on weekdays was added and that decreased the number of analysed participants to 163 at baseline and 105 in analysis of the intervention study. Two children at baseline and one child at follow-up did not attend school during the food recording and were therefore excluded from the present analysis.

The intervention was effective in increasing fruit and vegetable intake by 47% from baseline in the intervention schools but the control schools decreased their intake by 27% (Kristjansdottir & Thorsdottir, 2010). To further analyse the intervention effect and see where the intervention has most impact it is necessary to divide the three days dietary records into meals and places of consumption and to analyse who is in charge of the childs intake at that time. With that knowledge it is possible to see where the opportunities to improve fruit and vegetable intake even further might be. This knowledge can be used in future interventions in Icelandic schools.

10. THE PRESENT THESIS – FURTHER ANALYSIS OF INTERVENTION EFFECTS

The aim of the present thesis was to further explore the increase and decrease in fruit and vegetable intake in the "Nutrition of 7-9-year-old children" study.

The aim was to answer the following questions:

- Did the increase seen in fruit and vegetable intake, take place at the midmorning-snack in school, at lunch at school or at home?
- Where there any gender differences associated with the intervention effects?
- Where the intervention effects similar between different consumption groups, i.e. highest, medium and lowest at baseline?

The results of the analysis are presented in the enclosed manuscript.

Table 3 – Dietary interventions on children and adolescents (based on a review by de Sa, 2008).

Study	EU/USA	Age	Design	Participants	Data collection	Intervention	Results
Food Dudes, Ireland (Horne et al., 2009)	EU Ireland	4-11	Randomized controlled trial Follow-up: 1 year	2 experimental schools, 1 control 435 children	Observation, weighed measures	16 day intervention featuring video, rewards, letters from FD home packs and help with maintenance period Control: free FV	At 12 month follow-up children in experimental school were provided with and consumed significantly more lunchbox FV
Pro children study Norway, Netherlands, Spain (Te Velde et al., 2008)	EU Norway Netherland Spain	10-11	Cluster randomized controlled trial Follow-up: 2 years	n = 2106 students 62 schools in three European counties	Pro children questionnaires	Classroom curriculum Parental involvement Free FV during intervention Control: normal curriculum, FV dependent on country	Short-term increases in FV consumption, 20% ~20 g/d and preferences Long-term only in Norway
Pro children based Schoolgruiten', Netherlands (Tak, Te Velde, & Brug, 2007) (Tak, Te Velde, & Brug, 2008)	EU Netherlands	9-11	Non-randomized controlled trial Follow-up: 1 year	565 children of Dutch ethnicity 388 children of non-Western ethnicity mean age 9.9 years at baseline	Validated pro children questionnaires Questions on intake and determinants Children and parents completed questionnaires	(i) Availability and accessibility of FV at school Free FV twice a week at morning break (ii) Inc exposure to FV (iii) School curriculum changes Control: no exposure	Children of non-western ethnicity in intervention group reported significantly higher veg intake (+20.7 g day CI 7.6–33.7). Dutch children 0.23 F pieces per day (CI 0.07–0.39) No significant effects based on parent reports
Belgium West-Flemish (Haerens et al., 2007)	EU Belgian	11-15 7-8th grade	Cluster randomized controlled trial Follow-up: 2 years	5 schools intervention with support 5 schools intervention no support 5 schools control ~2840 pupils	Food frequency questionnaires 1 subset completed assessments of physical activity	School staff Increasing fruit to 2 pieces per day decreasing soft drinks, decreasing fat intake Environmental change focus with tailored computer feedback. Parental involvement. Control: no intervention	No statistically significant difference in fruit intake. Statistically significant decrease fat intake in girls. Increase in physical activity at year 2 for both sexes
Netherlands (Mangunkusumo, Brug, de Koning, van der Lei, & Raat, 2007)	EU Netherlands	9-12	Randomized controlled trial Follow-up: 3 months	30 7th grade classes 16 intervention 14 control Total of 675 children	Internet-administered questionnaire	School based intervention Combination of internet tailored advice for children followed by internet-supported brief dietary counselling by the nurse in the presence of at least one parent Control: no internet advice	FV intake did not differ significantly between intervention and control However knowledge was significantly different in treatment group

National school fruit scheme (NSFS), England (Fogarty et al., 2007)	EU UK	4-8	Non-randomized controlled study of National school fruit scheme (NSFS) implemented in different regions of country over 2 years Follow-up: 3 years	Random sample of 113 schools in East Midlands (intervention) and 122 schools in Eastern region (control) Students: 2003–10 470 2004–10 104 2005–8386	Fruit intake questionnaire completed by parents for 3 consecutive years, before and after participation	Intervention region: Free piece of school fruit every day for 4- to 6-year-old children (2002–04). In Western region NSFS implemented June 2003. Control (eastern region): 'no fruit' as NSFS implemented later (September 2004) and study controls then too old to qualify for participation in NSFS	May 2004 proportion eating F every day in intervention was markedly higher +11% (95% CI +7.4 to 14.6) But in May 2005 proportion fell to less than the control region (2.8%)
UK School Fruit and Vegetable Scheme (Ransley et al., 2007)	EU UK	4-6	Non-randomized controlled trial Follow-up: 2 years	Infant and primary schools in N-England 3703 children aged 4–6 years.	CADET (child and diet evaluation tool)	1 portion of F or V provided per child on each school day between February and December 2004 Control: no fruit	Increased FV intake across reception and year 1 of 0.5 portions (95% CI 0.3–0.7) and 0.7 portions (CI 0.3–1.0) at 3 months which fell to 0.2 at 7 months in reception and 0.2 in year 1 Impact on year 2 inc FV intake of 0.5 portions (0.2–0.9) 3 months fell to 0.2 at 7 months. (no longer eligible for free FV) No long term impact on V intake
Norwegian School Fruit Programme (Bere & Klepp, 2005; Bere, Veierod, Skare, & Klepp, 2007)	EU Norway	11-13	Cluster randomized controlled trial Follow-up: 3 years	9 schools—free fruit 9 schools—paid 20 schools no fruit Total: 1950 students	Survey Questionnaire	Initially free subscription to scheme then paid (E0.30) Control: nosubscription scheme	Free fruit—sustained effects on FV intake 3 years after intervention. Increased by 30–35 g/day
Norwegian School Fruit Programme Fruit and Vegetables Make the Marks (Bere et al., 2007)	EU Norway Hallway+	11-13	Cluster randomized controlled trial Follow–up: 1 year	9 intervention schools 10 control schools 369 pupils age 11.3 at baseline	Survey questionnaire 24 h FV recall parental questionnaire Food frequency questionnaire	Pupils receive free piece of F/carrot each day. Free fruit and educational programme	FV all day and at school 0.6 portions higher in intervention Sustained in 2nd year (no longer had free fruit or education)
Norwegian School Fruit Programme Fruit and Vegetables Make the Marks (Bere, Veierod, Bjelland, & Klepp, 2006)	EU Norway Telemark	11-13		9 intervention schools 10 control schools 369 pupils age 11.3 at baseline	Survey questionnaire 24 h FV recall parental questionnaire Food frequency questionnaire	Classroom component Parental involvement School Fruit Programme	No effect

Study	Region/Country	Age	Design	Sample	Assessment	Intervention	Outcome
Bash Street kids intervention (A. S. Anderson et al., 2005)	EU Scotland	6-7 and 10-11	Cluster randomized controlled trial. Follow up: 10 months	2 int schools 2 cont schools	Age appropriate assessments Food diaries Interviews	Increased provision of FV in schools (tuck shops and school lunches) Tasting opportunities Pont-of-purchase marketing Newsletters for parents Curriculum materials Control: no exposure	Intervention children tasted more FV over time (P < 0.001)22.4/32 to 27 no of foods tasted Also tasted several FV that had not been tasted at baseline. Weight of fruit intake increased in both groups. Intervention (+50 g) P = 0.042 Control (+7 g)
Pilot National School Fruit scheme (NSFS)(Wells & Nelson, 2005)	EU UK	4-6	Non randomized controlled trial Follow-up: 8 months	17 schools in low-income areas 8 NSFS 9 control n = 4192 students	24 h ticklisht And food frequency questionnaires	Free piece of school fruit for CHILDREN aged 4–6 in NSFS pilot schools every day Control: no fruit	Infants receiving free fruit statistically significant 50 g1day higher consumption (117g1d vs 67g1d excluding juices)
Food Dudes, UK (Horne et al., 2004)	EU UK	5-7	Non-randomized controlled trial Follow-up: 4 months	2 inner city London Primary Schools 794 Children 5 to 11-year old.	Observation Home using parental 24 h recall, plus subset of parents interviewed (paid £35)	16 day Ix: 6x 6min episodes of video, home packs, rewards for eating FV at snack and lunch some maintenance ix Control: received free FV	Significant higher increases in FV intake at snack time, lunchtime and at home in intervention group
'Be Smart', UK (Warren, Henry, Lightowler, Bradshaw, & Perwaiz, 2003)	EU UK	5-7	Randomized controlled trial Follow-up: 14 months	Children recruited from 3 primary schools in oxford, aged 5–7 years n = 213	Anthropometry Nutrition knowledge Dietary assessment by parents—24 h recall, food frequency questionnaire	1 control group, 3 intervention groups nutrition groups, physical activity group, combined nutrition and physical activity group	Significant improvements in nutrition knowledge were seen in all children (P < 0.01) Overall FV intake increased significantly P < 0.01 and P < 0.05
APPLES: Active programme promoting lifestyles in schools, UK (Sahota et al., 2001)	EU UK	7-11	Randomized controlled trial Follow-up: 1 year	10 primary schools in Leeds 634 children aged 7–11 years	24 h recall 3 day food diary growth measures	Teacher training, school meal changes, curriculum development, physical education, tuck shops Control: no intervention	Intervention children had increased intake of vegetables by~ +0.3 servings per day but no change in F intake
Nutrition education at primary school (NEAPS),Ireland (Friel, Kelleher, Campbell, & Nolan, 1999)	EU Ireland	8-10	Non-randomized controlled trial Follow-up: 3 months	821 children aged 8–10 years from 8 intervention and 3 control schools in urban and rural areas 453 intervention 368 control	5 day food diary also assessed knowledge and preferences	20 sessions over 10 weeks including worksheets, homework and exercise regime; parent involvement Control: no exposure	More intervention children consumed 4 or more FV per day intervention group demonstrated significant changes in reported behaviour and food preferences overall (P < 0.01)

23

APPLE program, New Zealand (Taylor et al., 2007)	New Zealand	5-12	Non-randomized controlled trial Follow-up: 2 years (FV only 1 year)	730 children aged 5–12 years 4 intervention schools 3 control schools	Measurements of height, weight, waist circumference, blood pressure, physical activity. Diet by validated short food questionnaire	(i) Community activity co-ordinators (ii) Teacher resources, cooled water filters (iii) Science lessons, healthy eating resource, interactivity	BMI significantly lower in intervention children (due to differences in relative weight) Fruit intake increased by 0.8 servings in intervention children (P < 0.01)
5 a day power play! Campaign, USA (de Sa & Lock, 2008; Foerster et al., 1998)	USA	9-10	Non-randomized controlled trial Follow-up: 1 school year	49 schools 151 classrooms (4th and 5th grade) 2684 cases established 15 schools control T1 19 schools T2 15 schools	California Children's Food Survey – 24 h recall self-reported food diary	T1 – power play! Activities conducted only in school. School Idea and Resource Kit T2 – power play! Activities in schools, community youth organisations, farmers' markets, supermarkets, mass media	Both intervention sites reported significant increases in self-reported FV intake compared with control site but not with each other. Increases highest for T2 (0.4 serving, from 2.9 to 3.3) compared with 0.2 serving (from 2.7 to 2.9 in T1).
School Garden project, USA (McAleese & Rankin, 2007)	USA	12	Non-randomized controlled trial Follow-up: 12 weeks	6th grade students at 3 elementary schools. 99 students	3x24 h recalls	1 group—control 1 group—nutrition education 1 group—nutrition education plus gardening activities	Gardening students increased FV servings more than others. Combined FV intake inc to 4.5 servings per day from 1.93
Paradis et al., USA (Paradis et al., 2005)	USA Canada	?	Non-randomized controlled trial Follow-up: 8 years	N= 458 in 1994 N= 420 in 2002 2 community elementary schools	7 day food FFQ Anthropometric measurements Physical activity questionnaire	Health education curriculum involving diet and physical activity (designed for diabetes prevention) delivered in grades 1–6 in community's 2 elementary schools. Community activities School nutrition policy Control: no exposure	Some early positive effects on skin fold thickness but not BMI, physical activity, fitness or diet. Key high-fat and high-sugar foods consumption decreased
Kids Choice school lunch program, USA (Hendy, Williams, & Camise, 2005)	USA	6-10	Randomized controlled trial Follow-up: 7 months	346 children 1st, 2nd and 4th grades	Observed FV intake Interviews with children	All children given same FV at lunch (2 choices F and V) Intervention: half classrooms randomly assigned to receive token reinforcement for fruit or vegetable consumption if they ate at least 1/8 cup of assigned food group Control: no reward	Intake increased during Ix but not measured after Preferences increased for range FV 2 weeks after but returned to baseline at 7 months (greater fruits than veg)

5 a day cafeteria power plus, USA (Perry et al., 2004)	USA	6-8	Randomized controlled trial Follow-up: 2 years	1668 students in 1st and 3rd grades form 26 elementary schools	Observations by trained staff	School food service involvement, daily activities and special FV events Control: no exposure	Significant increase of FV intake (P = 0.02) verbal encouragement by lunch staff significantly associated with higher intakes. Difference ~+0.3 servings per day
TEENS study, USA (Lytle et al., 2004)	USA Minnesota	12	Randomized controlled trial Follow-up: 2 years	16 schools with at least 20% of students approved for free and reduced price lunch. ~3600 students	Behavioural risk factor surveillance 24 h recall	4 groups Group 1: control Group 2: school environment interventions only Group 3: as 2 but with classroom lessons	Significant increase in intervention group 4 with peer leaders (+0.9 servings per day, P = 0.012) at interim evaluation but no significant effect at 2 year follow-up.
Gimme 5, USA (O'Neil & Nicklas, 2002)	USA	14	Randomized controlled trial (schools) Follow-up: 3 years	9th grade students in 12 schools (6 matched pairs) 2213 students	Knowledge, Attitudes and Practice questionnaire	Gimme 5 measurement questionnaire + intervention - school wide media campaign, classroom activities, school meal modification, parental involvement Control: measurements without intervention	No difference at follow-up. Initially reported consumption of FV servings was significantly higher in intervention schools but not sustained.
Gimme 5, USA (Baranowski et al., 2000)	USA	9-10	Randomized controlled trial Follow-up: 3 years	1253 children in 4th and 5th grade from 16 elementary schools	7 day food record Process evaluation	12 sessions over 6 weeks including handouts, posters, worksheets, newsletters, videos, point of purchase education at shops. Control: no exposure	Lower decrease in intervention vs control group: net effect of +0.3 servings per day
High 5, USA (Reynolds et al., 2000)	USA	10	Randomized controlled trial (matched pair design) Follow-up: 2 years	28 elementary schools pair-matched 1698 children 4th graders	(1) 24 h recall (2) Cafeteria observations (3) Parents—food frequency questionnaire	14 lesson curriculum delivered on 3 consecutive days each week. Components: classroom, parent, food service. Control: no intervention	Intervention group had higher intakes of FV at 2 years ~0.99 servings per day (P < 0.0001) Differences in psychosocial variables

Intergrated Nutrition Project (INP) (Auld, Romaniello, Heimendinger, Hambidge, & Hambidge, 1998)	USA	6-11	Non-randomized controlled trial Follow-up: 4 years	1250 children in 3 Denver schools only reports on year 3 and 4	(1) Plate waste assessment (2) Food recall/record (3) Classroom survey on knowledge and attitudes to FV (4) 5 min interview with kindergarten kids about knowledge of FV	(1) 24 weekly classes that included food preparation and eating. Taught by special resource teacher (2) Teacher training (3) Parent education (4) Community nutrition/food resource development control: no exposure	Treatment students consumed significantly more FV than comparison students: 0.19 more F serving, 0.25 more V servings and 0.4 FV servings in total. Treatment children demonstrated higher levels of knowledge
Planet Health USA (Gortmaker, Peterson et al., 1999)	USA	12-14	Randomized controlled trial Follow-up: 2 years	5 intervention and 5 control schools 1295 ethnically diverse grade 6 and 7 students	Food frequency questionnaires (also measured obesity, TV viewing hours)	School based interdisciplinary intervention. Teacher training, classroom lessons, physical activity, wellness sessions Control: usual curriculum	Higher increase in intervention group +0.32 servings per day (P = 0.003) but only in girls
Eat Well and Keep Moving, USA (Gortmaker, Cheung et al., 1999)	USA	9-10	Non randomized controlled trial Follow-up: 2 years	6 intervention schools, 8 matched schools for control 470 students initially 4th and 5th graders	Student food and activity survey and 24 h recall and youth food frequency questionnaire	Classroom based. Food school service and family involved Control: no exposure	Increase in the consumption of FV (0.36 servings 4184 KJ 95% CI 0.1–0.62 P = 0.01) = ~0.73 servings per day
5 a day power plus (C. L. Perry et al., 1998)	USA	9	Randomized controlled trial Follow-up:10 months	Children in 4th grade from 20 ethnically, culturally and economically diverse schools (10 matched pairs) N= 1750 initially	Health behaviour questionnaire forall; self-completed 24 h foodrecord for random sample; lunchroom observation	(1) Behavioural curricula (2) Parental involvement (3) School food service changes (4) Industry support Control: no exposure	Intervention students had a higher mean intake of FV than control. Difference was 0.4 servings per day at follow-up
CATCH study, USA (Cheryl L. Perry et al., 1998)	USA	8-11	Randomized controlled trial Follow-up: 3 years	5106 students initially of which subset of 1186 students were followed	24 h recalls at baseline and follow-up; 30 min face to face interviews also	Modifications in school food service, physical education, classroom curricula and parental involvement Control: no exposure	No difference at follow-up

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EFFECTS OF A SCHOOL-BASED INTERVENTION ON FRUIT AND VEGETABLE INTAKE AT SCHOOL AND AT HOME

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Abstract

Objective: To further explore the effects of the school-based intervention "Nutrition in Icelandic 7 – 9 - year-old children" on fruit and vegetable intake in the midmorning-break, in the school-lunch and at home. Gender difference was explored and the effects on those children with lowest levels of fruit and vegetable intake, at baseline, versus those with the highest level.

Design: School-based dietary intervention study on fruit and vegetable intake in 7 – 9 -year-old children, assessed with three-day weighed dietary records.

Setting: Six randomly selected schools in Reykjavik, Iceland. Three intervention schools and three control schools.

Subjects: 7 – 9 -year-old school children. 163 children were studied for baseline values, and 105 for comparison of baseline and follow-up fruit and vegetable intake.

Results: The highest proportional increase, 65% (P=0.047), in fruit intake was in the midmorning-snack but increase in vegetable intake was more evenly distributed. Boys in the intervention group increased their fruit intake by 61 g/day (P=0.001) in the midmorning-snack and the girls in the control group decreased their fruit intake by 72 g/day (P<0.001) in the midmorning-snack. The lowest tertile in the intervention group increased its schoolday fruit and vegetable intake by 109 g/day (P<0.001) and the highest tertile in the control group decreased its intake by 256 g/day (P=0.028).

Conclusion: Intervention and/or multi component nutritional education in schools are very effective in sustaining and improving fruit and vegetable intake in school-children. Most changes in intake from the present intervention are seen in the midmorning-snack.

Key words: school-based interventions, children, food-based dietary guidelines, fruits and vegetables

Introduction

Intake of fruits and vegetables is important in preventing severe public health problems, e.g. cancers, cardiovascular diseases and obesity[1,2]. These known health benefits are the main ground for the recommended intake of at least 400g of fruit and vegetables per day[2]. The Icelandic Public Health Institute recommends 500 g/day, thereof at least 200g fruits and 200g vegetables[3]. In northern Europe, large population groups seem to eat far less fruit and vegetables than recommended[4,5]. A pan-European cross-sectional study performed in 9 countries showed that 11 year old children consume far less than the recommended amount of fruit and vegetables and the intake was lowest among Icelandic children[6].

Schools provide optimal settings for health promoting interventions such as healthy eating and fruit and vegetable promotion[7,8]. The present study was a part of a school-based intervention study "Lifestyle of 7-9 year old children". The aim of the study was to further integrate physical activity into the school routine and to find ways to promote healthy food habits. The main focus of the dietary part of the intervention was on increasing fruit and vegetable intake[9]. The intervention components were based on determinants of food intake, especially determinants of fruit and vegetable intake[5,8,10-15] and on former findings of effective school-based interventions[8,16-18].

In the autumn 2006, a baseline study of the school based intervention showed that a large group of 7 year old children were far from reaching the food based dietary guidelines set for fruit and vegetable intake[19]. This is in line with previous studies of children's fruit and vegetable intake[20-22]. Two years later, the children in the intervention school had increased their intake of fruit and vegetable by 47%, while the children in the control schools decreased their intake by 27%[9].

Important information on where interventions have most impact can be found with further analysis of food diaries. The division of total intake into measurements of what is consumed at home and in schools is an important aspect to consider[13]. One study has analysed where and in which meal of the day fruit and vegetable intake is most common[23] and one intervention-study analysed in which meal of the day the change in intake took place[24]. Difference in intake as well as disparity of difference related to genders is an interesting aspect in intake. In a former review, 27 of 49 papers showed that girls tend to have a higher or more frequent intake of fruits and vegetables than boys, 4 papers observed higher intake

among boys and 18 papers found no gender difference in intake[13]. Gender difference in intake seems to be more prevalent in European countries than in the U.S.A.[13,25]. Few studies have analyzed where the intervention has the most impact compared to baseline intake amount, but some have tough found a tendency to a regression to the mean, that is, the ones with the lowest intake increase their intake and the ones with the highest intake decrease theirs[26-29].

The aim of the present study was to further explore the effect the intervention had on fruit and vegetable intake. The present study explored where the change in intake took place, if it was at home, at school during midmorning-snack or lunch. It explored if there was a gender difference in the intake change. It moreover explored the intervention-effect on schoolchildren according to baseline intake with the intervention- and control-group split into tertiles. It analyzed if those children classified as low consumers of fruits and vegetables changed their intake levels differently than higher consumers of fruit and vegetables.

Methods

Study population and design of the study

The data was collected in six randomly selected schools in Reykjavík – Iceland. Baseline measurements were performed in the autumn 2006 with a follow-up in autumn 2008. The schools were paired for similarity of size and quarters of Reykjavík[30] and the two schools in each pair were randomly assigned to the intervention or control group. Data collection took two weeks in each school and was performed from September to the end of November in the same sequence during the autumns of 2006 and 2008. Written consent of both parent and child was secured before measurements at baseline and follow-up. At baseline, 265 children were invited to participate in the present study and 216 returned dietary records (18% drop-out). After exclusion of incomplete records and records not done for one weekend day and two weekdays wherein children were attending school, 185 complete records where left for data analysis (70%). After exclusion of underreports[19] 163 records were studied for baseline values. At follow-up all children that participated in the baseline study and were still in the same school were invited to participate, in total 171 returned dietary records (21% drop-out). After exclusion of incomplete records and underreports[9] 130 records where left for data analysis, thereof 105 children were included in the data analysis at both occasions and used for the analysis of the present intervention study.

Approval for the study was obtained from the National Bioethics Committee (VSN b2006050002/03) as well as the Icelandic Data Protection Commission.

Intervention programme

The main focus of the dietary intervention was on increasing fruit and vegetable intake. Educational strategy was made based on the determinants of fruit and vegetable intake. Educational material was developed in collaboration with the teachers and was the same in all of the intervention schools. Homework assignments were set up and letters were sent out to involve the parents. The letters gave the parents information about the aims of the study and advice on how to encourage healthy food habits in children. Teachers encouraged the children to bring fruit and vegetables to school for midmorning-snack in all of the intervention schools. Intervention components are represented in more details elsewhere[9].

Assessments

The children's diet was assessed with three days weighed dietary records. The records were continuous over two weekdays and one weekend day. Parents received instructions at a meeting at baseline on how to record the child's diet. Written instructions were a component in the dietary record sheet at baseline and follow-up.

The children's intake of food was weighed with accurate electronic scale (PHILIPS HR 2393), provided by the researchers, except the school lunch which was recorded for each child by research staff members. Standard portion size was weighed at each school lunch, adjusted for leftovers and refills for each child.

Food based dietary guidelines and school meals

The Public Health Institute of Iceland published food-based dietary guidelines, for adults and children from 2 years of age (FBDG) in the year 2006. The guidelines for fruit and vegetable intake are "5 portions of fruit and vegetables, corresponding to 500 g per day for adults; children younger than ten years require smaller portions". In the present study this was defined as 400 g of fruit and vegetables or more per day, 200 g fruit and 200 g vegetables. To obtain this amount per day, it is recomended to distribute the intake over various meals and snacks in the day[3].

In Iceland, elementary schools offer lunch subscription programs. Parents have the option to subscribe their children in the lunch program and pay fees for the lunches. Most schools offer vegetables and/or fruits at lunch. For the midmorning-snack, the children bring snack from home.

Data analysis

Nutrient calculations were performed with ICEFOOD (program of the Icelandic Nutrition Council), using The Icelandic Nutrient Database (revised), as well as the Icelandic Nutrition Council Recipe Database 2002.

All statistical analysis were carried out using SPSS for Windows, version 11.0. The level of significance used was $P < 0.05$. Food group intake was checked for normality by visual inspection and by using the Kolmogorov-Smirnov test. Food intake distribution was generally skewed, and there were some zero values; therefore a non-parametric test (Mann-Whitney U) was used to test differences in food intake between intervention and control groups and Wilcoxon Signed Rank Test for difference in intake on individual level.

All results are shown for different time and places of intake. Habitual total intake is calculated from individual mean intake of two weekdays and one weekend-day. Schoolday total intake is calculated from individual mean intake of two weekdays wherein the children attended school. Schoolday at home intake is calculated from individual mean intake at home on two weekdays wherein the children attended school. Schoolday at morning-snack intake is calculated from individual mean intake of food eaten during the morning-snack at school on two weekdays wherein the children attended school. Schoolday at lunch intake is calculated from individual mean intake of food eaten at lunch in school on two weekdays wherein the children attended school.

Results

Table 1 shows the mean intake of fruit and vegetables for 7 year old children at baseline. The mean habitual intake was 133 g/d, but the mean fruit intake on schooldays was 33.8 g/day higher than the mean habitual intake (P<0.001). On schooldays, girls consumed significantly more fruit during the midmorning-snack at school than boys, 90.1 g/day vs. 50.1 g/day respectively (P=0.005). There was an insignificant difference in vegetable intake between boys and girls at all times or places at baseline.

Table 2 shows the mean fruit and vegetable intake at baseline and follow-up for the intervention and the control group separately and shows the mean of individual difference in food intake between baseline and follow-up. The intervention group changed their habitual fruit intake insignificantly by 25 g/day (P=0.142) while the control group decreased their fruit intake by 37 g/day (P=0.008) with significant disparity between groups (P=0.002). The disparity of the mean difference of fruit intake in the intervention and the control group was also significant on schooldays (P=0.005) and in the morning snack (P=0.001). At lunch at school, the control group increased their fruit intake by 12.6 g/day (P=0.232) while the intervention group decreased their intake by 5.2 g/day (P=0.055) with significant disparity between groups (P=0.032).

Figure 1a shows the mean difference in fruit intake for girls in the intervention and the control group. There was always a significant disparity of difference between girls in the intervention and the control group, but at lunch in school the disparity between the two groups was inverted (P=0.048), the intervention group decreased their intake (P=0.170) and the control group increased theirs (P=0.077). Girls in the control group decreased their total habitual intake from 181g/day to 122 g/day (P=0.001), their total schoolday intake from 227 g/day to 143 g/day (P=0.002), intake at home on schooldays from 87 g/day to 62 g/day (P=0.050) and intake in the midmorning-snack at school from 127 g/day to 55 g/day (P<0.001). No significant difference in fruit intake was seen for girls in the intervention group.

Figure 1b shows the mean difference in fruit intake between baseline and follow-up for boys in the intervention and in the control group. Significant increase in intake from 30 g/day to 98 g/day (P=0.001) was found in the intervention group during the midmorning-snack at school. No other occasions or places showed a significant difference in intake.

7

The change in fruit intake was different for boys and girls between baseline and follow-up. Boys in the intervention group increased their intake of fruits during the midmorning-brake by 68 g/day (P=0.001) while the girls in the intervention group decreased their intake insignificantly, making the disparity between genders significant (P=0.003). No other gender disparity of difference in fruit intake was seen in the intervention group.

The girls in the control group decreased their habitual total intake by 60 g/d, (P=0.001) while the boys increased their total intake insignificantly with significant disparity of difference (P=0.018). On schooldays, the girls decreased their total intake by 84 g/day (P=0.002) but the boys increased their total intake insignificantly, making a significant gender disparity of difference in the total intake schooldays (P=0.006). In the control group, the girls decreased their fruit intake during the midmorning-snack by 73 g/day (P<0.001) while the boys increased their intake insignificantly making the gender disparity of the difference significant (P=0.006).

Table 2 shows that vegetable intake increased significantly at all times and places but during the midmorning-snack in the intervention group, but decreased significantly in the control group only during the morning-snack (P=0.030) and increased significantly in lunch at school in the control group (P=0.014). The disparity of the difference in intake between intervention and control group was significant for total habitual intake (P<0.001) total schoolday intake (P<0.001), intake at home on schooldays (P=0.025) and during the midmorning-snack at school (P=0.001).

Figure 2a shows the mean difference of vegetable intake between baseline and follow-up for girls. The intervention group had significant increase in total habitual intake (P=0.006), total schoolday intake (P=0.003) and at lunch at school (P=0.004). Significant disparity of difference between intervention and control group was seen in total habitual intake (P=0.003), total schoolday intake (P=0.002), on schooldays at home (P=0.027) and during the midmorning-snack at school (P=0.020).

Figure 2b shows the mean difference of vegetable intake between baseline and follow-up for boys. The intervention group had significant increase in total habitual intake (P=0.001), total schoolday intake (P=0.003) and at lunch at school (P=0.003). Significant disparity of difference between intervention and control group was seen in total habitual intake (P=0.007), total schoolday intake (P=0.036) and during the midmorning-snack at school (P=0.017). No

disparity of difference in vegetable intake was detected between boys and girls neither in the intervention nor in the control group.

Table 2 shows total intake of fruit and vegetable combined. The intervention group increased their total habitual intake (P<0.001), total schoolday intake (P<0.001), schoolday intake at home (P=0.037) and intake during the midmorning-snack at school (P=0.001). The control group had significant decrease in total fruit and vegetable intake habitually (P=0.005), total intake on schooldays (P=0.018) and in the morning-snack at school (P<0.001). The control group increased their intake significantly in lunch at school (P=0.007). The disparity of the difference in fruit and vegetable intake was significant between intervention and control group in total habitual intake (P<0.001), total schoolday intake (P<0.001), intake at home on schooldays (P=0.009) and in the midmorning-snack at school (P<0.001).

To further analyse the intervention-effect on fruit and vegetable intake on schooldays, the intervention group and the control group were divided in to tertiles. In the intervention group (Figure 3a), the first tertile (N=19) had total schoolday fruit and vegetable intake less than 128 g/day at baseline. The intake increased by 109 g/day (P<0.001) to a mean intake 168 g/day at follow-up. The increase at home was 37% (P=0.005) and 55% during the midmorning-snack at school (P<0.001). The second tertile in the intervention group (N=20) had total schoolday fruit and vegetable intake between 128 g/day and 219 g/day at baseline. Their mean difference between baseline and follow-up was 81 g/day (P=0.005) raising the mean intake to 249 g/day (p=0.005). Increase in intake at home was of borderline significance (P=0.064) but explains 54% of the total schoolday increase. Significant increase in the midmorning-snack (P=0.040) explains 43% of the increase.

In the control group (Figure 3b), the first tertile (N=16) had total schoolday fruit and vegetable intake less than 169 g/day at baseline. There was a non significant increase of 81 g/day between total schoolday intake at baseline and follow-up. The intake at lunch was 72% of the total increase (P=0.007). The second tertile in the control group (N=15) had total schoolday fruit and vegetable intake between 169 g/day and 304 g/day at baseline. The decrease of total schoolday fruit and vegetable intake between baseline and follow-up was 115 g/day (P<0.001), to mean intake of 174 g/day, with 40% of the total decrease in intake at home (P=0.015) and 65% of the total decrease in the midmorning-snack (P=0.001). Small insignificant increase of 5% of the total decrease was in the lunch at school. The third tertile

in the control group (N=16) had more than 304 g/day intake in total schoolday fruit and vegetable intake at baseline and decreased their mean intake from 539 to 283 g/day (P=0.028). The decrease in intake at home was 59% of total decrease (P=0.028), 61% of the total decrease of borderline significance was in the midmorning-snack (P=0.075) but significant increase was seen in lunch at school (P=0.028) lowering the total decrease by 19%.

Discussion

The intervention had the strongest effect in increasing fruit and vegetable intake among boys and prevented decrease in intake of fruit and vegetables among girls. In the intervention group the largest proportion of the increase in fruit intake was in the midmorning-snack, and the most significant decrease in the control group was also in the midmorning-snack. For vegetables, the increase was similar for boys and girls and was evenly distributed over the day. The intervention effect had the greatest impact on the children having the lowest initial intake, and the decrease in the control group happened with the children having the highest initial intake. Encouragement and education in schools, similar to this intervention, is necessary to increase fruit and vegetable intake in school-children and hinder a decrease in intake from 7 to 9 years of age.

At baseline, when the children where 7 years old, their average intake of fruit and vegetables was less than half of recommendations. Mean habitual fruit intake was 133 g/day, or 67% of recommended amount and vegetable intake was 20% of recommended amount. Total schoolday intake was higher than habitual intake and that is probably because of high intake proportion in the midmorning-snack at school. This low intake of fruit and vegetables has also been seen in previous studies of the diet of Icelandic children[5,20-22].

Previous studies have either shown no age effect or decrease in fruit and vegetable intake with higher age. The decrease with age is more prevalent in European studies than U.S.A. studies[13,31-35]. In the control group this tendency clearly existed. The largest proportional decrease was in the midmorning-snack. In the intervention group the intervention did not only prevent this decrease but increased habitual total fruit and vegetable intake and the largest proportional increase was in the midmorning-snack. The increase was proportionally more in vegetable intake than in fruit intake, but the baseline intake was much lower for vegetables than fruit. The largest proportional increase in vegetable intake was at lunch in school. The control group did also increase their intake in lunch at school at follow-up. One might conclude that better vegetable availability in lunch at schools explains this increase in both groups but the present research does not examine that aspect.

Association between parental involvement and positive changes in vegetable intake has been found in previous studies[36]. A former paper from the same intervention study concludes that

encouraging children to bring fruit and vegetables from home to eat in the midmorning-snack may be a good strategy for increasing fruit and vegetable intake because the parents know what their children like and how to prepare it[9]. This seems to be the case because the largest increase in fruit and vegetable intake in the intervention group was in the midmorning-snack. Intake of fruit and vegetables at home on schooldays increased significantly in the intervention group but no disparity was found in intake difference between intervention and control group in lunch at school and the mean amount eaten at lunch at follow-up was almost the same for both groups. The intervention effect was seemingly strongest where the parents are in charge of what is bought and available for the children. That is consistent with Wind's et al. findings that indicate that fruit and vegetable promotion should focus on improvement in general availability especially at home. This is improved with parents' involvement in the intervention[15]. When a variety of fruit and vegetables are available, the children tend to choose what and how much they eat dependent upon their liking and familiarity[8,15].

Most former European studies have found that girls consume more fruits and vegetables than boys[13]. In the present study no significant gender difference was found in total intake at baseline but a little difference was found in the consumption pattern. Girls consumed almost double the amount of fruit compared to the boys in the midmorning-snack and it gave the girls half of their schoolday intake while the boys had one third of their schoolday intake in the midmorning-snack. Boys had more than half of their intake at home on schooldays. Boys and girls showed similar intake pattern of vegetables. At baseline less than 20% of the total schoolday intake of vegetables came from lunch at school so over 80% was eaten at home or brought from home for the midmorning-snack.

The intervention had different effects on fruit intake in girls vs. boys. Girls in the intervention group did not change the mean amount of their fruit intake while the girls in the control group decreased their intake significantly. On the other hand, boys in the intervention group increased their intake, but only significantly in the midmorning-snack while the boys in the control group did not change the mean amount of fruit intake. This is in contradiction with other findings that indicate that fruit and vegetable interventions works better on girls than boys[37,38] but some indicate that this is just the case for intervention effects on vegetable intake[39,40]. When vegetable intake was analyzed in the same way, boys and girls showed similar change in consumption. The intervention group increased their total habitual intake, total schoolday intake and intake in the lunch at school while the control group did not have

any change in vegetable intake. The reasons for this disparity of difference in fruit- vs. vegetable-intake is unknown. The reasons for the gender disparity of difference in fruit intake seen in this study are not clear. One might conclude that the known decrease in fruit and vegetable intake with age happens sooner for girls than boys. That might be because they mature earlier at this age and the boys will reduce their intake later. This is a topic for further study in the future.

The largest increase in intake in the intervention group was seen in the group with the lowest initial intake and the largest decrease in the control group was seen in the groupwith the highest initial intake. This is in line with former studies[26-29].

The intervention was successful in increasing fruit and vegetable intake. It is essential to prevent a fall in intake and encourage a rise in fruit and vegetable intake, especially for boys and the children with low initial consumption. In the intervention group the vegetable increase was higher than for fruits in g/day, but the baseline values were lower. Proportional increase was high at lunch both for intervention and control group but follow-up mean value was still rather low. There seems to be a lot of opportunities for increasing vegetable intake during school lunch. That does not only require good availability but also good peer influence, and role modeling of school staff since availability has been shown not to be enough to change intake pattern[27,28]. The intervention had most impact on the midmorning-snack and the home environment where the parents are in charge and the children can express their wants and taste preferences.

Conclusion

Nutrition education and intervention implementation can be very efficient and will reduce the downfall in fruit and vegetable intake seen in the control group in this study. It is important to increase the intake further. Intervention aimed at increasing vegetable intake is imperative, more so than for fruit since the initial intake of fruits are much higher than for vegetables at this age. A good place for that is the lunch at school, but this requires good collaboration with the school staff and the staff in the school canteen. Interventions including nutrition education and stimulation by increased availability in school similar to this intervention are necessary to improve fruit and vegetable intake in school-children.

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Table 1. Mean intake (g/d) of 7 year old children, all participants together (n=163), girls (n=87) and boys (n=76), shown at time and place of intake. P-values showing the difference between girls and boys (Mann-Whitney test), significant differences in bold.

Food group	All Mean (g/d)	(SD)	Girls Mean (g/d)	(SD)	Boys Mean (g/d)	(SD)	P -value
Fruits total (fresh fruits)							
Habitual total[1]	133	(100)	142	(100)	124	(101)	0.158
Schoolday total[2]	167	(130)	180	(131)	152	(128)	0.073
Schoolday at home[3]	74	(94)	68	(81)	82	(107)	0.710
Schoolday at Morning-snack[4]	72	(77)	90	(89)	50	(52)	**0.005**
Schoolday at Lunch[5]	21	(29)	23	(28)	19	(30)	0.315
Vegetables							
Habitual total[1]	41	(40)	38	(40)	44	(41)	0.250
Schoolday total[2]	48	(50)	45	(47)	53	(53)	0.373
Schoolday at home[3]	22	(32)	23	(33)	21	(31)	0.724
Schoolday at Morning-snack[4]	18	(33)	14	(27)	21	(38)	0.281
Schoolday at Lunch[5]	9	(14)	7	(12)	11	(16)	0.089

[1]Habitual total intake is calculated from individual mean intake of two weekdays and one weekend-day.

[2]Schoolday total intake is calculated from individual mean intake of two weekdays wherein the children attended school.

[3]Schoolday at home intake is calculated from individual mean intake of food eaten at home on two weekdays wherein the children attended school.

[4]Schoolday at Morning-snack intake is calculated from individual mean intake of food eaten in the Morning-snack at school on two weekdays wherein the children attended school.

[5]Schoolday at Lunch intake is calculated from individual mean intake of food eaten at lunch in school on two weekdays wherein the children attended school.

Table 2. Food intake, mean intake (25th, 50th and 75th percentiles), shown separately for intervention (n=58) and control schools (n=47) at baseline and follow-up, shown for place and time of intake. P-values are shown for the difference of intake at baseline and follow-up (Wilcoxon Signed Rank Test), significant differences in bold. P- values shown for disparity of mean difference between intervention- and control-group (Mann Whitney U), significant differences in bold.

Food group	Intervention Baseline Mean (g/d)	Baseline Percentiles (g/d) (25th,50th,75th)	Follow-up Mean (g/d)	Follow-up Percentiles (g/d) (25th,50th,75th)	Mean difference (g/d)	(SD)	P-value	Control Baseline Mean (g/d)	Baseline Percentiles (25th,50th,75th)	Follow-up Mean (g/d)	Follow-up Percentiles (25th,50th,75th)	Mean difference (g/d)	(SD)	P-value	Mean differnce Intervention/ Control P-value
Fruits total (fresh fruits)															
Habitual total[1]	109	(36, 85,160)	134	(48, 94, 186)	25	(114)	0.142	161	(85, 153, 193)	124	(60, 113, 168)	-37	(95)	**0.008**	**0.002**
Schoolday total[2]	136	(44, 114, 186)	168	(54, 120, 230)	31	(145)	0.135	198	(100, 175, 273)	151	(69, 141, 195)	-47	(141)	**0.025**	**0.005**
Schoolday at home[3]	65	(0, 31, 106)	73	(0, 31, 101)	8	(118)	0.357	78	(9, 53, 126)	64	(0, 30, 136)	-14	(105)	0.154	0.079
Schoolday at Morning-snack[4]	43	(0, 16, 74)	71	(0, 38, 106)	28	(99)	**0.047**	106	(50, 88, 148)	61	(0, 49, 93)	-46	(99)	**0.002**	**0.001**
Schoolday at Lunch[5]	28	(0, 20, 50)	23	(0, 0, 41)	-5	(33)	0.232	14	(0, 0, 20)	27	(0, 15, 45)	13	(42)	0.055	**0.032**
Vegetables															
Habitual total[1]	46	(14, 38, 71)	82	(29, 62, 128)	37	(55)	**<0.001**	43	(11, 31, 60)	34	(13, 27, 48)	-9	(49)	0.230	**<0.001**
Schoolday total[2]	52	(4, 39, 90)	94	(30, 81, 144)	42	(67)	**<0.001**	53	(15, 42, 88)	43	(8, 28, 55)	-10	(58)	0.234	**<0.001**
Schoolday at home[3]	23	(0, 6, 30)	38	(0, 28, 56)	15	(51)	**0.033**	27	(0, 10, 49)	19	(0, 0, 23)	-8	(46)	0.213	**0.025**
Schoolday at Morning-snack[4]	22	(0, 0, 33)	36	(0, 19, 55)	15	(57)	0.066	16	(0, 0, 26)	6	(0, 0, 0)	-11	(31)	**0.030**	**0.001**
Schoolday at Lunch[5]	8	(0, 0, 15)	20	(0, 21, 30)	13	(22)	**<0.001**	10	(0, 0, 15)	18	(0, 20, 33)	8	(21)	**0.014**	0.207
Fruits and vegetables															
Habitual total[1]	155	(73, 130, 221)	216	(125, 200. 272)	61	(126)	**<0.001**	204	(115, 180, 250)	158	(78, 139, 204)	-46	(109)	**0.005**	**<0.001**
Schoolday total[2]	188	(73, 171, 260)	262	(163, 234, 350)	73	(157)	**<0.001**	251	(144, 220, 335)	194	(112, 189, 249)	-57	(160)	**0.018**	**<0.001**
Schoolday at home[3]	88	(2, 57, 132)	111	(38, 76, 159)	23	(131)	**0.037**	104	(25, 75, 154)	82	(3, 50, 140)	-22	(119)	0.095	**0.009**
Schoolday at Morning-snack[4]	65	(0, 48, 110)	108	(37, 96, 153)	43	(97)	**0.001**	123	(56, 104, 167)	67	(0, 66, 101)	-56	(102)	**<0.001**	**<0.001**
Schoolday at Lunch[5]	36	(0, 24, 63)	43	(8, 33, 71)	7	(43)	0.216	24	(0, 15, 35)	45	(10, 45, 70)	21	(50)	**0.007**	0.086

[1]Habitual total intake is calculated from individual mean intake of two weekdays and one weekend-day.
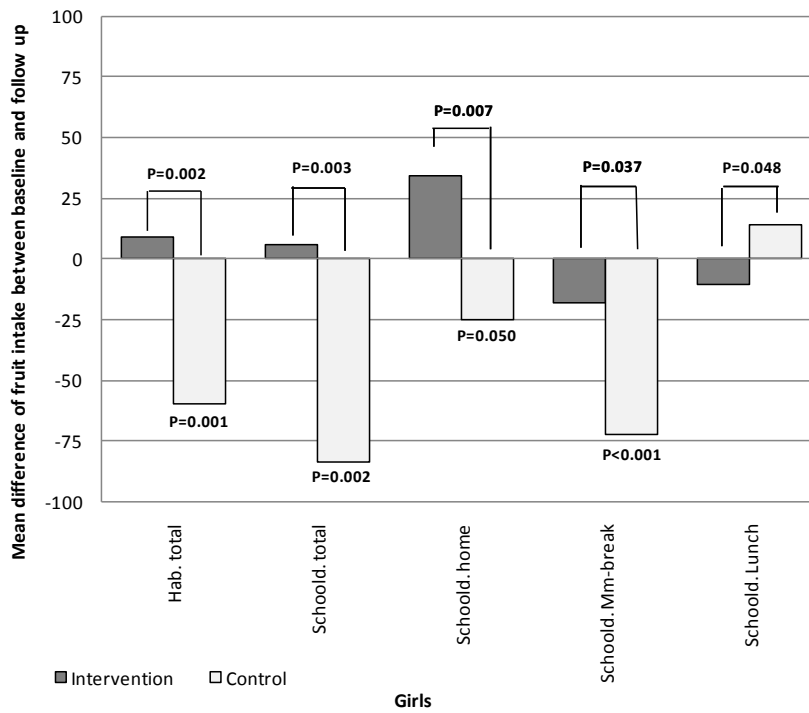[2]Schoolday total intake is calculated from individual mean intake of two weekdays wherein the children attended school.
[3]Schoolday at home intake is calculated from individual mean intake of food eaten at home on two weekdays wherein the children attended school.
[4]Schoolday at Morning-snack intake is calculated from individual mean intake of food eaten in the Morning-snack at school on two weekdays wherein the children attended school.
[5]Schoolday at Lunch intake is calculated from individual mean intake of food eaten at lunch in school on two weekdays wherein the children attended school.
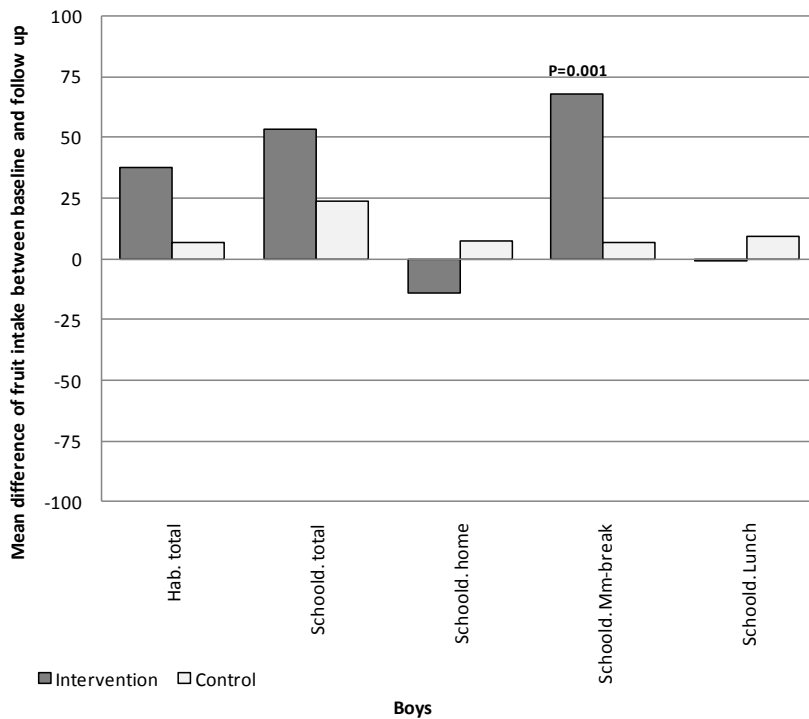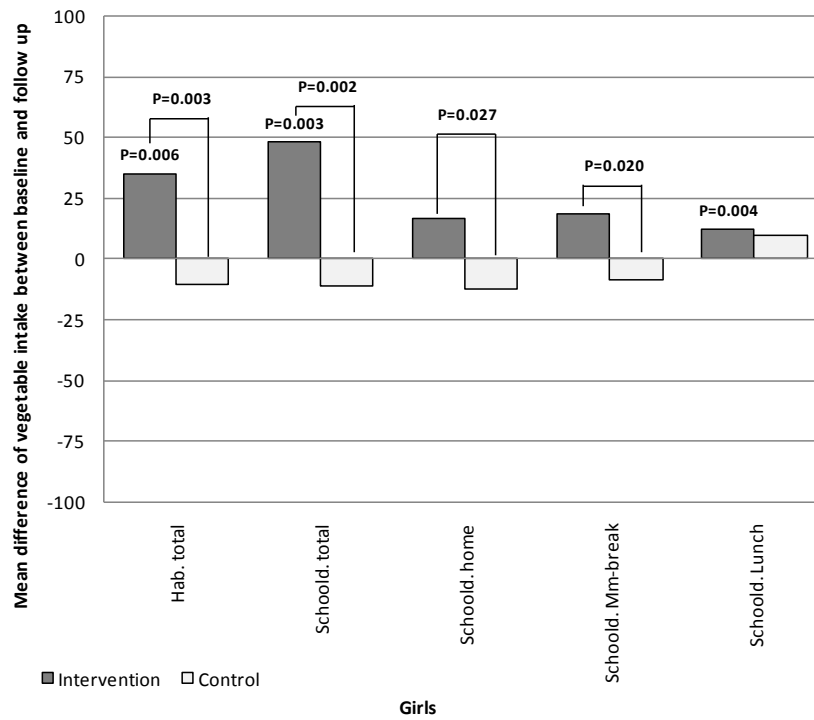
a)

b)

Figure 1 Mean difference between baseline and follow-up of fruit intake for: a) girls and b) boys, in the intervention-group and in the control-group. P-values are shown for the difference of intake at baseline and follow-up (Wilcoxon Signed Rank Test), significant differences in bold. P-values shown for disparity of mean difference between intervention- and control-group (Mann Whitney U), significant differences in bold.
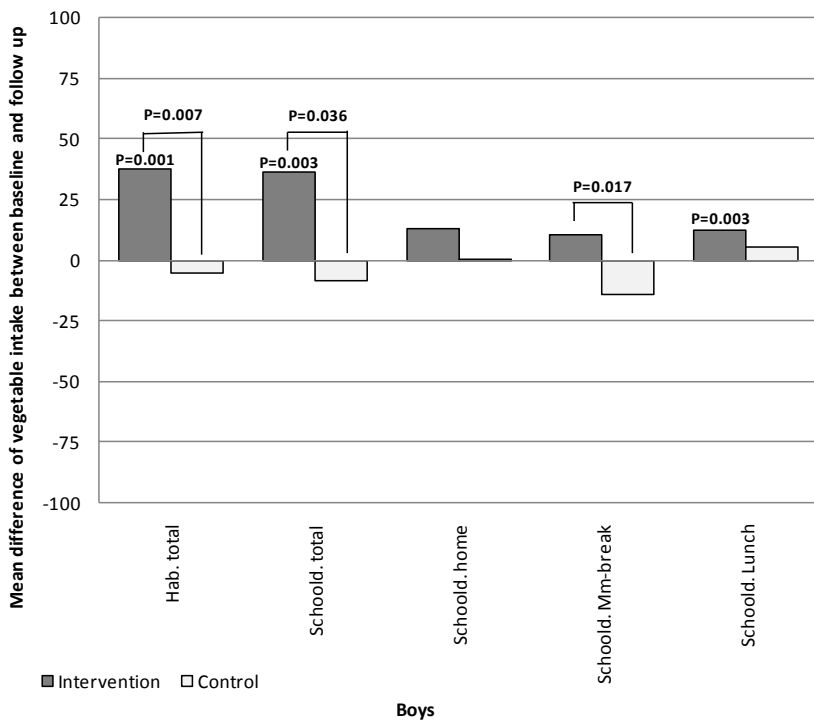
a)

b)

Figure 2 Mean difference between baseline and follow-up of vegetable intake for a) girls and b) boys, in the intervention-group and in the control-group. P-values are shown for the difference of intake at baseline and follow-up (Wilcoxon Signed Rank Test), significant differences in bold. P-values shown for disparity of mean difference between intervention- and control-group (Mann Whitney U), significant differences in bold.
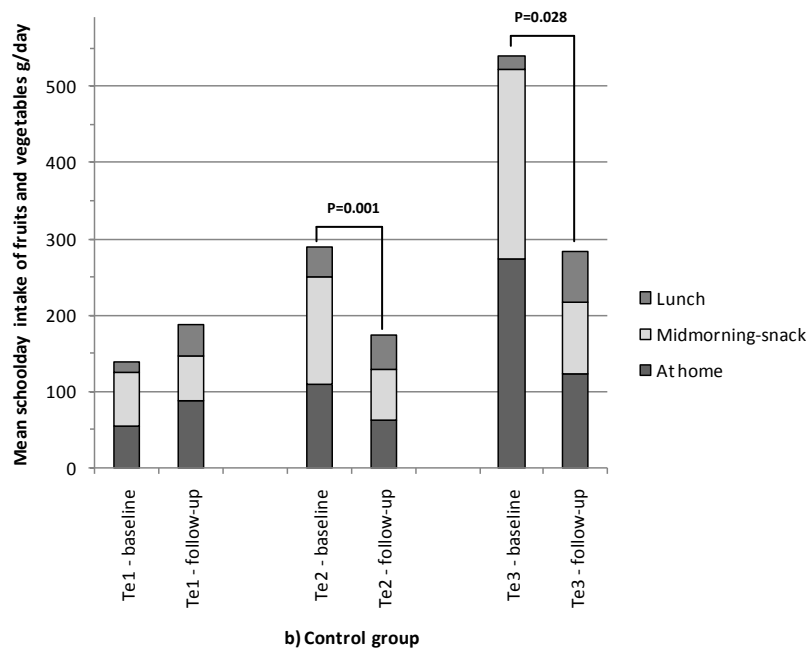
a)

a) Intervention group

b)
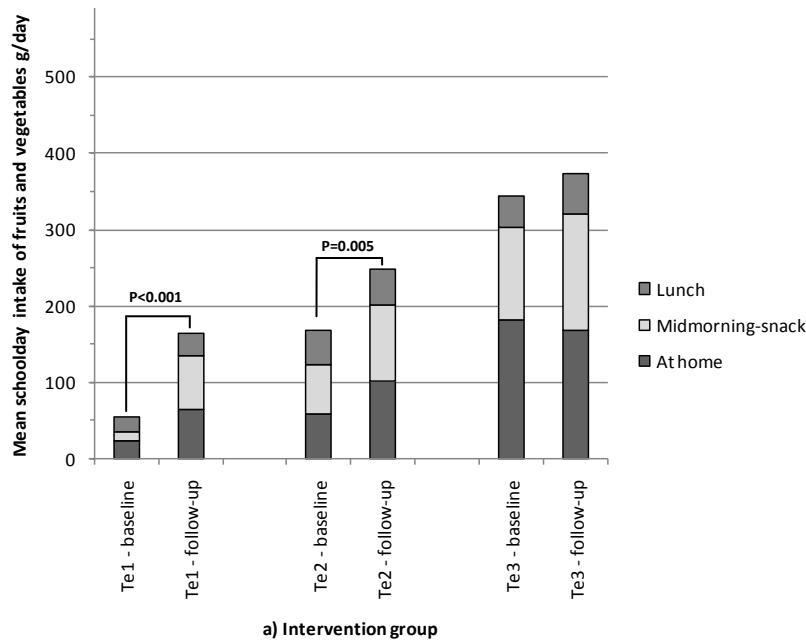
b) Control group

Figure 3 Mean schoolday intake of aggregated fruit and vegetable. The intervention-group (a) divided in tertiles(Te1-Te3) (N=19-20-19). Cut points 127.7 g/day and 219.0 g/day. The control-group (b) divided in tertiles(Te1-Te3) (N=16-15-16). Cut points 169.0 g/day and 304.0 g/day.

Significant P-values are shown for the difference of total schoolday intake at baseline and follow-up (Wilcoxon Signed Rank Test)