Sveriges lantbruksuniversitet
Swedish University of Agricultural Sciences

Faculty of Natural Resources and Agricultural Sciences
Department of Food Science

Whole grain and cereal fiber intake among children at high risk for obesity

Intag av fullkorn och kostfiber från spannmål hos barn med förhöjd risk för fetma

Karolina Andersson

Independent Project in Food Science• Bachelor Thesis • 15 hec • Ground G2E
Publikation/Sveriges lantbruksuniversitet, Institutionen för livsmedelsvetenskap, no 416
Uppsala, 2015

Whole grain and cereal fiber intake among children at high risk for obesity

Intag av fullkorn och kostfiber från spannmål hos barn med förhöjd risk för fetma

Karolina Andersson

Supervisor: Rikard Landberg, Department of Food Science, SLU.

Examiner: Lena Dimberg, Department of Food Science, SLU

Credits: 15 hec
Level: Ground G2E
Course title: Independent Project in Food Science – Bachelor Thesis
Course code: EX0669
Programme/education: Agronomy in Food Science

Place of publication: Uppsala
Year of publication: 2015
Title of series: Publikation/Sveriges lantbruksuniversitet, Institutionen för livsmedelsvetenskap
Serie no: 416
Online publication: http://stud.epsilon.slu.se

Keywords: obesity, children, whole grain, cereal fiber

Sveriges lantbruksuniversitet
Swedish University of Agricultural Sciences

Department of Food Science

Abstract

Obesity is a growing problem worldwide. Today, obesity is a more common cause of death than underweight and the prevalence increases. The energy intake has a crucial impact when it comes to developing overweight and obesity. It is important to establish a healthy relationship to food intake in early age since food preferences are created early. Whole grains and dietary fiber have shown to reduce the risk of many diseases associated with obesity, such as cardiovascular diseases, diabetes and some forms of cancer. Whole grain may also have an effect on weight gain. It is important to prevent obesity. Most of the obese adults were obese as youngsters and most of the obese youngsters were obese as children too. Obesity is associated with severe consequences particularly is childhood obesity associated with an increased risk of premature death. Many factors affect the obesity risk among children. Both inherited genes and surrounding environment have a great impact. A randomized controlled trial named Early STOPP (Stockholm Obesity Prevention Program) was initiated to find out if it is possible to implement healthier lifestyle in children with an increased risk of obesity. The families taking part of the intervention get continuously coaching during five years, in contrast to families belonging to the control group. Food diaries belonging to the children (3 years of age) taking part in Early STOPP were analyzed in the present study. The total cereal fiber and whole grain intake was estimated to be 5.4 respectively 16.8 g/day. No significant differences in cereal fiber or whole grain intake between the groups were seen. Neither were any significant variance between BMI and intake seen. The results are only based on the situation at 3 years of age. It would have been interesting to look at the development between year 1 and year 3 regarding change in whole grain intake, cereal fiber intake and BMI. Even if whole grains have not been shown to decrease body weight, an increased intake of whole grain is recommended due to the association with decreased risk of a number of diseases associated with obesity.

Keywords: obesity, children, whole grain, cereal fiber

Sammanfattning

Fetma är ett växande problem världen över. Idag är fetma en vanligare dödsorsak än undervikt och förekomsten ökar. Energiintaget är avgörande när det gäller att utveckla övervikt och fetma. Det är viktigt att skapa ett hälsosamt förhållningssätt till mat tidigt i livet eftersom det är då matpreferenserna utformas. Fullkorn och kostfiber har visat sig minska risken för många sjukdomar som förknippas med fetma, så som hjärt- och kärlsjukdomar, diabetes och vissa former av cancer. Fullkorn har eventuellt även en hämmande effekt på viktuppgång. Det är viktigt att förebygga fetma. De flesta vuxna med fetma var feta som ungdomar och de flesta feta ungdomar var feta redan som barn. Fetma medför allvarliga konsekvenser, inte minst så är fetma i barndomen förknippad med en förtida död. Både gener och omgivande miljö påverkar barnens risk att utveckla fetma. En intervention med randomisering vid namn Early STOPP (Stockholm Obesity Prevention Program) startades för att försöka ta reda på om det är möjligt att skapa en sundare livsstil bland barn med en ökad risk för fetma. Studien använder kontinuerliga samtal med familjen över en femårsperiod för att förhoppningsvis minska risken för att barnen utvecklar fetma. De familjer som tillhör kontrollgruppen har inte några kontinuerliga samtal. Matdagböcker tillhörande barn vid tre års ålder som deltar i Early STOPP analyserades i denna studie. Det totala fullkorns- respektive spannmålsfiberintaget beräknades till 5,4 respektive 16,8 g/dag. Inga signifikanta skillnader mellan intaget i de olika grupperna kunde ses. Några signifikanta skillnader mellan BMI och intag kunde inte heller ses. Resultaten baseras enbart på situationen vid tre års ålder. Det hade varit intressant att titta på utvecklingen gällande fullkorns-, spannmålsfiberintag och BMI mellan ett och tre års ålder. Även om fullkorn i sig inte visats minska kroppsvikten är ett ökat intag av fullkorn att rekommendera. Detta på grund av fullkornets påvisade effekt på en rad sjukdomar förknippade med fetma.

Nyckelord: fetma, barn, fullkorn, spannmålsfiber

Table of contents

Abbreviations **5**

1 Background **7**
1.1 Introduction 7
1.2 Obesity among children 8
1.3 Factors affecting obesity risk in children 9
1.4 Consequences of childhood obesity 11
1.5 Impact of dietary intake 11
1.6 Impact of whole grain and refined cereals 12
1.7 Dietary fibers 14
1.8 Whole grain and fiber intake 14
1.9 Biomarkers 15
1.10 Early STOPP 15
1.11 Aim 16

2 Subjects and Methods **17**
2.1 Original study population 17
2.2 Registration of diet 17
2.3 Statistical analyses 19

3 Results **20**

4 Discussion **22**

References **25**

Abbreviations

AR	Alkylresorcinols
BMI	Body mass index
CF	Cereal fiber
CHC	Child healthcare
E %	Energy percent (of total energy intake)
Early STOPP	Early Stockholm Obesity Prevention Project
GLM	General Linear Model
MJ	Mega joule
NNR	Nordic Nutrition Recommendations
NSP	Non-starch polysaccharides
P-value	Significance level
RCT	Randomized controlled trial
SCFA	Short chain fatty acids
SLV	Swedish National Food Agency
WG	Whole grain
WHO	World Health Organization

1 Background

1.1 Introduction

Malnutrition is a problem worldwide, in the developing countries, as well as in the western world (World Health Organization, 2013). Malnutrition includes not only underweight and nutrient deficiency but also overweight and obesity and is caused by too little, too much or simply wrong food (World Health Organization, 2014d). Today, half of the world´s population is affected by some sort of malnutrition (World Health Organization, 2014a). Overweight and obesity are defined as an excessive fat accumulation which might have negative effects on health (World Health Organization, 2015). This is a growing problem worldwide. Since 1980, the prevalence of obesity has more than doubled and today overweight and obesity are more common cause of death than underweight. In 2014, more than 1.3 billion adults were overweight and over 600 million were obese. This corresponds to 39 % and 13 % of the world´s population, respectively (World Health Organization, 2015). The highest proportion of obese adults is found in America, where almost 27 % of the population is classified as obese. In Europe the situation is almost as devastating, with an obesity rate at 23 % among the adult inhabitants. In Sweden the proportion of obesity increased from 18.8 % to 20.5 % between 2010-2014 (World Health Organization, 2014c).

Obesity and overweight develop after a long time of positive energy balance, i.e. the energy intake has been higher than the energy expenditure (van de Vijver *et al.*, 2009). Body Mass Index (BMI) is usually used when assessing the weight status and is calculated by dividing the weight in kilograms by the squared height in meters. According to The World Health Organization (WHO) a BMI exceeding or equal to 25 kg/m^2 is classified as overweight and 30 kg/m^2 and higher is classified as obesity. BMI is a rather rough measurement since it does not distinguish between fat mass and fat-free mass. The advantages are considered to be the sim-

plicity since the same method could be used by both men and women in all ages of adults (World Health Organization, 2015).

Whole grains (WG) have been shown to reduce the risk of a number of health problems, such as cardiovascular diseases, strokes, hypertension, diabetes and different forms of cancer (Borneo & Leon, 2012). It is therefore interesting to study the intake of WG among children with high risk of obesity and thereby also obesity related diseases (World Health Organization, 2014b). Natural plant foods are generally less energy dense compared to animal foods and products high in fat and sugar (Nordic Council of Ministers, 2014). The Swedish National Food Agency therefore recommends both adult and children to choose WG products when consuming cereal food products (Amcoff, 2012; Enghardt Barbieri, 2006).

1.2 Obesity among children

In 2013, the number of obese children under 5 years, were 42 million. In 2025 the number is estimated to be 70 million (World Health Organization, 2014b). According to WHO, 12.5 % of all children in the WHO European region are overweight, which is higher than in any other WHO region (World Health Organization, 2013). In Sweden 12 % of the 4-year-olds are estimated to be overweight and 3 % are classified as obese. It is difficult to compare the situation in different countries since different definitions and methods are used during collection and analysis of data. The highest rates in Europe have been reported from the Mediterranean region and the British Islands. In Spain for example 17.7 % of the 4 years olds are overweight and 15.5 % obese (Cattaneo *et al.*, 2010). Obesity is no longer a problem exclusively associated with high-income countries, but a fast growing problem in low- and middle-income countries (World Health Organization, 2015). This leads to a “double burden” of disease in many countries, where some parts of the population struggle with undernourishment and infectious diseases at the same time as the obesity and obesity related diseases increase. Children brought up in low- and middle income countries are more sensitive regarding prenatal and young child nutrition. Children, especially in urban settings, are surrounded by high-sugar, energy-dense and micronutrient-poor foods to a low cost and this results in a substantial increase in obesity among the young population (World Health Organization, 2015).

The consequences of widespread childhood obesity are severe. Obese children are more likely to develop insulin resistance and cardiovascular diseases, as a consequences of their obesity (World Health Organization, 2014b). There is a lot to gain in establishing good health relations to food in early age since food preferences are

created at an early stage in life (World Health Organization, 2014b). Most of the obese adults were obese already as youngsters and most of them were obese or overweight as children. Obese children were 12 times more likely to be obese as youngsters and obese youngsters had a 45 times greater risk to be obese as adults (Rooney *et al.*, 2011).

In Sweden, the number of overweight and obese schoolchildren seems to have leveled off during the last decade (Barnhälsovårdsenheterna i Stockholms län, 2014; Lissner *et al.*, 2010). These trends have been observed among both girls and boys between 10-11 years old from six different municipalities (Lissner *et al.*, 2010). The stabilization of the overweight and obesity rates are thought to be due to regional and local actions taken after an intense media attention. To decrease the prevalence of obesity among children to acceptable levels, more work is required (Lissner *et al.*, 2010). The child healthcare centers (CHC) in Stockholm County report that the proportions of overweight and obese 4-year-olds have not changed during the last seven years. One fourth of all preschool children in Sweden live in Stockholm County (Barnhälsovårdsenheterna i Stockholms län, 2014). The same trend has been seen in several European countries, the rates of overweight and obesity among pre-school children have not increased during the last 20-30 years (Cattaneo *et al.*, 2010).

1.3 Factors affecting obesity risk in children

All children may not have the same risk to develop overweight and obesity. Where and by whom they are born and raised have great impact on their later weight (Maffeis, 2000). Both genetic background as well as lifestyle determines obesity risk (Maffeis, 2000). The characteristics of the child, the parents as well as community and demographic factors affect the risk of developing obesity (Skelton *et al.*, 2011). The weight status of the child depends primarily on its energy intake respectively energy expenditure, which are factors mainly depending on the family characteristics. The type of food available at home and the amount of TV viewing are for instance decisive for the risk of developing childhood obesity. The socio-economic status and school lunch programs are factors that society can influence (Skelton *et al.*, 2011). Figure 1 summarizes different risk factors. The increased risk for obesity by having obese parents is continuing into adulthood (Morandi *et al.*, 2012). A study has shown that girls whose parents had a high dietary intake and low energy expenditure (obesigenic) had a greater increase in BMI than those from non-obesigenic families both between the age of 5-7 and 7-11 (Davison *et al.*, 2005). Parental behavior may have long-term effect on the health of their children which also might increase the risk of obesity. Therefore, it is important to

target high risk families in time and put in preventive actions (Davison *et al.*, 2005). Obesity among women in early pregnancy (1st trimester) increases the prevalence of obese children at the age of 2, 3 and 4 with 15.1 %, 20.6 % and 24.1% respectively. That was approximately 2.5 times higher than the prevalence of obesity among those who were born by normal weight women (Whitaker, 2004). Genetics have great significance regarding variation in BMI (Sørensen *et al.*, 1989). The impact of inherited genes seems to play an increasing role on weight, height and BMI during childhood and adolescence (Dubois *et al.*, 2012). A study examined genetic and environmental factors in 12,000 twin pairs, from birth to 19 years of age. The twins were recruited from four different countries: Sweden, Denmark, Canada and Australia. The results suggest that variability in weight, height and BMI are affected by inherited genes among both girls and boys from 5 months of age (Dubois *et al.*, 2012).

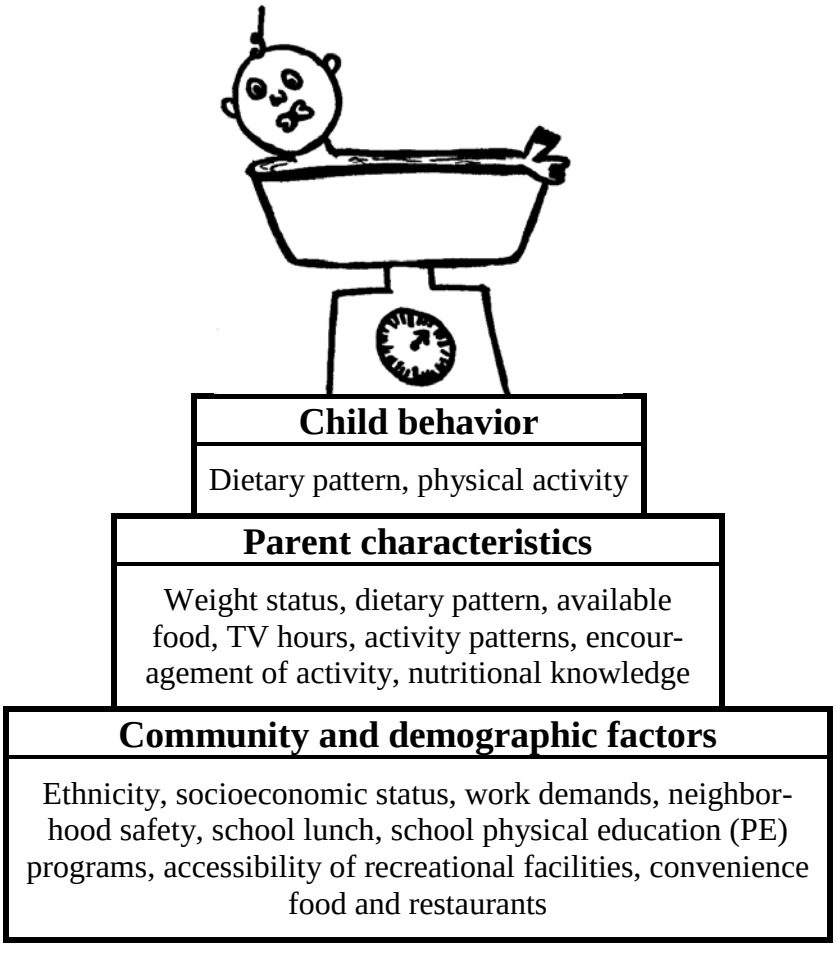

Figure 1*: Describes factors that may affect obesity prevalence and is modification of Skelton (2011).*

1.4 Consequences of childhood obesity

The consequences of childhood obesity are many. Obese children are often exposed to discrimination early in life and one type of consequence is therefore psychosocial (Dietz, 1998). Childhood obesity has also been shown to have considerable effect on the economy among young adults. Factors such as income and educational choices are affected by childhood obesity (Reilly *et al.*, 2003). Childhood obesity is an important risk factor for cardiovascular disease, insulin resistance, as well as endometrial, breast and colon cancer (World Health Organization, 2014b). There is a strong relationship between childhood obesity and cardiovascular disease and death in adulthood. Other risk factors of cardiovascular disease are for example high blood pressure, dyslipidaemia and hyperinsulinaemia and they are all associated with obesity (Reilly *et al.*, 2003). Obesity is associated with premature death (Franks *et al.*, 2010; Reilly *et al.*, 2003). A BMI greater than 25 kg/m^2 among 18 year olds are related to an increased mortality risk within 20 years (Reilly *et al.*, 2003).

1.5 Impact of dietary intake

Children´s food preferences are shaped early in life and the preference of the parents has a massive influence (Scaglioni *et al.*, 2008). Methods like offering rewards, over-controlling and communication of nutrition information has been shown to have negative effects on children's acceptance of food (Marquart, 2007). The most successful way to establish health food preferences is for the family to eat together and that the parents set a good example in terms of eating healthy foodstuff (Scaglioni *et al.*, 2008). The habits created during childhood have been shown to persist into adulthood (Kelder *et al.*, 1994). The Nordic Council of Ministers presented in 2014 the 5^{th} edition of Nutrition Recommendations, NNR 2012, which gathered guidelines for dietary composition and recommended intakes for the general population in the Nordic countries. NNR focus on prevention of obesity. High intake of reducing sugar and sugar sweetened beverages have been shown to be associated with higher risk of obesity (Nordic Council of Ministers, 2014). On the other hand, fiber-rich food such as whole grains, vegetables and fruits strongly are associated with reduced weight gain in epidemiological studies (Nordic Council of Ministers, 2014). Natural plant foods are generally less energy dense compared to animal foods and products high in fat and sugar (Nordic Council of Ministers, 2014). Evidence suggests that dietary patterns with energy dense, high fat and low fiber increases the risk for children to develop overweight and obesity. The obesity risk is better explained by general dietary patterns than specific nutrients or foods (Ambrosini, 2014). Swedish children eat too much added sugar (13-15 E %), saturated fat (14 E %) and salt in relation to what is recom-

mended. At the same time the intake of fibers and polyunsaturated fat is too low. The Swedish National Food Agency recommends an increased intake of WG, fruits and vegetables (Enghardt Barbieri, 2006).

1.6 Impact of whole grain and refined cereals

Cereals have for a long time been staple food and it is a source of all three main macronutrients as well as many vitamins and minerals (Borneo & Leon, 2012). The grain can roughly be divided into, starchy endosperm, germ and bran, with different nutrient composition (AACC International, 2015). See Figure 2. In Scandinavia, WG is typically defined as grains where all parts of the naked cereal kernel from the cereals, wheat, rye, oats, barley, maize, rice, millet, and sorghum are present in the same relative proportion as in the intact kernel (Frølich & Åman, 2010). Today, the outer layers and the germ are often removed during milling and most of the consumed cereals therefore only consist of the starch rich endosperm. Vitamins, minerals, fibers and phytochemicals existing in the bran are therefore lost to a great extent (Borneo & Leon, 2012). WGs have a lower energy density and together with the physico-chemical properties such as viscosity and bulking properties, beneficial effects on weight maintenance may be achieved (Nordic Council of Ministers, 2014). In the Scandinavian countries, wheat, rye and oats comprises the cereals that are consumed in greatest amount (Frølich *et al.*, 2013). The consumption of flour and groats have decreased in Sweden with almost 25 % in the period 1960-2012, however bread and pasta consumption has increased with 28 % and 900% respectively during the same period (Jordbruksverket, 2013).

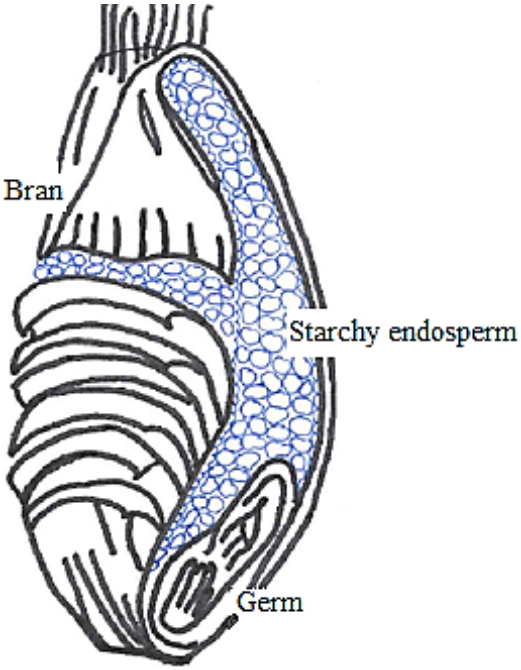

Figure 2: *Anatomical components of a grain, including germ, starchy endosperm and bran. A modification from Marquart (2007)*

A regular intake of WG has been shown to reduce the risk of a number of health diseases and related health problems, such as cardiovascular diseases, strokes, hypertension, diabetes and different forms of cancer (Borneo & Leon, 2012). WG contains many different functional components and dietary fibers. Some examples that are identified to have protective effect against the metabolic syndrome are arabinoxylans, β-glucans, fructans, inulin, resistant starch (Nylander, 2014; Borneo & Leon, 2012). The association between WG intake and weight reduction is uncertain. A meta-analysis with objective to evaluate the impact of WG and refined grains on body weight from randomized controlled trials concludes that WG intake does not decrease body weight (Pol *et al.*, 2013). In total, 2516 articles were screened and of them 26 were used in the analysis. WG had a small effect on body fat which might be a more sensitive measure (Pol *et al.*, 2013). In epidemiological studies, WG have been shown to reduce risk of long-term weight gain. A prospective cohort study with 27 082 healthy men between the age 40 and 75 were followed for 8 years. The study showed an inverse correlation between increased WG consumption (g/day) and weight gain. The dose-response relationship was strongest for foods with more than 25 % WG or bran. A problem with the observational studies is the risk of confounding. The confounding variables are many since a high intake of WG is associated with a healthier overall lifestyle and therefore adjustments for confounding variables must be made in the statistical analyses. All men tended to gain weight during the period (1.9 ± 5.2 kg), but the result

indicated that for every increase of WG with 40 g/day, the long-term gain of weight was reduced with 0.49 kg (Koh-Banerjee *et al.*, 2004). A cohort study with 75 521 women between 38 and 63 years, all registered as nurses; showed during a 10 year follow up a reverse relationship between an increase in WG intake and developing type 2 diabetes. A higher intake of refined grain was simultaneously related to an increased risk of type 2 diabetes. Considerations were made to known risk factors (Liu *et al.*, 2000).

1.7 Dietary fibers

WG contains both digestible carbohydrates such as starch and non-digestible carbohydrates. Non-digestible polysaccharides are either oligosaccharides or non-starch polysaccharides (NSP). The NSPs can be classified after their ability to dissolve in water. The bran part provides both soluble and insoluble NSPs (fibers) (Borneo & Leon, 2012). Cellulose and lignin are examples of insoluble fibers and gums and pectin are soluble fibers (Vaclavik, 2008; Wong & Jenkins, 2007). Dietary fibers constitute components in WG associated with improved health (Borneo & Leon, 2012). The definition for dietary fiber accepted by European Union 2008 includes all types of resistant starch and resistant oligosaccharides (Frølich *et al.*, 2013). Fiber-rich diets have shown to reduce the risk of coronary heart disease (CHD), obesity and certain cancers. β-Glucans for example cause reduction in blood cholesterol and increase satiety (Rebello *et al.*, 2014; Whitehead *et al.*, 2014). Intake of NSPs increases the amount of stool and the production of the short chain fatty acids (SCFA) acetate, propionate and butyrate (Buttriss & Stokes, 2008). SCFA are produced by the gut microflora and there are some evidence that these SCFA affects the health of the host (Tan *et al.*, 2014). WG provides fibers together with many micronutrients, essential fatty acids and some protein which have shown to have positive effect on health (Buttriss & Stokes, 2008).

1.8 Whole grain and fiber intake

The average WG intake for Swedish women is 39 g/day and 46 g/day for men (Amcoff, 2012). The Swedish National Food Agency recommends that WG products are chosen whenever consuming cereal food products. Such a replacement would imply approximate 70 g WG per day for women and 90 g per day for men, which is therefore recommended. Children from two years of age are recommended a diet with both WG and refined cereals. A too high intake of WG and fibers might result in diarrhea (Becker, 2012). No study has been reported where the average intake of WG among Swedish children has been estimated. In the UK, WG intake among children between 1.5 and 5 years of age was estimated to 2.7

g/MJ per day, which is below the recommendations (Mann *et al.*, 2015). Swedish children at the age of 4 have an average energy intake at 6.3 MJ/day (Enghardt Barbieri, 2006). If it is assumed that British children at the same age have the same energy intake as Swedish children then the result of the study conducted in the UK is that the average intake of WG is 17 g/day. In French children, the WG intake was below the recommendations as well. Children of age 3-6 year consumed in average 3 g WG per day (Bellisle *et al.*, 2014). Children from 2 years of age are recommended an intake of dietary fiber at 2-3g/MJ daily. The intake should then gradually increase from about 6 years of age to reach the recommended intake for adults of 25-35 g/day around adolescence (Nordic Council of Ministers, 2014). The average intake of dietary fibers among Swedish 4 year olds is 11 g/day (Enghardt Barbieri, 2006).

1.9 Biomarkers

There are a number of difficulties in estimating WG intake accurately in adults and children. Self-reporting is subjected to biases inherent to under- or overestimation of intake which may stem from difficulties for consumers to recognize WG foods among other cereal foods (van Dam & Hu, 2008; Kaaks, 1997). A biomarker may therefore be suitable to overcome the problems (Ocke & Kaaks, 1997). Alkylresorcinols (AR) are phenolic lipids that are appropriate to use as biomarkers for WG wheat and rye consumption under certain conditions (Landberg *et al.*, 2008). AR are mainly located in the bran fraction of rye, wheat and triticale (>500 µg/g). Barley also contains AR but in a considerably lower amount. AR are specific for wheat, rye and barley and has not been found in rice, oat, maize, millet and sorghum or in any other commonly consumed foods (Ross *et al.*, 2003). Intervention studies have confirmed that plasma AR concentration positively correlates with a greater WG intake (Landberg *et al.*, 2008). No study has been reported where AR have been used as a biomarker of WG intake in children. Before using AR as biomarkers of WG wheat and rye intake among children they need to be validated, i.e. plasma concentrations should be compared with estimated WG intake (although WG intake estimation is not expected to be without errors).

1.10 Early STOPP

A randomized controlled trial (RCT) named Early STOPP (Stockholm Obesity Prevention Program) was initiated 2009, with the objective to find a way in decreasing the number of obese children. The study is ongoing and children before the age of one, with either two overweight or one obese parent were recruited and

were followed for five years. The families taking part in the intervention get professional coaching during the five year period. The trial have several aims, for instance to find out if it is possible to implement a healthier lifestyle in children between 1 and 6 years old. Healthy habits concerns food intake, sleep and physical activity. Preventive actions may be most effective at young years and if Early STOPP is found to be effective, strategies can be implemented to protect children from developing obesity in the future (Svensson, 2014; Sobko *et al.*, 2011).

1.11 Aim

The aim of this BSc- thesis was to estimate the WG- and cereal fiber (CF) intake among children participating in the Early STOPP at 3 years of age. Differences between the intervention and the control group were studied to investigate if the coaching makes a difference in WG- and CF intake among the children. The hypothesis is that the children recruited to the intervention will have a higher WG- and fiber intake as a result of the recurrent coaching. Data on WG intake generated in this project will be used for future studies to evaluate AR as biomarkers of WG wheat and rye intake among children, but this is out of the scope of the current BSc-thesis.

2 Subjects and Methods

2.1 Original study population

In total 242 families were recruited continuously during 2013 to Early STOPP. In total, 182 high-risk families and 60 low-risk families were included. The recruitment took place at CHC within Stockholm County before the infants reached the age of one. Half of the recruited families took part of the intervention and got professional coaching four times during the first year and two times per year the following four years. The other half did not get any coaching. Moreover, a reference group with parents at normal weight (low risk group) was also recruited for comparisons. The families belonging to the reference group did not get any coaching. The coaching consisted of individual coaching for the parents in their home, concerning energy intake and expenditure as well as sleeping behaviors for their children (Svensson, 2014). Raw data for the Early STOPP study used for the current thesis was collected by the investigator team at Karolinska Institutet.

2.2 Registration of diet

In conjunction with the three year old follow up, 97 families handed in food diaries. The families were instructed to fill in the diaries during four consecutive days and either start on a Thursday or a Saturday, to get information on food and drink intake on both workdays and weekends. During the collection of material, three diaries were not found and one was extremely incomplete and therefore excluded. In total, 93 food diaries were therefore used and processed and regarded as the study population. Table 1 shows the characteristics of the study population included in this thesis. Most of the families have followed the instructions. To improve the estimation of volume and weight of the foods, the parents had a portion guide for assistance. The parents were told to inform the daycare staff and other persons

taking care of their child during the four days period about the study and ask them to contribute.

Table 1. *Characteristics of the study population included in this thesis.*

	Intervention (high-risk)	Control (high-risk)	Referens (low-risk)
N	36	29	28
Child gender (% boys)	47	59	43
Child gender (% girls)	53	41	57
Child BMI	16.2 ± 1.2	16.5 ± 1.6	16.3 ± 1.2
Maternal BMI	30.0 ± 6.2	31.8 ± 6.0	22.3 ± 2.1
Paternal BMI	28.2 ± 4.3	29.8 ± 5.3	22.9 ± 1.3

From the food diaries all cereal- based products and amounts were extracted by manually. Cereal-based products include products containing wheat, rye, barley, oat, maize, rice, millet and sorghum. For every product the reported intake was converted from household measure, volume and amount into weight in g by using standard measures as defined in "Nyckel till Portionsguide" by SLV (Livsmedelsverket, 2009). In total, 98 products were identified. CF content, total WG content and WG content from rye, wheat and barley (WG separate) for each product was collected from producers' websites and by contacting the companies. Reported amounts of products and whole grain and dietary fiber contents were then used to calculate the intake for each individual and registration day. For cereal based products such as pancakes, pizza, pie and waffles standard recipes were used to convert the available information to amount flour. Information about standard mixes of gruel and porridges from the producers was used to convert the available amount in volume into weight for the specific powders. To estimate the intake of WG from bread the same portion guides as the parents had access to where used. In most cases detailed information about name and brand of the bread was reported in the diaries. In cases where general product categories were reported such as "crisp bread", a mean value for all crisp breads reported in the study was used (Husman, Rågi, Delikatess, Falu Rågrut and Havre). The same method was used to convert information about gruel, were either year or brand were unknown. It was assumed that Nestlé and Semper were the most probable brands of gruel and that of the products mentioned by others were more likely than others available on the market. The dry matter was calculated by difference based on

reported macronutrients for each product. The content which did not correspond to protein, fat, carbohydrates, fiber or salt was supposed to be water.

2.3 Statistical analyses

Differences in dietary fiber, whole grain intake and BMI between treatment groups were investigated with General linear model (GLM). Differences between groups were also investigated with models where gender was included. Linear regression analysis was conducted where child BMI was the dependent variable and WG intake (total or separate grains) or total CF was entered as an independent variable along with parents BMI and treatment. Correlation coefficients were calculated for continuous variables. Statistical analyses were executed with Minitab version 16. A p-value <0.05 was considered statistically significant.

3 Results

The mean intake of WG in the whole study population was 16.8 g/day and the mean intake of CF was 5.4 g/day. No statistically significant difference was observed for total WG intake or intakes of separate cereals (rye, wheat, barley) or CF intake between groups (P>0.05). The average intake of CF, WG and WG separate for each group can be seen in Table 2 and 3. A significant difference in WG intake between boys and girls in the intervention group was observed (Table 3).

Table 2. *The mean intake (g/day) of CF, WG total and WG separate (rye, wheat and barley) for each group.*

	Intervention (high-risk)	Control (high-risk)	Referens (low-risk)	Total	*p-value*
Intake (g/day)					
CF	5.2 ± 2.2	5.1 ± 1.8	6.0 ± 2.2	5.4 ± 2.1	0.23
Total WG	15.4 ± 13.0	15.7 ± 5.6	19.8 ± 13.8	16.8 ± 11.6	0.26
WG (separate)	7.0 ± 5.4	8.3 ± 4.8	10.1 ± 7.5	8.4 ± 6.1	0.13

Table 3. *The mean intake (g/day) of CF, WG total and WG separate (rye, wheat and barley) for each group and gender. Different letters within each intake category indicate statistically significant differences, as evaluated by a post hoc t-test.*

	Intervention (high-risk)		Control (high-risk)		Referens (low-risk)		Total	
Intake (g/day)	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
CF	5.4[a]	5.0[a]	5.1[a]	5.2[a]	6.6[a]	5.5[a]	5.6	5.2
Total WG	20.2[a]	11.0[b]	15.5[a]	16.0[a]	23.8[a]	16.9[a]	19.4	14.3
WG (separate)	8.5[a]	5.7[a]	7.4[a]	9.7[a]	12.0[a]	8.7[a]	9.0	7.7

Multiple linear regression analysis was used to evaluate the effects of total CF intake, gender and group on BMI at the age of 3. The model was not significant, i.e. none of the factors included explained variation in child BMI at 3 years of age (Table 4). Multiple linear regression analysis was used to evaluate the effect of WG respectively separate WG intake, gender and group on the BMI as well (Table 4).

Table 4. P-values for factors included in multiple linear regression models where BMI at age was the independent variable.

Predictor		BMI child	
		Beta	p-value
Model 1	Group	-0,42	0,15
	Gender	-0,25	0,59
	CF intake	0,18	0,10
Model 2	Group	-0,39	0,19
	Gender	-0,20	0,67
	WG intake	0,02	0,28
Model 3	Group	-0,39	0,18
	Gender	-0,24	0,59
	WG separate intake	0,05	0,16

The correlation between CF and WG intake was well correlated (r=0.71, P<0.001) and the correlation between total WG intake and separate WG intake as well (r=0.70, P<0.001). The BMI of the children showed no statistically significant correlation to the BMI of the mothers (r=0.13, P=0.200) but a significant but weak correlation to the BMI of the fathers (r=0.24, P=0.02). No significant correlation between the parents was observed (r=0.13 P=0.20).

4 Discussion

The average intake of WG in the whole study population was 16.8 g/day. The average intake among Swedish children has not been estimated before. The result seems to be trustworthy compared to studies from other countries. Intake at the same level (17 g/day) have been reported in the UK (Mann *et al.*, 2015). Studies conducted in France on children at about the same age have on the other hand reported much lower intake, 3 g/day (Bellisle *et al.*, 2014). Crucial for the result is the commitment of the parents. Estimations are necessary when the reported information is insufficient. To minimize the loss of information conversations with the parents related to the submission of the food diary can be successful. Swedish National Food Agency recommends adults to consume WG products whenever consuming cereals, such a replacement corresponds to a WG intake at 70 g for women and 90 g for men (Becker, 2012). The intake among the children at 16.8 g/day is therefore considered reasonable. The intake of WG specifically from wheat, rye and barley corresponds to about 50 % of the total WG intake in all three groups.

The calculated cereal fiber intake for the whole study population was 5.4 g/day. It is important to note that only the fiber intake from cereals was estimated. The children probably ingested fibers from other sources as well. According to SLV the main sources of dietary fibers in the adult population is bread (28 %), vegetables (12 %), fruits and berries (11 %), potatoes (11 %) and flakes (5 %) (Amcoff, 2012). Children from 2 years of age are recommended a daily intake of dietary fiber at 2-3 g/MJ (Nordic Council of Ministers, 2014). The average total energy intake among Swedish 4 years old are 6.3 MJ/day (Enghardt Barbieri, 2006). The recommendation (2-3 g/MJ) corresponds therefore to about 13-19 g dietary fiber per day. The intake of CF in the study population (3 years old) at 5.4 g/day is considered to be in line with the recommendations if it is assumed that less than half of the dietary fiber intake comes from cereals. The dietary fiber intake among

Swedish children of 4 years of age have previously been estimated to 11 g/day (Enghardt Barbieri, 2006).

No significant differences in cereal fiber intake or intake of total whole grains or whole grain from rye, wheat or barley was found between the intervention groups in children at the 3 year follow up. The coaching did not seem to improve the total intake of CF and WG for children at this age. The intake was independent of gender. The significant difference in WG intake between boys and girls in the intervention group might be explained by a difference in total energy intake. The total energy intake of the study population has not been calculated and therefore assumptions regarding the proportion (g/MJ) of WG and CF intake are not possible. Two coaching occasions per year may be too little to have any impact on CF and WG intake in the long run. The intake of CF and WG was generally low among the general Swedish adult population and SLV recommends an increased intake (Amcoff, 2012).

There was no significant effect of gender, group and total CF intake on the children's BMI at the 3 year follow up. Neither was there any effect on total WG or separate WG, gender and group on the BMI. The relationship between WG intake and weight reduction are assessed as uncertain. A meta-analysis concluded that WG did not lead to significant decrease in body weight among adults (Pol *et al.*, 2013). WG have shown to reduce risk of long-term weight gain in epidemiological studies (Koh-Banerjee *et al.*, 2004). The risk of confounding in observational studies is a major problem that may explain the differences in results between epidemiological studies and interventions. A high intake of WG is associated with a healthier life overall (Koh-Banerjee *et al.*, 2004) and even if this is taken into account statistically, the result might be affected by residual confounding. A high BMI is better explained by general dietary patterns then specific nutrients (Ambrosini, 2014).

The results are only based on the situation for children at their three year follow up. It would have been interesting to look at the development between 1-3 year as well regarding change in WG intake and BMI. Early STOPP continues for two more years and after that, a final evaluation of the effect of coaching can be made. Even if an increased WG intake does not lead to decrease in BMI it could have other positive effects, such as affect body fat content. WG and dietary fiber have been shown to reduce the risk of cardiovascular disease, hypertension, diabetes and certain cancers as well as increase satiety (Rebello *et al.*, 2014; Whitehead *et al.*, 2014; Borneo & Leon, 2012). These effects have been shown, independently of body weight. It is therefore desirable to advocate a high intake of WG and die-

tary fibers. Since prevalence of childhood obesity in Sweden seems to have leveled off during the last years (Barnhälsovårdsenheterna i Stockholms län, 2014; Lissner *et al.*, 2010). The situation is not as acute as in other regions (World Health Organization, 2014b).

In the present study, food diaries were used to estimate whole grain intake and cereal fiber intake. The information from the food diaries has been interpreted and sources of errors might be miss-understanding and incorrect assumptions. The drop out was large since only 97 of in total 242 families handed over the food diary (at 3 year follow up). The parents might also have missed to fill in some information or for example misjudged the amount. As a complement to traditional dietary assessment used, AR could be used as a biomarker to reflect whole grain intake rye, wheat and barley. No study has evaluated or used AR as a biomarker among children. In the current population, children got 50% of the WG intake from wheat, rye and barley. AR is only present in wheat, rye and barley and, therefore, it is uncertain to what degree AR would capture whole grain intake in this population.

More work is needed to decrease the prevalence of childhood obesity in Sweden to acceptable levels (Lissner *et al.*, 2010). Even if WG not have been shown to decrease body weight, an increased intake of WG is to be recommended among children at high risk of obesity. Not least due to the effect of WG on a number of diseases associated with obesity.

References

AACC International (2015). *Whole grains*. http://www.aaccnet.org/initiatives/definitions/Pages/WholeGrain.aspx [2015-05-14].

Ambrosini, G.L. (2014). Childhood dietary patterns and later obesity: a review of the evidence. *Proceedings of the Nutrition Society*, 73(01), pp. 137-146.

Amcoff, E.E., A.; Enghardt Barbieri, H.; Lindroos, A. K.; Nälsén, C.; Pearson, M.; Warensjö Lemming, E. (2012). *Riksmaten - vuxna 2010-11 Livsmedels-och näringsintag bland vuxna i Sverige*: National Food Agency, Sweden.

Barnhälsovårdsenheterna i Stockholms län (2014). *Barnhälsovård årsrapport 2013*.

Becker, W.B., L.; Mattisson, I.; Sand, S. (2012). *Råd om fullkorn 2009 -bakgrund och vetenskapligt underlag*: National Food Agency, Sweden.

Bellisle, F., Hébel, P., Colin, J., Reyé, B. & Hopkins, S. (2014). Consumption of whole grains in French children, adolescents and adults. *British Journal of Nutrition*, 112(10), pp. 1674-1684.

Borneo, R. & Leon, A.E. (2012). Whole grain cereals: functional components and health benefits. *Food & Function*, 3(2), pp. 110-119.

Buttriss, J.L. & Stokes, C.S. (2008). Dietary fibre and health: an overview. *Nutrition Bulletin*, 33(3), pp. 186-200.

Cattaneo, A., Monasta, L., Stamatakis, E., Lioret, S., Castetbon, K., Frenken, F., Manios, Y., Moschonis, G., Savva, S., Zaborskis, A., Rito, A.I., Nanu, M., Vignerova, J., Caroli, M., Ludvigsson, J., Koch, F.S., Serra-Majem, L., Szponar, L., van Lenthe, F. & Brug, J. (2010). Overweight and obesity in infants and pre-school children in the European Union: a review of existing data. *Obesity Reviews*, 11(5), pp. 389-98.

Davison, K.K., Francis, L.A. & Birch, L.L. (2005). Reexamining obesigenic families: parents' obesity-related behaviors predict girls' change in BMI. *Obesity research*, 13(11), pp. 1980-1990.

Dietz, W.H. (1998). Health consequences of obesity in youth: childhood predictors of adult disease. *Pediatrics*, 101(Supplement 2), pp. 518-525.

Dubois, L., Ohm Kyvik, K., Girard, M., Tatone-Tokuda, F., Perusse, D., Hjelmborg, J., Skytthe, A., Rasmussen, F., Wright, M.J., Lichtenstein, P. & Martin, N.G. (2012). Genetic and environmental contributions to weight, height, and BMI from birth to 19 years of age: an international study of over 12,000 twin pairs. *Public Library of Science One*, 7(2), p.30153.

Enghardt Barbieri, H.P., Monika.; Becker, W. (2006). *Riksmaten - barn 2003 Livsmedels- och näringsintag bland barn i Sverige*: National Food Agency, Sweden.

Franks, P.W., Hanson, R.L., Knowler, W.C., Sievers, M.L., Bennett, P.H. & Looker, H.C. (2010). Childhood obesity, other cardiovascular risk factors, and premature death. *New England Journal of Medicine*, 362(6), pp. 485-493.

Frølich, W. & Åman, P. (2010). Whole grain for whom and why? *Food & Nutrition Research*, 54.

Frølich, W., Åman, P. & Tetens, I. (2013). Whole grain foods and health – a Scandinavian perspective. *Food & Nutrition Research*, 57.

Jordbruksverket (2013). *Sveriges offeciella statistik Livsmedelskonsumtion och näringsinnehåll*. http://www.jordbruksverket.se/webdav/files/SJV/Amnesomraden/Statistik,%20fakta/Livsmedel/JO44SM1401/JO44SM1401/JO44SM1401_tabeller2.htm [2015-05-14].

Kaaks, R.J. (1997). Biochemical markers as additional measurements in studies of the accuracy of dietary questionnaire measurements: conceptual issues. *The American Journal of Clinical Nutrtion*, 65(4 Suppl), pp. 1232-1239.

Kelder, S.H., Perry, C.L., Klepp, K.I. & Lytle, L.L. (1994). Longitudinal tracking of adolescent smoking, physical activity, and food choice behaviors. *American Journal of Public Health*, 84(7), pp. 1121-6.

Koh-Banerjee, P., Franz, M., Sampson, L., Liu, S., Jacobs, D.R., Jr., Spiegelman, D., Willett, W. & Rimm, E. (2004). Changes in whole-grain, bran, and cereal fiber consumption in relation to 8-y weight gain among men. *The American Journal of Clinical Nutrtion*, 80(5), pp. 1237-45.

Landberg, R., Kamal-Eldin, A., Andersson, A., Vessby, B. & Åman, P. (2008). Alkylresorcinols as biomarkers of whole-grain wheat and rye intake: plasma concentration and intake estimated from dietary records. *The American Journal of Clinical Nutrition*, 87(4), pp. 832-838.

Lissner, L., Sohlström, A., Sundblom, E. & Sjöberg, A. (2010). Trends in overweight and obesity in Swedish schoolchildren 1999–2005: has the epidemic reached a plateau? *Obesity Reviews*, 11(8), pp. 553-559.

Liu, S., Manson, J.E., Stampfer, M.J., Hu, F.B., Giovannucci, E., Colditz, G.A., Hennekens, C.H. & Willett, W.C. (2000). A prospective study of whole-grain intake and risk of type 2 diabetes mellitus in US women. *American Journal of Public Health*, 90(9), pp. 1409-1415.

Livsmedelsverket (2009). *Nyckel till Portionsguide*.

Maffeis, C. (2000). Aetiology of overweight and obesity in children and adolescents. *European Journal of Pediatrics*, 159(1), pp. 35-44.

Mann, K.D., Pearce, M.S., McKevith, B., Thielecke, F. & Seal, C.J. (2015). Low whole grain intake in the UK: results from the National Diet and Nutrition Survey rolling programme 2008-11. *British Journal of Nutrition*, pp. 1-9.

Marquart, L.J.J., D. R.; McIntosh, G. H.; Poutanen, K.; Reicks, M. (2007). *Whole grains & health*: Blackwell Publishing Ltd.

Morandi, A., Meyre, D., Lobbens, S., Kleinman, K., Kaakinen, M., Rifas-Shiman, S.L., Vatin, V., Gaget, S., Pouta, A., Hartikainen, A.L., Laitinen, J., Ruokonen, A., Das, S., Khan, A.A., Elliott, P., Maffeis, C., Gillman, M.W., Jarvelin, M.R. & Froguel, P. (2012). Estimation of newborn risk for child or adolescent obesity: lessons from longitudinal birth cohorts. *Public Library of Science One*, 7(11).

Nordic Council of Ministers (2014). *Nordic Nutrition Recommendations 2012*. Available from: http://dx.doi.org/10.6027/Nord2014-002 [2015-05-16].

Nylander, A.J., L.; Marklinder, I.; Nydahl,M. (2014). *Livsmedelsvetenska* 2:2. Studentlitteratur.

Ocke, M.C. & Kaaks, R.J. (1997). Biochemical markers as additional measurements in dietary validity studies: application of the method of triads with examples from the European Prospective Investigation into Cancer and Nutrition. *The American Journal of Clinical Nutrition*, 65(4 Suppl), pp. 1240-1245.

Pol, K., Christensen, R., Bartels, E.M., Raben, A., Tetens, I. & Kristensen, M. (2013). Whole grain and body weight changes in apparently healthy adults: a systematic review and meta-analysis of randomized controlled studies. *The American Journal of Clinical Nutrition*, 98(4), pp. 872-84.

Rebello, C., Chu, Y.-F., Johnson, W., Martin, C., Han, H., Bordenave, N., Shi, Y., O'Shea, M. & Greenway, F. (2014). The role of meal viscosity and oat beta-glucan characteristics in human appetite control: a randomized crossover trial. *Nutrition Journal*, 13(1), p. 49.

Reilly, J.J., Methven, E., McDowell, Z.C., Hacking, B., Alexander, D., Stewart, L. & Kelnar, C.J. (2003). Health consequences of obesity. *Archives of Disease in Childhood*, 88(9), pp. 748-52.

Rooney, B.L., Mathiason, M.A. & Schauberger, C.W. (2011). Predictors of obesity in childhood, adolescence, and adulthood in a birth cohort. *Matern Child Health Journal*, 15(8), pp. 1166-75.

Ross, A.B., Shepherd, M.J., Schüpphaus, M., Sinclair, V., Alfaro, B., Kamal-Eldin, A. & Åman, P. (2003). Alkylresorcinols in Cereals and Cereal Products. *Journal of Agricultural and Food Chemistry*, 51(14), pp. 4111-4118.

Scaglioni, S., Salvioni, M. & Galimberti, C. (2008). Influence of parental attitudes in the development of children eating behaviour. *British Journal of Nutrition*, 99, pp. 22-25.
Skelton, J.A., Irby, M.B., Grzywacz, J. & Miller, G. (2011). Etiologies of obesity in children: Nature and Nurture. *Pediatric clinics of North America*, 58(6), pp. 1333-1354.
Sobko, T., Svensson, V., Ek, A., Ekstedt, M., Karlsson, H., Johansson, E., Cao, Y., Hagstromer, M. & Marcus, C. (2011). A randomised controlled trial for overweight and obese parents to prevent childhood obesity - Early STOPP (STockholm Obesity Prevention Program). *BMC Public Health*, 11(1), p. 336.
Svensson, V. (2014). *Family-related obesity risk factors and dietary behaviours in high-risk populations: associations with child weight development.* Diss.: Karolinska Institutet, Stockholm.
Sørensen, T.I., Price, R.A., Stunkard, A.J. & Schulsinger, F. (1989). Genetics of obesity in adult adoptees and their biological siblings. *BMJ : British Medical Journal*, 298(6666), pp. 87-90.
Tan, J., McKenzie, C., Potamitis, M., Thorburn, A.N., Mackay, C.R. & Macia, L. (2014). Chapter three - The role of short-chain fatty acids in health and disease. in: Frederick, W.A. (ed. *Advances in Immunology*Volume 121) Academic Press, pp. 91-119. Available from: http://www.sciencedirect.com/science/article/pii/B9780128001004000039.
Vaclavik, V.A.C., E. W. (2008). *Essentials of Food Science*: Springer Science.
van Dam, R.M. & Hu, F.B. (2008). Are alkylresorcinols accurate biomarkers for whole grain intake? *The American Journal of Clinical Nutrition*, 87(4), pp. 797-798.
van de Vijver, L.P., van den Bosch, L.M., van den Brandt, P.A. & Goldbohm, R.A. (2009). Whole-grain consumption, dietary fibre intake and body mass index in the Netherlands cohort study. *European Journal of Clinical Nutrition*, 63(1), pp. 31-8.
Whitaker, R.C. (2004). Predicting preschooler obesity at birth: the role of maternal obesity in early pregnancy. *Pediatrics*, 114(1), pp. 29-36.
Whitehead, A., Beck, E.J., Tosh, S. & Wolever, T.M. (2014). Cholesterol-lowering effects of oat beta-glucan: a meta-analysis of randomized controlled trials. *The American Journal of Clinical Nutrition*, 100(6), pp. 1413-21.
Wong, J.M.W. & Jenkins, D.J.A. (2007). Carbohydrate Digestibility and Metabolic Effects. *The Journal of Nutrition*, 137(11), pp. 2539-2546.
World Health Organization (2013). *World health statistics 2013*
World Health Organization (2014a). *Countries vow to combat malnutrition through firm policies and actions*. http://www.who.int/mediacentre/news/releases/2014/icn2-nutrition/en/ [2015-05-14].
World Health Organization (2014b). *Facts and figures on childhood obesity*. http://www.who.int/end-childhood-obesity/facts/en/ [2015-05-14].
World Health Organization (2014c). *Obesity data by WHO region*. http://apps.who.int/gho/data/view.main.2480A?lang=en [2015-05-14].
World Health Organization (2014d). *WHO and FAO announce second International Conference on Nutrition*. http://www.who.int/nutrition/topics/WHO_FAO_ICN2_videos_malnutrition/en/ [2015-05-14].
World Health Organization (2015). *Obesity and overweight*. http://www.who.int/mediacentre/factsheets/fs311/en/ [2015-05-14].