Characteristics of adolescent boys using protein supplements

Diet, Lifestyle and Health
HLÍF: HEALTH AND LIFESTYLE IN HIGH-SCHOOL

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Thesis for the degree of Master of Public Health Sciences
University of Iceland
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HÁSKÓLI ÍSLANDS

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Abstract

Background: Icelandic diet has always been rich in proteins, but choice of protein sources have been changing partly due to strong beliefs related to the roles described to protein supplements suggesting an influence on body composition and health. Protein supplements are among the most commonly used ergogenic aids and their popularity has been increasing in recent years. The aim of this study was to examine their use among 18 years old high-school boys in Reykjavík, in accordance with their diet, lifestyle and health.

Methods: A cross-sectional study on health and lifestyle of 18-year olds (n=137 boys) was undertaken in three high-schools in Reykjavik. Data consisted of lifestyle- and food frequency questionnaires, 24-h-dietary recalls, graded treadmill test for fitness (VO_2max), anthropometric measurements along with Dual-energy X-ray absorptiometry scan (DXA), blood samples from fasting serum levels of triglycerides, total cholesterol (TC), Low-density lipoprotein (LDL), High-density lipoprotein (HDL), insulin, glucose and C-reactive protein (CRP) as well as resting blood pressure. Participants were divided into three groups based on the answers in the question: "How often do you consume protein bars, -powder or –drinks" i.e. protein consumers (PC) using protein supplements at least 1 day/week, occasional consumers (OC) using protein supplements less than once a week, and non-consumers (NC) consuming no protein supplements at all.

Results: Almost 31% boys consumed protein supplements at least 1 day/week. There was no significant difference in overall energy intake but PC had higher protein intake than NC and OC (2.1±1.0 vs. 1.5±0.6g/kg and 1.8±0.7, p=0.001). PC got significantly more vitamins from their diet than NC and OC. PC consumed more skyr than NC (129 g vs 44 g) but less than OC (154 g/d), p=0.013 like, PC they consumed more protein supplements than OC (350 g/day vs. 29 g/day), p<0.001. Significantly more PC felt they needed more nutrition knowledge than NC (p=0.026). PC and OC counted more on friends as a source of knowledge than NC (p=0.030), whose parents were their greatest knowledge source, compared to PC (p=0.042). More PC claimed they tried to eat healthier than NC and OC, and most of PC disagreed with the statement that they did not see the point thinking about their diet. PC were also more likely to exercise with a sport club or in a fitness centre than NC and OC. PC felt their fitness was better compared to NC and OC. PC had a lower body fat (17.1±6.3 vs. 21.7±8.0, p=0.002), and wished to be 6.4% heavier, compared with NC and OC who wanted to keep their weight (p=0.017). Diastolic pressure was lower among PC than OC and

NC as well as mean arterial pressure (MAP), TC and LDL. OC had a greater outcome from the VO_2max test than PC and NC.

Conclusion: Use of protein supplements is quite common. The main reasons seem to be associated with their wishes/efforts to gain weight and muscles.

Ágrip

Bakgrunnur: Prótínríkt fæði hefur ávallt verið hluti af íslensku mataræði. Prótín, bæði úr mat og prótínríkum vörum á formi fæðubótarefna eru notuð til vöðvauppbyggingar og hafa vinsældir þeirra farið vaxandi á undanförnum árum. Markmið þessarar rannsóknar var að skoða hvað einkennir unglingsstráka sem neyta prótíns á formi fæðubótarefna þar sem skoðaðir voru þættir tengdir næringu og næringarmynstri þeirra, lífsstíl og heilsu.

Aðferðir: Þversniðsrannsókn á heilsu og lífsstíl 18 ára ungmenna (n= 137 strákar) var gerð í þremur framhaldsskólum í Reykjavík. Gögnin innihéldu spurningar um lífsstíl og næringu, sólarhringsupprifjun á mataræði, þolpróf (VO_2max), ýmsar holdafarsmælingar – m.a. tvíorku röntgengeislagleypnimælingu (DXA-skönnun) – og blóðmælingar þar sem þríglýseríð, heildarkólesteról, LDL-kólesteról og HDL-kólesteról, insúlín og glúkósi voru mæld ásamt blóðþrýstingi. Þátttakendum var skipt í þrennt út frá spurningum um neyslu prótínbætiefna; PC – þeir sem nota prótínbætiefni a.m.k einu sinni í viku, OC – þeir sem neyta prótín bætiefna sjaldnar en einu sinni í viku og NC þeir sem aldrei taka inn prótínbætiefni. Næringarefni voru metin út frá sólarhringsupprifjun.

Niðurstöður: Rétt tæp 31% drengjanna neyttu prótínbætiefna a.m.k. einu sinni í viku. Ekki var marktækur munur hjá hópunum hvað varðaði heildarorkuinntöku en PC neytti meira af prótínum en NC og OC (2.1±1.0 vs. 1.5±0.6g/kg og 1.8±0.7, p=0.001). PC fékk marktækt meira af vítamínum úr sinni fæðu en NC og OC. Jafnframt borðaði PC meira af skyri en NC (129 g vs 44 g) en minna en OC (154 g/d), p=0.013 auk þess sem PC tók inn meira af prótínbætiefnum en OC (350 g/dag vs. 29 g/dag), p<0.001. Marktækt fleirum í hópi PC fannst þeir þurfa meiri fræðslu í næringarfræði en í NC hópnum (p=0,026). PC og OC nefndu frekar vini sem þá sem þeir fengju þekkingu um næringu frá en NC sem töldu foreldra helst gefa sér næringarupplýsingar. PC voru líklegri en NC til að stunda íþróttir með íþróttafélagi eða í líkamsræktarstöð. PC töldu sig frekar vera í góðu formi en NC og OC. Neðri mörk blóðþrýstingsins voru lægri hjá PC en NC (p=0,009) sem og meðalslagbilsþrýstingur (MAP) (p=0,042), heildarkólesteról (p=0,003) og LDL (p=0,004). PC var með lægri líkamsfitu (17.1±6.3 vs. 21.7±8.0, p=0.002), og óskaði þess að vera 6.4% þyngri, miðað við NC og OC sem voru ánægðir með þyngd sína (p=0.017). Neðri mörk blóðþrýstingsins voru lægri hjá PC miðað við OC og NC sem og meðal slagbilsþrýstingurinn (MAP), TC og LDL. OC kom betur út úr þolprófum en PC og NC.

Ályktun: Notkun prótínbætiefna er algeng hjá 18 ára unglingspiltum. Ástæða þess virðist einkum vera áhugi á þyngdaraukningu þar sem drengirnir trúa að prótín á formi fæðubótarefna hafi áhrif á líkamssamsetningu og heilsu.

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1 Introduction

The Icelandic diet has always been rich in proteins, but choice of protein sources have been changing partly due to strong beliefs related to the roles described to protein supplements.[1-3] Protein supplements are among the most commonly used ergogenic aids,[4] and their popularity and use have been increasing in recent years.[5,6] Protein supplement intake is often associated with high level of physical activity and many myths and beliefs have been linked with protein supplement use and its effects.[7] Even though it has been emphasised that food is the best source of nutrition for healthy adolescents,[8] beliefs have been reported as a strong predictor of intentions to use dietary supplements[9] but more nutrition knowledge has been associated with less supplement use.[10] Eighteen years old adolescents are growing adults. They have just reached the age of majority but their independence is not complete since most of them still live at home, and therefore, have to abide their parents' rules and eat what is prepared for each meal.[11-13] It is a time of major changes whether they are biological, cognitive or sociocultural.[14] During the adolescent years, a person's lifestyle changes along with their food habits as their independence increases.[11,12] Adolescents spend a lot of time outside their homes, which influences their dietary behaviour.[11,13] Nutrition during adolescents is very important and energy needs are different depending upon gender, body composition, physical activity and growth.[13] It has been verified that dietary behaviours develop in childhood[15] and may influence adult life and health.[16]

Adolescence is also a time of struggles, finding who one is and what one stands for, whilst at the same time looking for acceptance from their friends and peers.[14] Many food and health choices are affected by the opinions and behaviour of their friends.[13] Nutrition knowledge is important for adolescents to be more critical about what they learn, hear and read about nutrition as well to make their own choices in food consumption without getting influenced by nutritional myths.[17]

The main purpose of this thesis was to study characteristics of adolescent boys, who consume protein supplements, and its association with their diet, knowledge and attitude towards nutrition as well as lifestyle and general health. Lifestyle factors such as nutrition (food items consumed, nutrients, physical activity, general health (blood pressure,

triglycerides, total cholesterol, LDL, HDL, insulin, glucose, C-reactive protein (CRP), fitness (VO_2max)), as well as questions about their own attitude towards their physical health and body image, were examined. To my knowledge characteristics of protein supplements users as they appear in this thesis have not been studied as thoroughly as in this thesis before. Therefore it is intriguing to see whether boys who consume protein supplements differ from non-consumers, both in their dietary choices and health. To answer these questions, 24-h recall, questions about physical activity and health, attitude towards nutrition, as well as variables approaching physical condition, including body composition and blood samples, were investigated.

2 Literature review

2.1 Nutrition recommendations and nutrients

2.1.1 Nordic Nutrition Recommendations

Nutritionists in the Nordic countries have worked together for the past decades in setting guidelines for recommended intakes of nutrients and dietary composition.[18] At first the main objective of the recommendations was to prevent deficiency disorders but deaths due to vitamin and mineral deficiency were common in the past before it was discovered that vitamins and mineral were vital components of the diet. Nowadays the main focus of the recommendations is no longer on the deficiency disorders but rather on maintaining good health and preventing major chronic diseases.[18] The first official Nordic Nutrition Recommendations (NNR) were published in 1980, where the main goal was to reduce consumption of fat and increase consumption of carbohydrates and fibre.[18] The latest edition (4th edition) was published in 2004 and was updated according to the newest researches and a chapter about physical activity was added.[18] NNR are an important basis for various usage such as planning diets for groups, teaching nutrition information, food and nutrition policy, and for the evaluation of dietary intake.[18] Iceland is a part of the NNR, but special Icelandic recommendations have also been developed.[19]

2.1.2 Nutrition recommendations in Iceland

The first nutritional recommendations were published in 1987[20] by the Nutrition Council of Iceland. The nutritional recommendations were published in order to promote a better health for the nation. At that time, the Icelandic Nutrition Council thought the NNR were suggesting too rapid change in fat and salt consumption for Icelanders in one step. Therefore, the Icelandic recommendations allowed for relatively more fat and salt than the NNR. These first recommendations were for public use as well as being an important tool for institution such as at hospitals, homes for the elderly, schools and canteens, and for the food industry.[20] The main purpose of these recommendations was to encourage people to have diversity in their food choices from the four food categories: grains; milk products; vegetables and fruits; meat; fish and eggs. It also had the purpose of directing the public towards lower fat consumption, especially from saturated fat by using oils and unsaturated fats instead, as well as to reduce

added sugar intake and watch salt consumption. The public was also encouraged to consume cod liver oil every day as a source of Vitamin D.[20]

In spring 1989 the Icelandic government and the parliament accepted a *Nutrition and consumer policy for Icelanders*.[21] The National nutrition policy was followed by the development of the so-called nutritional goals and a nationwide research on the diet of Icelanders in 1990.[21] The second edition of the recommendations was published in 1994.[22] These recommendations continued reducing fat in the diet with even more challenging changes for the public. In the 1987 recommendations,[20] it was recommended that no more than 35E% should come from fat and the proportion of mono- and polyunsaturated fats should add up to 40E% of the total fat energy. Protein was suggested to be at least 10E%.[21] In 1994 total energy of fat was changed to 25-35E%, thereof no more than 15E% from saturated fat. No changes were done for the total energy of proteins, still ≥10E%.[22] With these new recommendations the food circle was also introduced, which showed the recommendations graphically.[22] In 2006, the Public Health Institute of Iceland published the 3rd edition of the dietary recommendations.[19] These recommendations have the same goals as the first two, mainly health promotion and to encourage people to eat healthy, but were divided into food based recommendations including recommendations on physical activity. In those new recommendations, the total energy from proteins was changed to 10-20E%.[19] The new recommendations were in line with NNR 2004[18] and more detailed than before. The food based dietary guidelines are general and approachable for the public,[19] as can be seen in Table 1.

Table 1 - Food based dietary guidelines

Consume a variety of foods
Vegetables and fruits 500 g a day or 5 a day
Fish at least twice a week
Bread (≥6g fibre) and other wholegrain foods
Low fat milk products - two portions a day (or 500 g)
Oil or soft fat instead of saturated fats
Moderate salt consumption
Cod liver oil or other Vitamin D source
Drink water
Watch the weight
Eat moderate amounts
Exercise daily

2.2 Nutrition knowledge and beliefs

Findings in recent studies suggest that adolescents and young adults have significant amount of knowledge about nutrition and know the difference between a healthy and an unhealthy diet.[23-25] Adolescents believe that healthy eating involves moderation, balance and variety. Despite this knowledge they find it difficult to eat healthy and often consume food that is known to be unhealthy and they do not follow healthy eating recommendations.[1,2,24,25]

Girls seem to have better control over their diet and more nutrition knowledge than boys.[24,26,27] They have been reported to have healthier eating habits, lower consumption of dietary fat and they consume more fruits and vegetables as well as having a diet richer in fibre than boys.[24,26] Velazquez et al.[28] found an association between adolescents' perceptions of dietary practices and their dietary behaviour. Adolescents consuming foods with higher fat content were more likely to have predominately unhealthy food habits compared to adolescents eating foods with lower fat content.[28] Adolescents with high perceived healthiness scored high on the healthy eating index[29] and low on the unhealthy eating index compared to adolescents with low perceived healthiness.[28] When looking at studies involving healthy or balanced diet, most of the studies focus on fruit and vegetables along with fats, as seen above, but protein does not get much attention as an important part of a balanced diet. In a review article, more nutrition knowledge was associated with less supplement use in general.[10]

Davys' et al.[23] reported in 2006 in a study of undergraduate college students that most of their knowledge came from their family, through education, the media (magazines, newspapers, television and books) and friends. A significant difference was found between gender in the research, where more females claimed that they got most of their knowledge from family and magazines.[23] Davys´ findings[23] were in line with Freisling et al.[30] where older adolescent girls reported magazine articles and booklets as the sources they used most, as well as TV programmes, family/friends, and school. The internet was in 9th place of 13.[30] Other studies have reported that a majority of people seek information about health and nutrition on the internet nowadays.[31-33] In a recent Canadian research the use of nutritional information from 2004 - 2008 showed that a growing number of people have been acquiring nutrition knowledge from the internet although it is not their main source.[34]

In Icelandic basic education (elementary school), nutritional health education is mostly given in home economics[35] as well as in natural sciences[36] and physical education.[37] In high-school, the subject is optional and mostly in physical education.[38]

Nutrition knowledge is important for people in order to make healthy dietary choices easier and more in line with actual scientific knowledge rather than beliefs, myths or propaganda.[17] Wardle et al. studied the association between nutrition knowledge and fruit, vegetable and fat intake. Adults with good nutrition knowledge consumed more fruits and vegetables than participants with poorer nutrition knowledge and participants with good nutrition knowledge did not consume as much fat as the ones with poor knowledge.[17] In Wardle's et al study however, nothing was mentioned about the roles of protein or its importance for the body. That is in line with De Vriendts' et al.[39] findings in a study of young and middle-aged women in Belgium, which found a positive association between nutrition knowledge and a higher consumption of fruit and vegetables.[39] In adults, healthier dietary habits have furthermore been associated with higher education.[17,39,40] In an American study,[41] among 11-13 years old, an association was found between nutrition knowledge and eating behaviour in older girls but not among younger adolescents or boys.[41] An observational study[42] reported that students who enrolled in a nutritional education program were more interested in nutrition after the program than the control group who did not attend a program, even though not much else changed in their dietary behaviour.[42]

In Davys' et al.[23] research, students were asked about their beliefs about nutrition and dietary behaviour. Gender difference was evident regarding how much sugar, carbohydrates and fat they felt they ate (too much or not enough), as well as feeling the need to lose weight. More females agreed on those questions than males. Both genders thought that consumption of fruit and vegetables was a part of a healthy diet and they believed that eating variety of foods was important for good health.[23] In another study,[43] four different focus groups were formed; young adolescents (boys group and girls group) teachers and parents. They were, among other things, asked about their beliefs towards the relationship between early adolescent behaviour, health, dietary habits, preferences, influences and barriers. Qualitative analyses from the focus groups revealed that the adolescents sensed that there was a relationship between their behaviour and their health despite the fact that it was not clear to them what healthy eating really meant apart from fruits and vegetables. Fruits and vegetables

were also the food items they liked most as a preferred healthy food. As unhealthy food items, they mentioned fast food, candy, cookies, sweetened beverages and potato chips, and the concept unhealthy food was clearer in their minds than healthy foods. However, they disagreed on whether drinks such as milk, juice and energy drinks were healthy or not. For most of the adolescents taste was the main reason for food choices, not the health benefits of the food.[43] Findings in some studies have pointed out that young people do not find it important to eat healthy food because they are young[25,33,44] and they believe that the body can cope with unhealthy eating,[44] which makes consumption of unhealthy food more acceptable in their minds.

An Australian study[45] examined organic foods and beliefs towards it amongst adults. In their findings most of the participants thought organic food was better for the environment, tasted better and was generally healthier than traditional food. On the other hand cost and availability was found to be barrier to their consumption. In the study females were also more likely than males to agree that organic food was healthier,[45] which is in accordance with other similar researches.[46]

Males have been reported more likely than women to believe that protein supplements are performance enhancing[7] even though studies have not consistently support that.[47]

2.2.1 Nutrition misinformation

It is a fact that endless information about nutrition and health can be found on the rapidly expanding internet. In 2007, Wilson reported in her article that when she searched for *nutrition advice,* on the Google search engine, 46.000.000 websites came up.[48] In February 2012 when the same search was done for this thesis 180.000.000 websites came up. Researches show that the mass media is the most popular source and that people increasingly rely on the internet as their main source for nutrition information.[48] There are numerous chat rooms, blogs and all kinds of forums online, with unreliable information e.g. about nutrition and health.[49] Therefore it might not be a coincidence that people experience confusion when the media contains confusing and inconsistent information.[49] What is written on the internet or reported in the media is not always accurate and can be misleading.[50,51]

There is a lot of food and nutrition misinformation around, such as: *Food fads,* which is when someone believes in some types of food, vitamins,

minerals and their ability to cure disease or as being the ultimate solution for weight loss.[49] *Health fraud* when one sells a product that does not work or has not been proven to work.[49] The main purpose is for the seller to gain something from it e.g. money. *Misdirected claims* is when consumers are misinformed about the product, for example products that are advertised as being low in carbohydrates but are actually very high in calories.[49] To be conscious about misinformation, as described above, may help people to make informed decisions about their dietary choices e.g. what types of protein sources they should use for a balanced and healthy diet.

2.2.2 Popular diets

Popular diets or fad diets are diets that become popular over a certain period of time. These diets often promote quick weight loss, recommend or require supplements, or certain foods are limited or avoided in the diet.[13] Some of these diets also specify what should be eaten and when and most of them are short term.[52] Over the past few years protein has been the fad nutrient and fat and carbohydrates have been the "bad" nutrient that makes people gain unwanted weight.[13] These low carbohydrates diets have become popular among those who want to lose weight and many athletes believe that increased protein intake maintains their muscle tissue.[53,54] Perhaps fad diets have become even more popular due to the media attention which they received while they were a novelty.[55] Popular fad diets through the years are for example the Atkins diet,[56] with unlimited protein and fat consumption but extremely low carbohydrate consumption and the Zone diet, 30E% protein, 40E% carbohydrates and 30E% fat.[57] The Paleo diet[58] has also become popular. It recommends consumption of lean meat, eggs, lean poultry, fish, vegetables, fruit, berries, nuts and seeds.[58] No dairy, grains, sugar, potatoes or rice are allowed in the Paleo diet.[58] Looking at these diets it is no wonder that protein has become so popular.

As described in the chapters above, adolescents get their nutrition knowledge from many sources. Fitness centres are popular for the general public and fitness instructors working there have different experiences and educational backgrounds, ranging from online courses to university degrees and everything in between.[59-61] Kruseman et al.[62] studied nutrition knowledge among 26 fitness instructors in Switzerland in 19 fitness centres. Of the instructors, 96% gave nutritional advice to their clients, and half of them made calculated nutrition plans for their clients. The results showed that the counselling approaches used by the instructors were insufficient,

especially when it came to essential nutrients, carbohydrates, protein and fat. Fifty-six percent of the instructors participating in the study recommended protein supplements for their clients. This research had some limitations because the researchers only got a 42% return rate of the questionnaires.[62] In 2010, Stacey et al.[63] reported a systematic review were it was examined from where the fitness instructors got their knowledge and how they translated it to their clients. Their results showed that fitness instructors holding Master's- or Doctoral degrees in were more likely to use scientific journals than instructors with undergraduate degrees or lower also had difficulties in determining the accuracy and credibility of the information.[63] Fitness instructors claimed they had gotten most of their knowledge from books, magazines, friends and colleagues as well as from past experience.[62,63] When seeking information from fitness instructors, trustworthy knowledge about nutrition is important.

2.3 Adolescents diet

Adolescents' diet is influenced by numerous factors such as taste, hunger and cravings,[64] as well as by social and environmental influences such as family, friends and peers.[11] Accessibility and food availability in schools, restaurants and work have also been mentioned as an important factor along with the mass media, marketing and advertisement. Not to mention different social and cultural norms around eating.[11,64] Recent studies show that girls think more about the quality of their diet than boys.[65-68]

Adolescents observe lack of time as one of the barriers to healthy eating as well as limited availability of healthy food in schools, not to mention their lack of concern about following healthy eating recommendations.[12,14,69] As factors affecting their food selection, they have mentioned things such as convenience and taste,[64,69-71] health,[70,71] weight control,[64,70] family and friends,[43,64,69-71] habits[64] school environment[43] and price.[44,64,69,70] A positive association between family-meals during adolescence and nutritious eating has been found.[72] On the other hand, not all researchers have found significant relationships between vegetable, fruit and milk product consumption and family meals.[73]

2.3.1 Meal patterns

Adolescents tend to skip breakfast and lunch and girls are more likely to skip breakfast than boys.[14,65,73] As adolescents get older, skipping breakfast tends to increase among both genders.[74-77] Skipping breakfast can affect

concentration and educational performance.[11,14] In a large review article, several cross-sectional researches found associations between breakfast skipping and obesity.[78] It has been suggested that adolescents who skip breakfast have a higher intake of fats and a lower intake of carbohydrates from their total daily energy compared with adolescents who have breakfast.[74] Findings suggest that girls that eat breakfast irregularly feel that they are too heavy compared to girls who consume at least three meals a day.[73,75] The former group also consumed less fruits, vegetables and dairy foods.[73] Adolescents with irregular breakfast habits also tend to skip lunches and dinners.[75] Sjöberg et al.[75] reported that adolescents who consumed breakfast irregularly consumed less protein, calcium, fibres and zinc. In addition, girls did not get enough iron and vitamin C. Boys who skipped breakfast also had higher body max index (BMI) than girls.[75] These findings are in accordance with Matthys et al.[79] research on breakfast habits in adolescents in Belgium, where it was reported that adolescents that consumed a good quality breakfast had an overall better dietary pattern than adolescents that consumed a low-quality breakfast or no breakfast at all.[79]

Adolescent snacking in between meals has increased in the past decades both in USA and Europe.[78] Sjöberg et al.[75] suggested that one third of the total energy in adolescents' diet came from in-between meals and that half of the energy from snacks came from unhealthy snacks. That is in-between meals are in some cases replacing the regular meals. Adolescents with irregular breakfast habits tend to get more of their total energy from in-between meals than ones with regular breakfast habits.[75]

2.3.2 Whole-grain and fibres

It is recommended that people choose whole-grain products instead of refined grains, that is, consume bread rich in fibre (>6 g/100 g), whole-wheat, whole-wheat pasta, barley and brown rice instead of white-wheat, white pasta and refined rice.[19] Consumption of whole-grain and fibres affects health in many good ways. Whole grains affect glucose and insulin responses, due to their slower rate of digestion, which produces small rises in the blood sugar.[80,81] In Slavins' et al.[81] review article several studies found association between fibre consumptions and reduced risk of coronary heart diseases and some types of cancer.[81] In O'Neils et al.[82] study, findings showed significant associations between increased whole grain consumption and over all diet quality and nutrient intake, both for children

and adolescents, despite generally low consumption of whole grains in their research.[82]

Just as whole-grain, fruits and vegetables are important sources of vitamins, minerals, and dietary fibre. The energy density of fruit and vegetables is usually low but the nutrient density is very high.[13,18] The antioxidants in fruits and vegetables are protective against many diseases,[18,83] including coronary heart disease, some cancers and it has been shown that fruit and vegetable consumption may help in weight management.[84] Guidelines for fruit and vegetables consumption are 500 g/day, with at least 200 g/day of fruit and 200 g/day of vegetables.[19] One glass of fresh fruit juice may be added as one portion of fruit which helps most people come closer to the recommendations.[19] Studies have shown that adolescents have difficulties meeting the recommend amounts of fruit and vegetables.[70,72,73,58,61,62] In the national dietary survey in 2010-11[1] the consumption of fruits and vegetables in the age group 18-30 years old, was below the recommendations as it was in other age groups. Young males consumed slightly more vegetables than young women or on average 118 g/day compared to 106 g/day which equals around one and a half tomato a day. When looking at fresh fruit and berries, females consumed more or 124 g/day compared to 85 g/day for males which is like the consumption of a small banana or one little apple daily. If fresh juice is taken into account, females also consumed more juice or 160 g/day compared to 133 g/day.[1] The diet of Icelandic 9 and 15 years old children and adolescents was issued in 2006.[85] Findings from that study also showed a very low consumption of fruits and vegetables in the 15 years old age group and the adolescents were far from reaching the recommendations.[85] Studies outside of Iceland have shown that girls consume more fruits and vegetables than boys.[66-68] Girls also seem to drink more fruit juice, water and diet sodas. [67]

2.3.3 Fish and cod liver oil

Fish is an important source of protein,[86] iodine and selenium.[18] Fatty fish, as salmon is also a major source of vitamin D and long-chain omega-3 fatty acids.[18] Therefore fish consumption, as well as that of cod liver oil or other vitamin D source, are recommended as important components of the diet.[18,19] Findings in a 16 years follow-up study suggested that fish and omega-3 fatty acids consumption may reduce risk of coronary heart disease in women.[87] Regular fish consumption was also positively associated with good dietary behaviour in women, compared to those who consumed fish

seldom or never.[87] It has been shown that consumption of fatty fish (three times a week) or fish oils has been associated with lowered blood pressure, which may lower the risk of coronary heart diseases.[88] Consumption of fatty fish has also been associated with lower cholesterol in blood as well as a reduction in triglycerides.[89] Findings in a study by Kim et al.[90] on fish consumption and school grades, showed that adolescents who consumed fish once a week or more received better grades, after adjusting for gender and the parents' educations.[90] Vitamin D, whose intake is mostly dependent on cod liver oil intake in Iceland, is important for calcium absorption[13] and Steingrímsdóttir et al.[91] findings have suggested that Vitamin D sufficiency is more important than increased high calcium intake for sufficient calcium stores in the body.[91] The average intake of fish is 36 g/day for males compared to 26 g/day for females, which counts as a fish meal every 4-5 days for males and every 5-6 days for females. The most popular fish is haddock/cod whereas consumption of fatty fish as salmon and trout is very little or 4 g/day, which is hardly a mouthful. As reported in the national dietary survey 2010-11, young people (18-30 years old) are not consuming enough fish and only around 22% consume cod liver oil every day.[1]

2.3.4 Milk products

Milk and milk products are good sources of protein and other nutrients such as calcium, potassium, riboflavin and selenium,[86] which are important to gain strength and maintain healthy bones.[18] In Iceland milk products are the primary source of calcium. Milk is rich in saturated fats, therefore, consumption of low-fat milk and low-fat dairy products has been recommended.[19] According to a review by Spence's et al.[92] observational studies have shown negative or neutral associations between dairy products' consumption and a healthy weight and body composition in adolescents and children.[92] It was also reviewed that milk product consumption may have a positive or neutral effects on body weight or body composition.[92]

Icelanders have a special high-protein, low-fat cultured milk product called skyr. Skyr has about 11.5 g protein per 100 g and is almost fat free.[86] When looking at food availability data (national food balance sheets), one can see that sales of skyr have been increasing significantly over the past 10 - 15 years. In recent years more products, such as drinks from skyr have been marketed, allowing for even more increases in sales, especially around their first marketing in 2005.[93]

Milk consumption has been reported to decrease significantly from adolescence into adulthood[94] and it has also been reported that adolescents have difficulties fulfilling their needs of calcium-rich food.[70,72,73,95] According to the national dietary survey 2010-11, both genders in the age group 18-30 years are reaching recommendations in milk product consumption.[1] The dietary guidelines advise two portions of low-fat milk and low-fat dairy products a day.[19]

2.3.5 Meat

Red and white meat, including poultry, are good sources of protein.[86] Meat is also rich in iron, zinc and B vitamins.[13] It is very common to consume red meat in Iceland and males consume 50% more red meat and poultry than females.[1] That is in accordance with other studies on adolescents and meat consumption.[66,95] No recommendations exist for red or white meat consumption as it does for fish, vegetables, fruits, fibres and milk products. However, red meat contains saturated fat which should be limited in the diet and therefore it should be consumed in moderation. Red meat, especially when processed, has also been associated with colorectal[13,96] and kidney cancer.[13]

Poultry, especially chicken breast, has been popular as a low-fat protein source, particularly among fitness instructors. Numbers from the food availability data between 1998-2008 show a 40% increase per inhabitant over these 10 years.[97]

2.3.6 Protein supplements

According to all the advertisement in the mass media, a selection of websites selling protein supplements as well as the broad selection of protein supplements in supermarkets and special health stores, it is safe to assume that protein supplements have been becoming more and more popular in Iceland over recent years. An Icelandic questionnaire based on research on Icelandic high-school students[5] showed that those who were physically active within sports clubs or fitness centres, and especially those involved in body building, consumed protein supplements and other nutritional supplements more frequently than high-school students who were not physically active.[5] Increased consumption of protein- and diet drinks has also been reported in the national nutrition survey 2010-2011 for the age group 18-30 years old.[1]

Not many studies have been carried out on protein supplement intake among adolescents in Europe but a little bit more is known about the topic in the USA.[98] A Finnish study researched the use of dietary supplements and anabolic-androgenic steroids from 1991-2005.[6] Between these years dietary supplement use rose significantly, especially protein intake among 16-18 years old boys.[6] Bell et al.[7] studied supplement use in adolescents and in their findings protein intake was the second most commonly used supplement after multivitamins,[7] but vitamins and herbal supplements are very popular among adolescents. Creatine is also popular among adolescent boys.[99] Dietary- and protein supplement use has been associated with greater physical activity and sports participation both inside and outside sport clubs[6,7,98,100] Findings suggest that daily supplement users consume higher proportions of energy from carbohydrates and proteins but smaller proportions of energy from total fat and saturated fat.[100]

2.3.7 Changes of dietary behaviour with age

Eighteen years old adolescents are growing adults. They are going from adolescence to adult, even though most of them still live at home, and therefore, still have to abide their parents' rules and eat the meals prepared for them at home. Most adolescents have a busy schedule and are often away from home due to school, work and their social life.[11,12] They tend to change their lifestyle and food habits during their evolvement to independence. Therefore, they often eat away from home.[73] Moreover they struggle with their self-image, trying to find themselves at the same time as they look for their acceptance by peers.[14] Despite the importance of a good diet, studies have reported that adolescents generally have poor eating habits and do not meet dietary recommendations.[11]

An American longitudinal study[101] found that average fat and carbohydrate consumption decreased and protein intake increased significantly from adolescence into adulthood. When looking at gender difference, fat and carbohydrate consumption increased among males while it decreased among females. The change in total carbohydrate consumption as a proportion of total energy intake was not significant for females. Both genders consumed significantly more protein as adults than as adolescents and got less energy from added sugar.[101] Meal pattern was not taken into consideration in this study but it has been shown that older adolescents and younger adults tend to skip meals[66,70] and their fast food

consumption increases.[66,70,76] In other studies it has been reported that vegetable consumption increases with age.[94]

2.4 Essential macronutrients

The essential energy sources for the body are protein, carbohydrates and fats. For adolescents, energy is needed both for maintenance and for growth.[13] Energy is usually measured in kilocalories (kcal)[13] or in kilojoules (1 kcal = 4.2 kJ).[18]

2.4.1 Protein

Protein plays a critical role in building and maintaining the body. It builds enzymes and hormones and it supports and helps maintain body tissue as well as helping to maintain fluid balance and acid-base balance.[13] Protein helps control appetite and improves satiety whilst providing energy.[13] It transports substances (lipids, vitamins, minerals and oxygen) through the body and acts like a channel in the cell membranes as well, defending the body against disease.[13] All proteins are a combination of 20 unique amino acids; nine of them are essential and must be consumed through the diet. Eleven are nonessential and can be produced by the body.[13] High quality proteins are proteins that contain all of the amino acids the body needs and are found in animal and soya products.[13] Proteins are considered incomplete if one or more essential amino acid is missing as is in plants.[13] Complementary proteins are made of two incomplete proteins, something vegetarians need to make sure they get all the necessary amino acids in their diet. [13] Protein cannot be stored in the body in the same way as fat and needs to be consumed every day.[13] Protein gives 4 kcal/g just like carbohydrates.[13]

The recommendation on diet and nutrients for Icelanders report that daily protein intake should be 10-20E%.[102] Dietary requirements for protein intake is often measured as intake per kilogram of body weight and 0.8 g/kg/day has been recommended as a satisfying amount of good proteins for most people.[13] Recommendations for athletes differ a bit from the dietary requirements and can be up to 1.6-1.7 g/kg/day, depending upon which kind of sport they participate in.[103,104] Both underconsumption and overconsumption of protein can be harmful. Protein deficiency can cause kwashiorkor and/or marasmus.[13] Overconsumption of animal proteins may cause osteoporosis and increase the workload of the kidneys[13] and there is a possibility of high protein intake interlinking lower intake of other

important nutrients as carbohydrates and lipids, with possible deficiency of vitamins and minerals. Proteins consumed beyond what the body needs are either stored in the body as fat or glycogen,[13] and big portions of proteins do not automatically result in muscle gain or athropy.

2.4.2 Carbohydrates

Carbohydrates are composed of carbon, hydrogen and oxygen. One gram of carbohydrates is four kcal and it is found in plant foods. It is also found in lactose (milk sugar).[13] The main role of carbohydrates is to supply fuel in the form of glucose.[13]

Carbohydrates are divided into three groups: monosaccharides e.g. glucose and fructose; disaccharides e.g. sucrose, lactose, and maltose; and polysaccharides e.g. glycogen, starches and fibres. Glucose is the most important sugar – the fuel for the body.[13] Other carbohydrates are converted into glucose mostly by the liver. When looking at disaccharides' glucose is always one of two molecules and polysaccharides are all made of glucose molecules.[13] Fructose is found in fruits as well as in honey.[13] Fructose has also been isolated in high-fructose corn syrup[13] as well as in agave syrup,[105] which has been becoming increasingly popular as a "natural" sweetener.

Glycogen is glucose stored in muscles and liver and its storage and release is controlled by hormones.[13] Starches are stored in plants like glycogen is stored in the body. [13] They are mostly found in wheat, rice, root crops e.g. carrots and tubers e.g. potatoes[13]. When they are consumed the body changes them into glucose and uses it as energy. Fibres are found in plant foods. [13] Fruits, vegetables, whole grains and legumes are rich in fibres. They are difficult to digest by digestive enzymes. [13] Fibres are either soluble or insoluble. Water-soluble fibres are non-starch polysaccharides that dissolve in water to form a gel, while insoluble do not dissolve in water and go through the digestive tract.[13]

By consuming carbohydrates that can be converted into glucose in the body, the body is getting a preferred source of energy for the brain and nervous system.[13] The total amount of energy (E%) from carbohydrates should be 50-60E% of which sugar should not be more than 10E% of the total energy from carbohydrate.[102] Fibres are recommended 25 g for 2400 kcal diet.[102]

2.4.3 Lipids

Fatty acids are the basic units that make up the triglycerides and phospholipids.[13] Lipids have more kilocalories per gram than protein and carbohydrates, or nine kilocalories per gram. The length of fatty acids varies from 2-24 carbons. Short-chain fatty acids contain two to four carbons, medium chain fatty acids have 6-10 and long chain fatty acids have 12 or more carbons. [13] There are three types of lipids: triglycerides; phospholipids; and sterols.[13] Most fatty acids are incorporated into triglycerides, or about 95%. Triglycerides are composed of three fatty acids attached to a glycerol. Lipids are either saturated fats (solid at room temperature) or unsaturated (oils).[13] Saturated fat consists of triglycerides that only contain saturated fatty acids and all of the carbons are bounded with hydrogen. Saturated fats are solid at room temperature. Unsaturated fat on the other hand have at least one carbon that is not bound to hydrogen and is instead double bounded to another carbon.[13] Saturated fats are found in animal products such as meat, whole-milk products, cheese, butter and eggs. Some vegetable oils e.g. coconut and palm oils are high in saturated fat.[13] Fatty acids with one double bond are called monounsaturated but fatty acids with more than two double bonds are called polyunsaturated.[13] Olive oil and canola oil are rich in monounsaturated fatty acids. Polyunsaturated fatty acids can be found in sunflower- corn and soybean oil.[13] The body can make all of the fatty acids except two, these are the long-chain omega-3 fatty acid (alpha-linolenic acid) and the long-chain omega-6 fatty acid (linoleic acid). Fatty fish like salmon, trout and halibut are a good source of omega-3 and vegetables oils are a good source of omega-6.[13,18]

Phospholipids and sterols make up only about five percent of the lipids in the diet.[13] Phospholipids are compounded similarly to triglycerides but instead of one fatty acid they have phosphate/choline group.[13] It is soluble in both water and fat, therefore, they play an important role for the cell membrane as they help lipids move back and forth across the cell membrane into the watery fluid on both sides.[13] Phospholipids are popular in the food industry as an emulsifier under the name of lecithin.[13] Sterols are the third type of lipids with its “famous" cholesterol aboard.[13] Cholesterol is an important part of cell membrane as well as precursor for vitamin D, bile acids and sex hormones.[13]

The total energy intake from fat should be between 25-35E% and no more than 10E% of the fat energy should be saturated fat. Energy from

monounsaturated fat should be 10-15E% and 5-10E% from polyunsaturated fat, thereof 1E% from omega-3 fatty acids.[102]

2.5 Dietary assessment methods

Epidemiology has helped researchers connect diseases with their underlying causes for the past centuries. Nutritional epidemiology studies the relationship between health or disease and nutrition. Most common research designs used in nutritional epidemiology are descriptive studies such as cross-sectional (prevalence), ecological (correlational) and analytic (case-control, cohort and clinical/controlled trial) studies.[106] Several dietary assessment methods are available to measure diet in nutrition research. The most common include 24 hour dietary recalls (24-h recall), food frequency questionnaires (FFQ) and food records.[107,108] In the next two chapters 24-h recalls and food frequency questionnaires will be explained since these are used in this thesis.

2.5.1 24-h recalls

Twenty four hour dietary recall is a retrospective approach, an interview method based on consumption of foods and beverages consumed in the previous 24 hours or in the previous day.[106,108] It is open ended and based on an in-depth interview.[106] It is either carried out over the phone or in person (face to face).[108] During the interview the respondents are asked to list everything they have eaten or drunk on the previous day. First it is a brief history of the consumption, usually listing the first meal until the last one without interruption. That listing is followed by questions about the food intake, when and where the food was consumed, quantity, additional foods and nutrients as well as food preparation.[106] The interviewer must have the skills necessary to gather more information about the consumption e.g. portion sizes, how it was prepared etc. When all the information has been collected, it is good to go through the list again to prevent missing food items. The interviewer needs to be properly trained, have a good knowledge about nutrition, nutritional habits and know common recipes and food preparation to get detailed answers and to manage the accuracy of the data.[106,108] The interviewer has to be able to ask questions in a non-judgmental manner and to use open-ended questions that do not influence responses from the respondent.[106] During the interview the food items are coded and entered into a database where they are analysed for nutrient content.[106,108]

The accuracy of the dietary intake depends on the short-term memory of the respondent [106] and the portion sizes.[106] For this reason it is important for the participants to have the correct tools such as household measures, cups, spoons, bowls and glasses and/or photos of serving sizes or household measures.[106] To get the best picture of the food consumption it would be best to use all seven days of the week for the interviews since there can be a systematic difference in dietary intake on different days.[106] However, often that is not possible, and therefore, it is important to have a good balance of the days e.g. weekdays and weekend days.[106] To get the best results the participant in the interview should not know when the interview will take place.[106]

The strength of the 24-h recall is that it is based on actual intake. [98,100] It may be used to estimate relative intake of energy and other food-components e.g. vitamins and nutrients. The interviews are short, between 20-30 minutes long and it is easy to have people participate in them. [98,100] 24-h-recalls can be done over the phone which is a very good option. [98,100]

The weaknesses are the respondents' dependence on memory as well as it being difficult to estimate portion sizes accurately.[108] Underreporting is also common.[108] Individuals' diets vary from one day to another, therefore 24-h recalls are unsuitable to examine individual diets[108] It is also possible that nutrients that can only be found in specific food items will not be measured, but these recalls can help to estimate quantity of food and nutrition consumed in bigger groups or populations.[101,102] Repeated 24-h recalls can be used to estimate individuals' food consumption.[109,110]

2.5.2 Food frequency questionnaires

FFQ are like the 24-h recall a retrospective approach to measure food consumption and are a common method in nutritional epidemiology research. It is of self-administered design where the respondents are asked to estimate their usual food or/and nutrient intake from a list of predefined food items (checklist).[108] Information is usually collected by frequency, which is to say how frequently one consumes or drinks certain food items. Sometimes participants are also asked about portion sizes, giving semi quantitative results.[108] FFQ is a useful tool to estimate food usually eaten over a period of time.[108] By using FFQ it is also possible to collect information about food items seldom consumed and also to rank individuals into low or high consumers.[108] Moreover it is a useful tool to look at correlation between food consumption and diseases. Advantages of

the method are that it is an inexpensive method and it does not take a long time for the respondent to complete. The disadvantages are that the quantification of food intake may be inaccurate unless portion sizes are used. It is also a disadvantage that the memory of food pattern in the past is required and actual food consumption can influence the report of consumption in the past. It can also be a weakness that the food frequency questionnaires are not open ended.[108]

3 Methods

3.1 Study design and data

The data in this thesis is from a larger study *HLíF - Health and Lifestyle in High-Schools* (Icelandic: Heilsa og lífsstíll í framhaldsskóla), which examined health and lifestyle of Icelandic high-school students. It is a cross-sectional study with data collected from September 2008 throughout January 2009. The participants were students born in 1990, from three different high-schools in Reykjavik, Iceland. Two of the schools were academic high-schools, one with a class-based system and the other one with a unit-credit system. The third school was a technical high-school. At the time of the study, the students were or would be 18 years old that year. All participants gave written consent prior to participation in the study. For the students who had not reached 18 years of age, a written permission to participate in the study was collected from parents/legal guards.

3.2 Participants

The groups were selected from the question: "How often do you consume protein supplements?" in the FFQ in the questionnaire (chapter 3.3.3.). The sample consists of non-consumers (NC), who answered never, occasional consumer (OC), who answered less than once a week and protein consumers (PC), who answered once a week or more. In appendix 10 distributions for each category are shown, that is before the variables were combined into these three categories.

In table 2, the participation of the boys in each component of the study is shown.

Table 2 - Participation in individual component of the research

	n (%)
Agreed to participate	152 (52)
In at least one measure	147 (53)
Weight	145 (53)
Height	146 (53)
BMI	145 (53)
Skinfold measures	146 (53)
Waist measure	145 (53)
VO_2max test	132 (53)
24 h- recall	124 (50)
Pedometer	106 (50)
Blood pressure	146 (53)
Blood sample	131 (52)
DXA	134 (53)
Questionnaire	141 (52)

BMI= body max Index - VO_2max = maximal oxygen uptake,
DXA= Dual-energy X-ray absorptiometry

3.3 Measures

Here the measures that were used in this thesis will be described in detail. Descriptions of other measurements performed in this research project but not included here are described elsewhere.

3.3.1 Food frequency

Food frequency of various foods was measured through the questionnaire. Twenty-two items were used to assess food frequency consumption both reflecting healthy dietary habits based on the *Recommendations on diet and nutrients for Icelanders*[19] and some specific food items considered to be less healthy. The products asked about, were whole grains, vegetables, fresh potatoes, fruits and berries, fish, meat, vegetables and/or bean stews, sugar-sweetened and sugar-free carbonated drinks, carbonated water, tap water, dairy products, fast food, crisps, French fries and popcorn, pre-made sandwiches and goods from the bakery. Response options were: never; less than once a week; once a week; 2-3 times a week; 4-5 times a week; 6-7 times a week; many times a day; and no answer. Based on the distribution of frequencies some responses where combined together for more meaningful results. Only the question about the protein consumption was

used in this study but in appendix 7 comparisons of answers to FFQ and 24-h dietary recall is shown.

3.3.2 24-h recalls

Data on food consumption were collected in face-to-face 24-h recall interviews. The participants were asked to list everything they had eaten the day before; how much they consumed and how the food was prepared and served (i.e. additional condiment). Photos were used to estimate food portion sizes. Interviews were performed Tuesday, Thursday, Friday and Monday. This 24-h recall was already developed and validated for the research The Diet of Icelanders 2002.[2] To calculate energy and nutrient intakes, the data was entered into an interview-based program, ICEFOOD developed in 2002 for The Diet of Icelanders research.[2] The database included 450 food codes from the Icelandic Nutrition Council (ISGEM).[2] Nutrient losses due to food preparation were taken into account.[2]

3.3.3 Questionnaire

The questionnaire consisted of 18 subject questions with different number of subitems, asking about health, physical activity and lifestyle, food frequency and nutrition attitude and knowledge. The questionnaire was completed through the internet but participants got a password for the survey by e-mail and their e-mail address was their login.

3.3.4 Body composition

Weight and height were measured by an investigator. Height was measured to the nearest mm with stadiometer (Seca 206) and body mass was determined to the nearest 0.1 kg using Seca weight. Body mass index (BMI) was calculated ($kg*m^2$).[111] Waist was measured in cm to the nearest 0.1 cm.

Body composition was established by the sum of four (triceps, thigh, suprailiac, abdomen) and seven (subscapular, triceps, chest, midaxillary, abdomen, suprailiac, thigh) skinfolds in millimetres as well as it was measured with Dual-energy X-ray Absorptiometry (DXA). DXA measures bone mineral density (BMD), soft lean tissue and fat tissue. DXA is one of the best ways to measure body compositions when considering precision, accuracy and reliability.[112,113] Specific methods for all of the variables above have been described elsewhere.[114]

3.3.5 Dietary behaviour - supplement use and meal frequency

Participants were asked about supplement consumption. Supplements asked for were cod-liver oil, cod-liver oil softgels, calcium, iron, multivitamins, vitamin C, vitamin B, and if they consumed other food supplements, participants could write what kind of supplements they were consuming. Response options available were: yes; no; and I don't want to answer. It was also possible to add the name of the supplements one did take if it was not mentioned on the list.

Questions about meal frequency were included in the research; about how often one consumed breakfast, lunch, dinner, morning snacks, afternoon snacks and snacks in the evening or during the night. Response options were: never; less than once a week; about once a week; few times a week; daily/almost daily; I don't want to answer. The questions were combined into daily or less frequent than daily.

3.3.6 Health behaviour and attitude

Questions regarding health behaviour were asked. Participants were for instance asked whether they tried to eat healthy and if their family situation, school or work environment, and/or food prices prevented healthy eating. Participants were also asked about how they viewed their body, with statements like "I think I am in good shape"; "I am satisfied with my body" etc. Response options were: describes me very well; describes me quite well; neither nor; describes me badly; describes me very badly; and no answer. Answers were combined together in: describes me very well/well; neither nor; and describes me badly. In addition, participants were asked about how much they would like to weigh (ideal weight), which was combined into percentages of their bodyweight for a more specific outcome.

3.3.7 Nutrition knowledge

Nutrition knowledge was estimated through 32 questions with response options right; wrong; I don't know; or I don't want to answer. The items asked about included nutritional trends often published in media, advertisements etc. as well as questions regarding nutrition knowledge based on the Icelandic dietary guidelines. Examples of trend questions were: Icelanders don't get enough protein; and spelt flour is healthier than whole-wheat. Knowledge questions were for instance: There is the same amount of calories in 100 g of carbohydrates as in 100 g of protein; you get

enough vitamin D from the sunlight in Iceland just like anywhere else; there is a lot of fibres in chicken. During analysis, the number correct answers were split into 4 different groups, i.e. 8 correct answers or less, 9-16 correct answers, 17-24 correct answers and 25 correct answers or more.

Participants were asked about the source of their nutritional. Response options were multiple and included: I feel like I need more knowledge; knowledge from family, friends, school, health professionals, media and advertisements. Response options within each part of the question were: yes, no, and no answer.

3.3.8 Basal Metabolic Rate (BMR)

Underreporting is known in 24-h recall interviews.[115] To detect underreporting in the 24-h recall BMR was calculated from the Mifflin-St Jeor equation[116] and the energy intake divided with the Basal Metabolic Rate (EI/BMR). No participant was eliminated from the study since the main findings did not change when calculations were performed without under-reporters.

3.3.9 Physical activity

Physical activity was assessed with questions about how much the boys exercised outside regular physical education lessons in their high-school. This approach was used rather than results from the pedometers, since more boys answered the questionnaire compared to pedometers users. It is also a concern for this study that the pedometers are not sensitive to non-ambulatory activities e.g. cycling, weight lifting and swimming.[117] It is also possible that the participants were not wearing it as required, e.g. forgot to put it on, take it off etc.

3.3.10 Fitness test - VO_2max

Aerobic fitness was assessed with VO_2max text (maximal oxygen uptake). VO_2max is the maximum amount of oxygen in millilitres, one can use in one minute per kilogram of body weight. Participants ran on a treadmill (same speed). Incline started at 0°with adjustment every two minutes until the participant could not continue. Exhaled air was sampled and oxygen consumption (VO_2) and volume of carbon dioxide (VCO_2) were measured to calculate the respiratory exchange ratio (RER). Heart rate was measured with heart rate monitor and perceived exertion (RPE) was measured on the Borg RPE scale (6-20), from rest to maximum exertion.[111]

3.3.11 Blood samples

Blood sample was taken after 12 hour fast in two labelled bottles with the participant´s study ID. Total cholesterol (TC), high-density lipoprotein (HDL) triglycerides, glucose, insulin and C-reactive protein (CRP) were measured at the Landspitali-University hospital. Low-density lipoprotein (LDL) was calculated with the Fridewald equation.[118] LDL= TC – HDL – triglyceride /2.2, and the formula was adjusted for calculations in mmol/l.[119] Values and cut offs for triglycerides,[120] TC,[121] HDL,[120] and LDL[120] are showed in appendix 5.

3.3.12 Blood pressure

Resting blood pressure was obtained after the participants had rested quietly for 10 minutes. The mean of three measures was used for statistical analyses. In appendix 9 classification of blood pressure[122] is shown.

3.3.13 Statistical analyses

All statistical analyses were carried out using SPSS (Statistical Package for the Social Science 19.0) for Windows and Excel 2007 was used for minor calculations. Data are described as mean and standard deviations. Kolmogorov-Smirnov test was used to estimate the normality of the data distribution. One-way Analysis of variance (ANOVA) was used to compare the protein supplement use groups and Bonferroni test was used to see where significant difference between the groups. For non-normal distributed data, Kruskal-Wallis test was used. Pearson's chi-square test was used to determine the difference in distribution between two categorical variables. All statistical significance was set at 0.05.

3.3.14 Permission

The study was accepted by the Icelandic National Bioethics Committee (VSN: 07-125-S1), The Icelandic Data Protection Authority (Permission S3612/2008) and Icelandic Radiation Safety Authority (SÁA-290902008-26).

4 Results

Here data on the use of protein supplements among 18 year-old high-school boys is presented. The following results are percentages.

4.1 Participants

Table 3 shows the size of the three protein supplement groups; non-consumers (NC), occasional consumers (OC) and consumers (PC), respectively.

Table 3 - Protein supplement use

NC	OC	PC
n (%)	n (%)	n (%)
75 (54.7)	20 (14.6)	42 (30.7)

Characteristics of the boys participating in the study are presented in table 4. According to the basic question on supplement use from the FFQ there was no difference in consumption pattern between schools (p=0.346), but based on the 24-h recall, significantly higher amounts of protein supplements were consumed in the class-based school compared with the other two schools (p<0.001, appendix 2). Most of the participants lived at home and came by car to school, but OC and PC were more likely to live with their parents/guardians (P=0.036). OC and PC had a non-significant trend to come driving in their own car compared with NC (P=0.053). Most of the participants were categorised as normal weight according to BMI, PC=77.5% OC=85%, and NC=67.6% (more details are in table 5). Differences were not found between the groups regarding alcohol consumption and smoking but 86.8% said they drank alcohol beverages occasionally and just over 19% smoked on some occasions; 11.4% of them on a daily basis.

Table 4 - Characteristics

	NC	OC	PC	P value
	n (%)	n (%)	n (%)	
High-school type				
Unit-Credit system	30 (40.5)	7 (35.0)	12 (28.6)	0.346
Class-based system	21 (28.4)	9 (45.0)	19 (45.2)	
Technical high-school	23 (31.1)	4 (20.0)	11 (26.2)	
Residence				
With parents/legal guards	65 (87.8)	19 (95.0)	30 (90.5)	**0.036**
I live alone	0 (0.0)	1 (5.0)	3 (7.1)	
With other than parents/legal guards	9 (12.2)	0 (0.0)	1 (2.4)	
Transportation to school				
In my own car	30 (40.5)	11 (55.0)	26 (61.9)	0.053
I get a lift to school	15 (20.3)	2 (10.0)	11 (26.2)	
With bus	22 (29.7)	4 (20.0)	4 (9.5)	
I walk/run	7 (9.5)	3 (15.0)	1 (2.4)	
BMI				
Underweight (< 18.5)	2 (2.7)	0 (0)	0 (0)	0.507
Normal weight (18.5-24.9)	50 (67.6)	17(85)	31 (77.5)	
Overweight (25-29.9)	15 (20.3)	1 (5.0)	7 (17.5)	
Obesity (≥ 30)	7 (9.5)	2 (10.0)	2(5.0)	
Day of 24-h recall				
Monday	8 (12.3)	2 (11.8)	10 (27.0)	0.098
Wednesday	26 (40.0)	10 (58.8)	12 (32.4)	
Thursday	90(13.8)	3 (23.5)	5 (18.9)	
Sunday	22 (33.8)	1 (5.9)	8 (21.6)	
Cigarette smoking				
Never smoked/Quit smoking	54(76.1)	15 (75.0)	37(90.2)	0.434
Yes, not daily	7 (9.9)	2 (10.0)	2 (4.9)	
Yes, daily	10 (14.1)	3 (15.0)	4 (4.9)	
Drinking				
No	10 (16.4)	1 (5.0)	7 (16.7)	0.446
Yes	64 (86.5)	19 (95.0)	35 (83.3)	

Calculated with Chi-square test. Sign. level 0.05

4.2 Body composition

In table 5, descriptions of body composition divided by protein supplement consumption are shown. PC users had a significantly lower body fat percentage compared with NC and OC measured as the sum of 7 skinfolds or calculated as bodyfat % (P=0.010 vs P=0.002, respectively). They also had significant less trunk fat (p=0.006) and more lean soft tissue in their trunk (P=0.018). There was not a significant difference between fat or lean soft tissue in arms and legs but a non-significant trend was found where PC had less arm fat.

Table 5 - Body composition

	NC			OC			PC			P value
	n	Mean	SD	n	Mean	SD	n	Mean	SD	
Height (cm)	74	181.5	6.5	20	183.7	7.5	41	182.5	6.1	0.409
Weight (kg)†	74	78.3	14.3	20	78.4	16.6	41	76.0	12.6	0.668
BMI (kg/m^2)†	74	23.1	3.9	20	22.9	3.5	41	23.4	4.1	0.686
WC (cm)†	74	83.9	11.2	20	83.0	13.0	41	79.6	7.6	0.231
Sum 4 skin (cm)†	74	65.2	26.9	20	58.4	25.6	41	51.3	24.8	0.067
Sum 7 skin (cm)†	**74**	**116.4**	**47.6**	**20**	**103.0**	**42.9**	**41**	**88.5**	**42.8**	**0.010**
Body fat (%)†	**70**	**20.1**	**7.2**	**20**	**22.1**	**8.1**	**40**	**17.1**	**6.2**	**0.002**
Fat Trunk (kg)†	**70**	**8.7**	**5.8**	**20**	**8.9**	**6.6**	**40**	**5.9**	**4.2**	**0.006**
LST Trunk (kg)†	**70**	**5.9**	**4.2**	**20**	**26.9**	**3.7**	**40**	**28.7**	**4.2**	**0.018**
Fat Arms (kg)†	70	1.9	1.0	20	2.0	1.4	40	1.5	0.8	0.067
LST Arms (kg)	70	7.1	1.0	20	7.0	1.2	40	7.5	1.4	0.189
Fat Legs (kg)†	70	6.4	3.1	20	6.5	3.9	40	5.4	2.8	0.159
LST Legs (kg)	70	20.0	2.9	20	19.9	3.1	40	20.7	2.9	0.516
BMD (g/cm^2)	70	1.3	0.1	20	1.3	0.1	40	1.3	0.1	0.414

† Variables not normally distributed calculated with Kruskal Wallis test. Normally distributed variables calculated with One-Way ANOVA. Sign. level 0.05

WC= Waist circumference, BMI= body mass index, Sum 4/7 skin = sum of 4 or 7skinfolds, LST = lean soft tissue, BMD = bone mineral density.

4.3 Nutrition

4.3.1 Energy

Table 6 shows daily intake of energy and nutrients based on the 24-h recall. Significant difference was found between protein intake (P=0.022) where PC consumed more protein in grams on average on the recall day of the interview than NC and OC. There was also a non-significant trend in fibre consumption, where the PC got more fibres from their diet than the NC and the OC (P=0.065).

Table 6 - Daily intake of energy and nutrients based the on 24-h recall

	NC n=65		**OC n= 17**		**PC n=37**		**P value**
	Mean	SD	Mean	SD	Mean	SD	
Energy (kcal)	2806	1221	3091	1145	3099	1034	0.398
Energy (kJ)	11745	5112	12937	4792	12969	4325	0.398
BMR (kcal/min)	1.5	0.7	1.7	0.7	1.7	0.6	0.315
Protein (g)†	**116**	**45**	**137**	**54**	**163**	**98**	**0.022**
Total fat (g)†	100	48	114	62	101	42	0.883
SFA (g)†	40	22	44	21	37	17	0.506
MUFA (g)†	32	16	40	28	33	15	0.714
PUFA (g)†	14	9	16	13	17	10	0.221
Long Omega 3	0.57	0.85	0.15	0.11	0.36	0.46	0.314
Trans FA (g)†	3	3	4	1	4	4	0.622
Cholesterol (g)†	347	244	345	114	407	355	0.524
Total Carbohydrates (g)	347	169	374	137	376	143	0.623
Added sugar (g)†	91	96	90	60	82	67	0.664
Fibre (g)	20	8	22	12	24	9	0.065
Alcohol (g)†	6	25	1	3	3	14	0.208

† Variables not normally distributed calculated with Kruskal Wallis test. Normally distributed variables calculated with One-Way ANOVA. Sign. level 0.05.
SFA = saturated fatty acids, MUFA= monounsaturated fatty acids, PUFA = polyunsaturated fatty acids, FA= fatty acids.

In table 7 the division of the energy giving nutrients is presented Between groups a significant difference was found between energy from protein as well as for protein intake g/kg/day. All the groups consumed large amounts of protein ranging on average from 1.5 g/kg/day in NC up to an average of 2.1 g/kg/day in PC (P=0.001). The total protein as a proportion of E% was 21E% for PC compared to 17.1E% for NC and 17.9E% for OC (p=0.048). PC got significantly less SFA from the total energy, 11 E% compared to 12.8 E% NC and 12.7E% OC (p=0.026).

Table 7 - Daily intake of energy based the on 24 h recall

	NC n=65		**OC n=17**		**PC n=37**		**P value**
	Mean	SD	Mean	SD	Mean	SD	
Protein g/kg/day	**1.5**	**0.6**	**1.8**	**0.7**	**2.1**	**1.0**	**0.001**
E% protein†	**17.1**	**4.8**	**17.9**	**5.0**	**21.0**	**8.1**	**0.048**
E% Total fat	31.7	8.8	33.0	8.0	29.7	8.6	0.613
E% SFA	**12.7**	**4.1**	**12.8**	**3.5**	**11.0**	**3.5**	**0.026**
E% MUFA†	10.1	3.5	11.3	4.1	9.5	3.5	0.227
E% PUFA†	4.5	2.3	4.4	2.7	5.0	2.6	0.512
E% Omega-3 FA.†	0.2	0.3	0.0	0.0	0.1	0.1	0.214
E% Carbohydrates†	49.6	9.5	48.5	5.3	48.5	8.8	0.794
E% Added sugar†	11.6	9.0	11.7	4.7	10.3	6.8	0.572
E% Alcohol†	1.3	5.0	0.3	0.9	0.5	2.9	0.205

Variables not normally distributed calculated with Kruskal Wallis test. Normally distributed variables calculated with One-Way ANOVA. Sign. level 0.05. SFA = Saturated fatty acids. MUFA= monounsaturated fatty acids, PUFA = polyunsaturated fatty acids, FA= fatty acids

4.3.2 Food items

Consumption of common food items according to 24-h recalls is shown in table 8. Significant differences were found between the protein supplement groups, when looking at protein supplement consumption with PC consuming more of these supplements than OC ($p<0.001$). A significant difference was also found in skyr consumption ($p=0.013$) where NC consumed much less skyr than OC and PC. Non-significant trends were found for fibre-rich bread and salty snacks where PC consumed more of both than NC and OC.

Table 8 - Food items, average intake from 24 h recall

	NC n=65		OC n=17		PC n=37		P value
Food item g/day	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	
Meat †	116	108	117	80	113	98	0.918
Fish†	20	58	15	57	19	45	0.801
Poultry†	29	66	52	101	52	87	0.382
Bread ≥6 g fibre†	7	26	0	0	12	37	0.142
Cereal, rich in fibre†	10	28	4	10	20	58	0.771
Vegetables and potatoes	134	162	100	149	84	102	0.318
Vegetables w/o potatoes†	96	124	68	73	61	83	0.467
Fruit and berries †	83	121	63	82	86	118	0.866
Fruit, berries and juice †	305	379	419	633	353	460	0.954
Protein supplement†	**0**	**0**	**29**	**121**	**350**	**920**	**<0.001**
Milk products†	576	583	705	532	646	477	0.411
Skyr†	**44**	**107**	**154**	**280**	**129**	**177**	**0.013**
Water†	872	812	789	689	1089	1021	0.546
Sports drinks†	3	25	29	121	16	83	0.476
Energy drinks†	15	87	59	166	14	82	0.246
Sodas†	413	698	375	584	380	614	0.985
Chips, popcorn†	6	19	15	63	21	44	0.057
Fast food†	127	190	197	231	122	205	0.352
Sugary foods†	38	78	31	34	16	22	0.270

† Variables not normally distributed calculated with Kruskal Wallis test. Normally distributed variables calculated with One-Way ANOVA. Sign. level 0.05.

In appendix 4 description of each food item category is shown and in appendices 7 - 8 answers to food frequency questions are shown as well as a comparison between 24-h recall and answers in the food frequency questionnaire.

4.3.3 Vitamins and supplement intake

The PC were getting significantly more vitamins and minerals from their diet than the NC, and in most instances also more than OC, as seen in table 9. A non-significant trend was also found for most of the vitamins where PC were getting most and NC the least except for Vitamin D where OC had the lowest intake. The vitamins and minerals were calculated from the food consumption in the 24-h recall including dietary supplements. In appendix 1, the same table can be viewed with exclusion of vitamins and minerals derived from dietary supplements.

Table 9 - Daily intake of vitamins and minerals including dietary supplements based the on 24 h recall

	NC n=65		OC n=17		PC n=37		P value
	Mean	SD	Mean	SD	Mean	SD	
Vitamin A (RJ)†	1230	1181	1695	3422	2201	3423	0.124
Retinol (µg)†	882	949	1477	3465	1781	3143	0.119
Beta-Carotene (µg)†	2080	4187	1298	914	2514	3543	0.128
Vitamin D (µg)†	10	8	4	4	16	31	0.089
Vitamin E (mg)†	**12**	**9**	**14**	**14**	**46**	**90**	**0.005**
B1-Thiamin (mg)†	**2**	**1**	**2**	**1**	**4**	**4**	**0.003**
B2-Riboflavin (mg) †	**3**	**2**	**3**	**1**	**5**	**5**	**0.023**
Niacin (mg)†	**44**	**20**	**51**	**21**	**75**	**75**	**0.007**
B6-Pantothenic acid (mg)†	**2**	**2**	**3**	**1**	**5**	**7**	**0.002**
Folate (µg)†	**433**	**285**	**492**	**274**	**925**	**1268**	**0.003**
Vitamin B12 (µg)†	**6**	**4**	**8**	**9**	**11**	**13**	**0.022**
Vitamin C (mg)†	203	233	199	197	313	545	0.464
Calcium (mg)†	1503	890	1648	806	1994	1299	0.083
Phosphorus (mg)†	**2095**	**900**	**2338**	**863**	**2751**	**1354**	**0.041**
Magnesium (mg)†	**353**	**138**	**402**	**160**	**619**	**564**	**0.002**
Sodium (mg)†	4286	2025	4500	2353	4624	1776	0.523
Potassium (mg)†	3609	1419	4086	1942	4512	1989	0.111
Iron (mg)†	**16**	**10**	**18**	**6**	**34**	**40**	**0.001**
Iodine (µg)†	166	140	156	108	343	493	0.052
Selenium (µg)†	**86**	**49**	**96**	**45**	**121**	**75**	**0.021**

† Variables not normally distributed calculated with Kruskal Wallis test. Normally distributed variables calculated One-Way ANOVA, sign. level 0.05.

In the questionnaire, participants were asked about their supplement intake. Liquid cod liver oil was consumed by almost 29% of NC but only 14% of the PC (p=0.031, table 10). Significantly more of the PC took in multivitamins (p=0.002) than other groups and the use of other supplements was also more common among PC compared with NC and OC (p<0.001). An open question followed the question on use of "other" supplements where participants could write what kind of supplements they were using. Among supplements written down were protein supplements most frequently mentioned of PC, whereas none in the other two groups mentioned protein supplements.

Table 10 - Cod liver oil and other dietary supplement

Nutrient	NC n (%)	OC n (%)	PC n (%)	P value
Cod liver oil	**21 (28.8)**	**1 (5.0)**	**6 (14.3)**	**0.031**
Cod liver oil tablets	15 (20.5)	2 (10.5)	14 (33.3)	0.109
Cod liver oil or tablets	32 (44.4)	3 (15.8)	15 (35.7)	0.069
Multivitamins	**8 (11.1)**	**3 (15.0)**	**16 (38.1)**	**0.002**
Vitamin C	15 (21.1)	3 (15.0)	14 (33.3)	0.201
Other supplements	**2 (2.7)**	**0 (0.0)**	**31 (26.2)**	**<0.001**

Calculated with Chi-square test. Sign. level 0.05

Table 11 shows meal patterns among protein supplement users. No significant difference was between the groups for meal patterns. A non-significant trend was found in lunch consumption, which was never skipped in OC (P=0.091), but they had a tendency to skip breakfast instead (p=0.153).

Table 11 - Meal pattern

Daily consumption	NC n (%)	OC n (%)	PC n (%)	P value
Breakfast	49 (66.2)	9 (45.0)	29 (69.0)	0.153
Lunch	59 (79.7)	20 (100.0)	34 (81.0)	0.091
Dinner	72 (97.3)	18 (90.0)	39 (92.0)	0.331
Morning snack	23 (31.1)	5 (25.0)	13 (31.0)	0.863
Midday snack	41 (55.4)	8 (40.0)	26 (61.0)	0.268
Evening snack	21 (28.4)	4 (20.0)	9 (21.0)	0.606

Calculated with Chi-square test. Sign. level 0.05

4.3.4 Nutrition knowledge

Nutrition knowledge was measured with 32 questions in the questionnaire. The correct answers were categorized in four even quarters. No significant difference was found between the protein supplement groups (p=0.873, table 12).

Table 12 - Nutrition knowledge questions

Correct answers	NC	OC	PC	P value
	n (%)	n (%)	n (%)	
8 or less	10 (13.7)	2(10.0)	4 (9.5)	0.873
9-16	20 (27.4)	8 (40.0)	13 (31.0)	
17-24	41 (52.2)	10 (50.0)	23 (54.8)	
25 or more	2 (2.7)	0 (0.0)	2 (4.8)	

Calculated with Chi-square test. Sign. level 0.05

In the questionnaire three questions were about proteins. Those questions are shown in appendix 11. No significant difference was found between the answers and the groups.

In table 13 answers about the participants' nutrition knowledge sources are viewed. Significant differences were found between the groups in their answers. Parents were a less common source of knowledge in PC compared to the other groups (p=0.042), friends, however, rated lower in NC (p=0.030) who also felt least in need for more information (p=0.026). When asked about whether they had learned about nutrition or health in different subjects at school a significant difference was found between learning in home economic classes where PC said they got most of their knowledge (p=0.005).

Table 13 - Knowledge sources

Where do you get your knowledge?	NC n (%)	OC n (%)	PC n (%)	P value
Parents	**55 (74.3)**	**13 (68.4)**	**21 (51.2)**	**0.042**
In school	44 (59.5)	8 (40.0)	19 (46.3)	0.191
Sports coach/ fitness instructor	41 (56.9)	12 (63.2)	28 (68.3)	0.485
Friends	**33 (44.6)**	**13 (72.2)**	**26 (65.0)**	**0.030**
Health professionals e.g. nutritionists	25 (34.7)	6 (65.3)	16 (39.0)	0.777
Unorthodox e.g. homoeopath	5 (7.1)	2 (11.1)	2 (5.6)	0.758
Mass media	38 (52.8)	8 (40.0)	24 (61.5)	0.288
Advertisements and shop consultants	16 (21.9)	6 (30.0)	16 (36.8)	0.237
I need more knowledge	**21 (28.4)**	**11 (57.9)**	**19 (46.3)**	**0.026**
Was nutrition or health taught in one of those classes?				
Home economics classes	**39 (73.6)**	**8 (50.0)**	**32 (91.4)**	**0.005**
Nature science classes	39 (60.9)	10 (50.0)	19 (48.7)	0.420
In physical education classes	54 (84.4)	15 (78.9)	28 (75.7)	0.550
Civics classes	26 (38.8)	7 (35.0)	16 (41.0)	0.904
Nutrition classes	16 (50.0)	4 (44.4)	16 (66.7)	0.359

Calculated with Chi-square test. Sign. level 0.05

4.3.5 Dietary behaviour and attitude

Table 14 shows dietary behaviour and attitude towards healthy eating. Significantly greater proportion of the PC group claimed they tried to eat healthy compared to NC and OC (p=0.034) and most of the PC (95%) answered the statement *I don't see the point of thinking about my diet* –did not describe them well/very well compared to 64.4% of the NC and 70% of the OC (p=0.003). There was not a significant difference in other answers but a trend was found in the home environment statement where PC felt it was least of a barrier compared to NC and OC (p=0.069).

Table 14 - Dietary behaviour

Dietary behaviour	NC n (%)	OC n (%)	PC n (%)	P value
I try to eat healthy				
Describes me very well/well	42 (56.8)	8(40.0)	31(73.8)	**0.034**
Neither nor	23 (31.2)	11 (55.0)	10 (23.8)	
Does not describes me very well/well	9 (12.2)	1 (5.0)	1 (2.49)	
My home environment is a barrier				
Describes me very well/well	8 (10.8)	3 (15.0)	2 (4.8)	0.066
Neither nor	7 (9.5)	5 (25.0)	2 (4.8)	
Does not describes me very well/well	59 (79.7)	12 (60.0)	38 (90.5)	
School and the nearest environment is a barrier				
Describes me very well/well	19 (26.4)	6 (30.0)	13 (31.0)	0.207
Neither nor	21 (29.2)	10 (50.0)	10 (23.8)	
Does not describes me very well/well	32 (44.4)	4 (20.0)	19 (45.2)	
I think about food prices				
Describes me very well/well	52 (71.2)	14 (70.0)	31 (73.8)	0.914
Neither nor	10 (13.7)	4 (20.0)	5 (11.9)	
Does not describes me very well/well	11 (15.1)	2 (10.0)	6 (14.3)	
I don't see the point thinking about my diet				
Describes me very well/well	6 (8.2)	3 (15.0)	0 (0.0)	**0.003**
Neither nor	20 (27.4)	3 (15.0)	2 (4.8)	
Does not describes me very well/well	47 (64.4)	14 (70.0)	40 (95.2)	

Calculated with Chi-square test. Sign. level 0.05

4.3.6 Physical activity and general health

Physical activity was evaluated with questions from the questionnaire. When looking at the protein supplement consumption groups, a non-significant trend was found in total physical activity (p=0.070), with PC being the most active (table 15). A trend was also found in physical activity within the school (p=0.079), but with a less distinctive direction of the results. Significant differences were found within participation in sport clubs (p=0.016) and fitness centres (p=0.002), both being most frequently visited by PC. There was also a significant difference between the groups in the statement “exercising does not interest me at all” (p=0.005), where almost all of the PC and OC disagreed with the statement.

Table 15 - Physical activity

	NC n (%)	OC n (%)	PC n (%)	P value
Total physical activity				
Once a week	40 (54.1)	9 (45.0)	13 (31.0)	0.070
2-3 times a week	31 (41.9)	9 (45.0)	22 (52.4)	
4-5 times a week	3 (4.1)	2 (10.0)	7 (16.7)	
With your school but outside PE classes				
Never	28 (38.9)	9 (45.0)	20 (55.6)	0.079
≤ 1 x a week	29 (40.3)	5 (25.0)	5 (13.9)	
2-5 times a week	15(20.8)	6 (30.0)	11 (30.5)	
Sports club				
Never	51 (75)	14 (70.0)	14 (41.2)	**0.016**
≤ 1 x a week	3 (4.4)	1 (5.0)	2 (5.9)	
2-5 times a week	14 (20.6)	5 (25.0)	18 (52.9)	
Fitness centre				
Never	15 (20.8)	1 (5.0)	1 (2.6)	**0.002**
≤ 1 x a week	29 (40.3)	6 (30.0)	9 (23.1)	
2-5 times a week	28 (38.9)	13 (65.0)	29 (74.4)	
Exercising does not interest me at all (describes me...)				
well/rather well	6 (8.1)	0 (0.0)	1 (2.4)	**0.005**
neither nor	14 (18.9)	1 (5.0)	0 (0.0)	
badly	54 (73.0)	19 (95.0)	41 (97.6)	

Calculated with Chi-square test. Sign. level 0.05

Table 16 show the results from the VO_2max test. A significant difference was found between the protein supplement groups (p=0.022), the difference being between the NC and the OC (p=0.018) but not PC and OC. In appendix 3 categorized values for the VO_2max test used in this research can be viewed.

Table 16 - VO_2max

	NC n=70		OC n=20		PC n=39		P value
VO_2max	Mean	SD	Mean	SD	Mean	SD	
	50.2	7.5	54.2	6.7	51.6	7.4	0.022

Calculated with One way - ANOVA, sign. level 0.05

When looking at participants' physical health in table 17, there was a significant difference between diastolic blood pressure (p=0.009) and MAP (p=0.042) as well as in TC (p=0.003) and LDL (p=0.004) where PC was lower than both NC and OC. A non-significant trend was found within the triglycerides (p=0.086) where PC had lower triglycerides values than NC and OC. No significant difference was between PC, OC and NC in glucose, insulin and CRP.

Table 17 - Blood pressure and blood variables

	NC			OC			PC			P value
	n	Mean	SD	n	Mean	SD	n	Mean	SD	
Systolic (mHg)	74	122	11	20	123	11	41	121	11	0.395
Diastolic (mHg)†	**74**	**72**	**7**	**20**	**71**	**8**	**41**	**68**	**5**	**0.009**
MAP†	**74**	**88**	**7**	**20**	**88**	**8**	**41**	**86**	**6**	**0.042**
HR rest	74	75	13	20	72	14	41	69	13	0.214
HR max†	69	197	10	20	198	8	35	196	8	0.755
TC (mmol/L)†	**70**	**4.29**	**0.81**	**20**	**4.19**	**0.46**	**38**	**3.83**	**0.42**	**0.003**
HDL (mmol/l)†	70	1.28	0.26	20	1.33	0.24	38	1.32	0.26	0.478
LDL (mmol/l)†	**70**	**2.52**	**0.71**	**20**	**2.39**	**0.47**	**38**	**2.12**	**0.36**	**0.004**
Triglycerides (mmol/l)†	70	1.09	0.54	20	1.05	0.41	38	0.87	0.33	0.086
Glucose (mmol/l)†	70	4.73	0.84	20	4.57	0.23	38	4.56	0.31	0.401
Insulin (mmol/L)†	70	10.1	7.3	20	8.6	4.0	38	8.1	6.3	0.242
CRP (mmol/l)†	69	1.23	1.49	20	0.76	0.78	38	1.08	1.59	0.160

† Variables not normally distributed calculated with Kruskal Wallis test. Normally distributed variables calculated with One-Way ANOVA. Sign. level 0.05. MAP = Mean arterial pressure, HR rest = resting heart rate, HR max =maximum heart rate, TC = total cholesterol HDL = high density lipoprotein, LDL =low-density lipoprotein, CRP=C-reactive protein.

A significant difference was found in answers to the question "I feel like I am in a good shape" (p=0.016, table 18), where 85.7% PC said it suited them well/rather well compared to just over 55% of the NC and OC.

Table 18 - Body Image

	NC n (%)	**OC** n (%)	**PC** n (%)	**P value**
Body image (weight)				
Too light/light	22 (29.7)	8 (40.0)	15 (35.7)	0.387
Average weight	32 (43.2)	6 (30.0)	21 (50.0)	
Too heavy	20 (27.0)	6 (30.0)	6 (14.3)	
I feel like I am in a good shape				
Suits me well/rather well	42 (56.8)	11 (55.0)	36 (85.7)	**0.016**
Neither nor	25 (33.8)	7 (35.0)	3 (7.1)	
Suits me badly/very badly	7 (9.5)	2 (10.0)	3 (7.1)	
I am satisfied with my body				
Suits me well/rather well	43 (58.1)	14 (70.0)	31 (73.8)	0.362
Neither nor	16 (21.6)	2 (10.0)	7 (16.7)	
Suits me badly/very badly	15 (20.3)	4 (20.0)	4 (9.5)	
I am satisfied when I think about how I will be looking in the future				
Suits me well/rather well	42 (56.8)	13 (65)	34 (81.0)	0.116
Neither nor	20 (27.0)	5 (25.0)	6 (14.3)	
Suits me badly/very badly	12 (16.2)	2 (10.0)	2 (4.8)	

Calculated with Chi-square test. Sign. level 0.05

Table 19 shows participants´ dream weight as a proportion of their current weight. A significant difference was found between the groups where the PC group wanted to be 6.4% heavier than they were today, whereas the dream weight of the other groups were closer to their real weight (p=0.013).

Table 19 - Dream weight as a proportion of current weight

	NC n=68 Mean (SD)	**OC** n=18 Mean (SD)	**PC** n=38 Mean (SD)	**P value**
Dream weight (%)	**-0.1 (10)**	**-0.5 (10)**	**+6.4 (12.9)**	**0.013**

Calculated with One-Way ANOVA. Sign. level 0.05.

5 Discussion

The main goal of this thesis was to study characteristics of adolescent boys using protein supplements by looking at their protein intake along with their nutritient intake, dietary pattern, nutrition knowledge, health behaviour, and attitude towards nutrition as well as physical activity and general health. Just over 31% or 42 boys of the sample reported protein supplement use at least once a week.

The study showed that compared with their counterparts that do not use protein supplements on a regular basis, the boys who consumed protein supplements once a week or more had higher protein intake both in E% and g/kg. They got significantly more vitamins from their diet, probably due to the fortification of the protein supplements, but were less likely to consume liquid cod liver oil, which is the only supplement recommended by authorities to be taken at all ages. They also consumed more skyr as well as other dietary supplements. Significantly higher proportion of PC felt they needed more nutrition knowledge than they already had and they relied more on friends as their knowledge source compared with OC and NC. They also tried to eat healthy and felt it was important to think about their diet.

PC had lower body fat. Their diastolic pressure and MAP was lower as well as their TC and LDL. However the difference was little and and clinically insignificant compared with OC and NC who also were in good shape and therefore these findings cannot say whether in general their health was better than OC and NC. PC were, in general, satisfied with their body and level of fitness, which they thought was good, but they wished to be heavier than they already were, despite their good physique. These boys were also more likely to exercise with a sport club or in a fitness centre than OC and NC.

5.1 Dietary behaviour and nutrition

In general, average protein intake was high. Calculation from the 24-h recall gave 21E% from proteins in the PC, which were significantly different from the NC group and the OC, who got between 17-18E%, which is very high and above what dietary guidelines suggest.[19] PC were getting 2.1 g/kg/d from protein but protein intake is recommended 0.8-1.0 g/kg for most people[13] and upto 1.6-1.7 g/kg for active people and athletes, depending on the type of sport.[103,104]

The high protein consumption in the PC influenced the fat and carbohydrate consumption. The PC consumed significantly less saturated fat than NC and OC, or 11E%, which was less than in the national dietary survey where the average intake was 13E%[1] and close to the recommendations.[19] Consumption of omega-3 fatty acids was low in all groups, similar to the national survey[1] and below recommendations in all groups,[19] which is not surprising given the low frequency of taking liquid cod liver oil and few fish meals each week. The E% from carbohydrates were a bit more than in the national survey, 48.8% and 47% for PC compared to 44.8% in the survey,[1] but still less than recommended.[19] The carbohydrate consumption does not come as a surprise since the diet of Icelanders has been rich in protein and fat at the carbohydrates expense[1,2] and our findings reflect that.

PC did not differ from OC and NC in consumption of most food items. The only significant difference was found in intake of protein supplements where PC was much higher in average intake than OC and NC, who did not consume any. Significant difference was also found in skyr consumption but PC consumed less skyr than OC, which may tell us that PC rather used protein supplements to increase their protein intake instead of skyr and other foods. Another suggestion is that that in this young age, where most of the participants are still living at home, there may be a number of teens as in the OC group who are choosing skyr as a surrogate for protein supplements since parents may discourage use of the latter. It was interesting to see that PC who claimed they try to eat healthy and say it is important to think about their diet, did not reach recommendations of fruits and vegetables, fish and fibres and they obviously do not look at fish as an important protein source. When compared to the latest national dietary survey, consumption of fruit and vegetables and fish was lower in this study. In appendices 7 and 8, the answers to the FFQ are demonstrated.

Vitamin and mineral intake was calculated, both including and excluding dietary supplements in the 24-h recall. In appendix 1 vitamin calculations without dietary supplements, are viewed. The difference between these calculations lies in the use of supplements in tablet form, but supplements such as protein powder and shakes are included in both calculations since they are consumed as foods, i.e. the way of consumption made the definition. All the groups were getting enough of vitamins and minerals except the OC who did not fulfil their vitamin D needs. In some cases PC were close to or above the upper limits of nutrients as in potassium, iron

and retinol which is something that should be taken into consideration, and may even be harmful. More studies need to be done with repeated 24-h recalls to see if this is a coincidence or something that needs to be looked at more closely.

Dietary supplement intake was rather common among the all the boys and that is in line with other studies.[6,7,123,124] In the written answers about other supplements that the participants consumed, protein supplements were consumed significantly more often by the PC group compared with other groups. These findings are in line with other studies on protein and dietary supplement intake.[4,6,7,98,123,125] Additionally to the protein powder, the most common supplements were creatine and glutamine, which also have been reported as a popular supplement in other studies on young males and athletes.[99,123,126] The boys said they were taking these supplements after exercising in the gym for recovery or to build up muscles. As protein supplement intake has been associated with frequent sports participation[5-7,98] these findings do not come as a surprise but a majority of the PC exercised regularly and as stated above they are using the supplements to build up muscles and for recovery.

5.1.1 Knowledge and knowledge sources

Nutrition knowledge was estimated from the questionnaire, where the participants' general nutrition knowledge was studied. There was no significant difference in nutrition knowledge. Over all the nutrition knowledge was not very high. Most of the protein supplement consumers' boys answered 17-24 questions correct. It was surprising to see those results, especially among the PC who claimed nutrition was important to them and one would assume that nutrition knowledge was important to them. When looking at knowledge questions, regarding protein, no significant difference was found between the groups. Those questions are shown in appendix 11.

Nutrition knowledge is one of the factors that may influence adolescence dietary choices as seen in the Wardle et al.[17] research on nutrition knowledge and food intake. In their adult study, nutrition knowledge was significantly associated with healthy eating e.g. fruits and vegetables and less fat consumption.[17] In a research on young adolescents in 6^{th}-8^{th} grade, a positive association was also found between nutrition knowledge and eating behaviour of seventh- and eighth grade girl students, but not among boys or in grades that did not get any nutrition lessons.[41]

Croll et al.,[25] in sample of 203 senior high school students, found that knowledge regarding healthy and unhealthy food was quite good. However, they had difficulties following healthy eating habits.[25] Similar findings were found in Turconi et al.[24] research on Italian adolescents. They had some knowledge but had difficulties acting accordingly.[24] Perhaps if the boys in this research had gotten more nutrition education and knew how to use that information, the results might have been different, at least in regards to consumption of food scientifically acknowledged as healthy, such as vegetables and fruits, fish and food rich in fibres.

Friends, sport coaches/fitness instructors, and the mass media played an important role as a source for nutrition for the participants in the study In a research[4] about misconception about protein supplements, most of the protein supplement users said they had gotten their advice on protein supplements, as well as information about protein supplements, from their coach/trainer.[4] Friends and the mass media also played an important role, as a nutrition source.[4] This is in accordance with the findings in this thesis despite the lack of knowledge of exactly what kind of advice friends and trainers were giving, but that would be an interesting future study. The same holds true for the nutritional education, no information was collected on how much nutrition education these trainers/coaches have acquired in their training. Over 50% of fitness instructors in a Kruseman et al. study advised protein supplement to their customers[62] despite admitting that their own nutrition knowledge was not sufficient. Coaches and trainers have also been reported as the primary resources for dietary supplement use in other studies.[10,62,126] Unfortunately, in our questionnaire, the internet as a source for nutrition knowledge was not an answer option, but in the open ended question “where do you get your knowledge,” the internet was the only additional source mentioned by the participants. The internet is a common used source for all kinds of health information as described elsewhere in this thesis.

5.1.2 Physical activity and general health

PC had significantly less body fat, or 17.1% compared to 21.7% body fat in the NC. The average PC consumers are categorized with average body fat but NC and OC are considered with high body fat percentage.[127] The distribution of the participants across body fat classification categories is

shown in appendix 6. PC also had less abdominal fat and more lean soft tissue than the NC and OC.

Results from the VO_2max test came out good for all the groups[111] although OC got slightly better results than NC and PC. Similarly the blood sample results were positive where the average total cholesterol in NC, OC and PC was below 5 mmol/l, which is considered desirable.[121] LDL in all groups was below 3 mmol/l. In a new research on the same cohort, more specific results on this matter are studied.[128] Since the boys were more or less eating the same food items, the protein supplements do not seem to be affecting the blood samples, neither as a good nor bad addition to their diet. It is more likely that the amount and type of exercise is responsible for different outcomes.

About 85% of PC thought they were at a good level of fitness compared to just over 55% of the NC and OC. PC were also more optimistic about their future appearances (non-significant trend). When asked about how they looked at their current weight, no significant difference was found between PC, OC and NC. However, when participants were asked about their desirable weight, PC wished to be 6.4% heavier than their current weight, whereas other groups (OC and NC) had a desirable weight very close to their current weight. This is very interesting, especially since the PC claim that they exercise more often in the fitness centres than other participants as well as claiming that they were in good shape. In fact they do not differ from other boys in the study except that they want to gain more weight. Studies have shown that young males usually report that they wish to gain weight,[10,129-131] which is in line with PC wishes in this study. Protein supplements have been reported among beneficial nutrition supplements for gaining weight,[4,123,132] which may be the reason why PC use protein supplement, rather than to perform better in sports. Is it a matter of looking fit rather than being fit?

5.2 Strengths and limitations

The strengths of this study are how many elements/factors were examined, that is nutrition, physical activity, body composition measurements, blood tests, and VO_2max test. The methods used in the study are very reliable, such as the VO_2 max test and the DXA scan. It is also a strength that the study was made in three different high-schools. On the other hand, we have a rather small sample and the high-schools are all in Reykjavik, not far from each other. With a bigger sample and more urban and rural high-

schools, the results might have been different. Furthermore, young people not attending high school may be very different from those scholars and thus there is an underlying participation bias.

It would also have been very good to have the 24-hour food recall interviews on more weekdays, including both Friday and Saturday, especially to see average alcohol consumption as well as fast food consumption. Two interviews would also have been preferable to get a closer look at the food consumption, not just for a group but also for individuals as was done in the national dietary survey 2010-2011.[1] It is also important to consider a potential underreporting and also normal day-to-day variations in intake since energy intake was measured by one 24-h recall per person,[115] which does not reflect normal intake. One 24-h recall is rather a window into the lives of people for one day and it is normal to have single days with lower protein intake, which may simply reflect low energy intake on that given day. The average for each group should, however, be more representative. In this study no under-reporters were excluded since their results did not change the significance in the outcomes.

Most of the interviews were also taken during the autumn (September-November) which may have influenced the students' food consumption due to seasonal differences.

5.3 Future perspectives

Sport coaches and fitness instructors played an important role for giving nutrition advice and therefore, it is very important that they have had proper nutrition education to be able to give nutrition advice based on scientific knowledge. It was frustrating to see how few of the boys who were obviously trying to live a healthy lifestyle did seem to be aware of real, proven dietary hazards such as low intake of vitamin D, since cod liver oil intake is scarce in this group and thus omega-3 intake is also low. Once again, fitness instructors and sport coaches play a critical role in encouraging their clients to consume cod liver oil or another source of vitamin D (and long chain omega-3 fatty acids) as a part of healthy diet.

Nutritional beliefs are strong and therefore it is necessary for adolescents to know how to get information about nutrition and health, and be able to criticize what they are told, whether it comes from their trainer, family members, friends or from web sites or chat rooms on the internet. Most of the PC came from the same school with a class-based

system. Therefore, one can assume that they are classmates. In my job as a teacher, I have noticed that certain atmosphere often arises in the classroom. Therefore, the diets of PC might just be a fad over a short period of time. This study gives a good picture of characteristics of protein consumption of 18 years old high-school boys. Protein has been found to be one of the most commonly used ergogenic aids and this study supports that. Physically active boys consume great amounts of protein, more than recommended. It is important that adolescents get more nutrition education, in order to know what healthy dietary choices are all about and how it affects their health and lifestyle. It is also important that those who work with young people receive proper nutrition education as part of their training, since they are an important link in the nutrition education of young people, who often seek their advice, and thus they have better opportunities than many others to reach young people.

6 Conclusion

Characteristics of protein consumers as seen in this study are boys who fare well off. Most of them were in a private school, commuted between home and school in their own cars and it seemed that they had money and time to exercise in fitness centres as well as buying protein supplements, which is a rather expensive protein supply. They seem to overestimate their health and despite that they claimed they were in a good shape, they wished to be heavier than they were.

The boys who consume protein at least 1 day/week do not differ much, nutritionally or physically, from their counterparts apart from the fact they want to gain more weight. Health messages, including nutrition and weight management, may be too complicated since most of the foods that we know to be important for health are missing in the diet among these otherwise health concious young men.

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Appendix 1

Protein supplement consumers, vitamins calculated without dietary supplements

	NC		OC		PC		P value
	Mean	SD	Mean	SD	Mean	SD	
Vitamin A (RJ)†	**1084**	**1151**	**1600**	**3440**	**1501**	**1477**	**0.031**
Retinol (µg)†	**739**	**897**	**1383**	**3483**	**1084**	**1099**	**0.033**
Beta-Carotene (µg)†	2064	4130	1298	914	2495	3041	0.111
Vitamin D (µg)†	**6**	**9**	**3**	**3**	**10**	**14**	**0.009**
Vitamin E (mg)†	**9**	**6**	**13**	**11**	**37**	**63**	**0.003**
B1-Thiamin (mg)†	**2**	**1**	**2**	**1**	**3**	**2**	**0.001**
B2-Riboflavin (mg) †	**2**	**1**	**3**	**1**	**3**	**2**	**0.007**
Niacin (mg)†	**40**	**18**	**49**	**17**	**62**	**40**	**<0.002**
B6-Pantothenic acid (mg)†	**2**	**1**	**2**	**1**	**4**	**3**	**<0.001**
Folate (µg)†	**372**	**197**	**459**	**205**	**635**	**456**	**0.001**
Vitamin B12 (µg)†	**6**	**4**	**8**	**9**	**9**	**7**	**0.005**
Vitamin C (mg)†	152	152	193	193	220	195	0.301
Calcium (mg)†	1459	907	1648	806	1965	1227	0.064
Phosphorus (mg)†	**2056**	**914**	**2338**	**863**	**2721**	**1328**	**0.031**
Magnesium (mg)†	**343**	**139**	**400**	**159**	**587**	**463**	**0.001**
Sodium (mg)†	**4225**	**2024**	**4500**	**2353**	**4575**	**1827**	**0.486**
Potassium (mg)†	3555	1435	4086	1942	4501	1977	0.070
Iron (mg)†	**15**	**9**	**17**	**6**	**26**	**21**	**<0.001**
Iodine (µg)†	**146**	**131**	**147**	**87**	**235**	**200**	**0.025**
Selenium (µg)†	**85**	**48**	**96**	**45**	**120**	**69**	**0.013**

† Not normally distributed, calculated with Kruskal Wallis test. Normally distributed variables calculated One-Way ANOVA, Significant level 0.05

Appendix 2

Average consumption of protein supplements compared between high-schools.

Protein supplement consumption	n (%)	Mean (g)	SD (g)	P value
Unit-Credit system	48 (38.7)	28	111	p<0.001
Class-based system	50(40.3)	231	805	
Technical high-school	26 (21.0)	27	100	

Calculated with Chi-square. Sign. level 0.05

Appendix 3

Values for the Borg Scale and Values for Maximal Aerobic Power

Borg RPE Scale[111]

6- No exertion at all

7 Extremely light

9 Very light

11 Light

13 Somewhat hard

15 Hard (heavy)

17 very hard

19 Extremely hard

20 Maximal exertion

Values for Maximal Aerobic Power[111]	
Male 20-29 years old	
Very poor	≤38.00
Poor	38.10-42.19
Good	42.20-45.69
Excellent	45.70-51.09
Superior	≥51.10

VO_2max test results categorized

	NC n (%)	OC n (%)	PC n (%)	P value
Poor	5 (7.1)	1 (5.0)	1 (2.6)	0.511
Very poor	5 (7.1)	1 (5.0)	0 (0.0)	
Good	6 (8.6)	1 (5.0)	4 (10.3)	
Excellent	20 (28.6)	5 (25.0)	7 (17.9)	
Superior	34 (48.6)	12 (60.0)	27 (69.2)	

Calculated with Chi-square test. Sign. level 0.05

Appendix 4

Definitions of food item variables

	Food items
Meat	All red meat, reindeer, whale, sausage meat, hotdogs and meat fillings
Fish	All fish and shellfish
Poultry	Chicken and wild bird
Bread	All bread with more than 6 g fibre /100 g
Cereal	Whole wheat cereal
Vegetables and potatoes	All vegetables, raw and cooked and potatoes
Vegetables w/o potatoes	All vegetables, raw and cooked
Fruit and berries	All fruits and berries, frozen and fresh
Fruit, berries and juice	All fruits and berries, frozen, fresh and fruit juices
Protein supplement)	Protein drinks, bars and power
Milk products	All milk product including ice-cream and cheese
Skyr	Skyr – with and without sugar
Water	Tap water
Sports drinks*	Gatorade, Powerade etc.
Energy drinks*	Magic, Energy power etc.
Sodas	Soda drinks with and without sugar
Chips, popcorn	Chips and popcorn
Fast food	Hamburgers, Crepes, fried chicken, hotdogs deep fried fish and shrimps, pizza
Sugary foods	Candy , sugar and honey
Dietary Supplements	Vitamins and minerals

Appendix 5

Classification and values for triglycerides, TC, HDL, LDL

Protein supplement consumption

Triglycerides categorized [120]	**NC** n (%)		**OC** n (%)		**PC** n (%)	
Normal <1.70	62	(88.6)	19	95.0	38	1.00
High borderline 1.70-2.24	6	(8.6)	0	0.0	0	0.00
High 2.25-2.61	2	(2.9)	1	5.0	0	0.00

Chi-Square test, p= 0.141

Total cholesterol values[121]	mmol/l
Suitable	<5
Acceptable	<6
High	6-8
Very high	> 8

LDL Cholesterol Level[120]	**mmol/l**
Optimal	< 2.60
Near or above optimal	2.60-3.35
Borderline high	3.36-4.10
High	4.11-4.90

HDL Cholesterol level[120]	**mmol/l**
Low	< 1.05
Normal	1.05-1.30
High	>1.30

Appendix 6

Classification for body fat percents and tables that show distribution of body fat in the samples.

Fat percent[127]	NC	OC	PC
	n (%)	n (%)	n (%)
Very low	25 (34.7)	4 (20.0)	22 (55.0)
Low	8 (11.1)	5 (25.0)	6 (15.0)
Medium	14 (19.4)	7 (35.0)	10 (25.0)
High	15 (20.8)	2 (10.0)	1 (2.5)
Very high	10 (13.9)	2 (10.0)	1 (2.5)

Chi-Square test, p=0.017

Classification of Body Mass Index[133]	
Classification	**BMI**
Underweight	<18.50
Normal weight	18.50 - 24.99
Overweight	>25.00
Obese	> 30.00 - 34.99

Appendix 7

Comparison of 24-h-dietary recall and answers to FFQ, question 13, in the questionnaire.

24h Bread ≥6 g fibres FFQ vs. 24- recall

	N	Mean	SD	Std. Error	MIN	MAX	P value
<1 x/week	34	8	35	6,0	0,00	180	0.556
1-3 x/week	55	7	28	3,8	0,00	140	
≥4 x/week	27	8	22	4,2	0,00	100	

One way ANOVA - Kruskal-Wallis test, sign level. 0.05

Cereal rich in fibre FFQ vs. 24- recall

	N	Mean	SD	Std. Error	MIN	MAX	P value
≤1x/week	71	7	23	2,7	0	120	0.224
≤2 x/week	47	19	54	7,9	0	300	

One way ANOVA - Kruskal-Wallis test, sign level. 0.05

Potatoes 24-h recall vs. FFQ

	N	Mean	SD	Std. Error	MIN	MAX	P value
≤1x/week	28	39	95	18,0	0	375	0.769
2-3 x/week	58	48	97	12,7	0	460	
≥4 x/week	32	34	64	11,3	0	230	

One way ANOVA - Kruskal-Wallis test, sign level. 0.05

Vegetables cooked and raw 24-h recall vs. FFQ

	N	Mean	SD	Std. Error	MIN	MAX	P value
≤1x/week	58	40	75	9,8	0	410	0.004
2-3 x/week	47	112	105	15,3	0	430	
4-5 x/week	13	153	164	45,4	0	585	

One way ANOVA - Kruskal-Wallis test, sign level. 0.05

Fruits and berries FFQ vs. 24- recall

	N	Mean	SD	Std. Error	MIN	MAX	P value
<1 a week	11	35	87	26,2	0,00	280	0.006
1-3 x a week	37	45	78	12,8	0,00	350	
4-5 x a week	39	99	118	18,9	0,00	570	
> 6 x a week	31	120	142	25,4	0,00	534	

One way ANOVA - Kruskal-Wallis test, sign level. 0.05

Fish consumption FFQ vs. 24- recall

	N	Mean	SD	Std. Error	MIN	MAX	P value
≤1x/week	54	10	38	5,2	0	221	0.179
2-3 x/week	59	25	61	7,9	0	260	
≥4 x/week	5	49	102	45,5	0	231	

One way ANOVA - Kruskal-Wallis test, sign level. 0.05

Meet consumption - FFQ vs. 24- recall

	N	Mean	SD	Std. Error	MIN	MAX	P value
≤1x/week	3	148	115	66,5	68	280	0.853
2-3 x/week	36	128	126	20,9	0	660	
4-5 x/week	38	109	82	13,4	0	300	
≥6 x/week	41	105	90	14,1	0	369	

One way ANOVA - Kruskal-Wallis test, sign level. 0.05

Sodas and sugary drinks FFQ vs. 24- recall

	N	Mean	SD	Std. Error	MIN	MAX	P value
<1 x/week	32	61	154	27,2	0,00	500	<0.001
1-3 x/week	29	300	574	106,6	0,00	2500	
4-5 x/week	24	314	656	133,9	0,00	3000	
≥ 6 x/week	33	555	677	117,9	0,00	3230	

One way ANOVA - Kruskal-Wallis test, sign level. 0.05

Diet sodas and drinks FFQ vs. 24- recall

	N	Mean	SD	Std. Error	MIN	MAX	P value
<1 x/week	29	9	46	8,6	0,00	250	0.046
1-3 x/week	41	119	296	46,2	0,00	1130	
4-5 x/week	21	192	413	90,0	0,00	1250	

One way ANOVA - Kruskal-Wallis test, sign level. 0.05

Carbonated water FFQ vs. 24- recall

	N	Mean	SD	Std. Error	MIN	MAX	P value
≤1x/week	51	27	100	14,0	0	500	0.664
2-3 x/week	33	70	181	31,5	0	800	
≥4 x/week	34	150	288	49,5	0	1400	

One way ANOVA - Kruskal-Wallis test, sign level. 0.05

Tab water FFQ vs. 24- recall

	N	Mean	SD	Std. Error	MIN	MAX	P value
<7 x/week	44	575	622	93,8	0	2820	<0.001
Often a day	75	1135	926	106,9	0	4600	

One way ANOVA - Kruskal-Wallis test, sign level. 0.05

Candy, cakes and sweets, FFQ vs. 24- recall

	N	Mean	SD	Std. Error	MIN	MAX	P value
<1 x/week	35	67	174	29,3	0	943	0.065
1-3 x/week	45	63	94	14,1	0	524	
4-5 x/week	27	60	88	17,0	0	390	
≥ 6 x/week	12	70	67	19,4	0	195	

One way ANOVA - Kruskal-Wallis test, sign level. 0.05

Protein supplement consumption FFQ vs. 24-h recall

	N	Mean	SD	Std. Error	MIN	MAX	P value
Never	65	0	0	0,0	0	0	<0.001
< 1 x/week	17	29	121	29,4	0	500	
=>1 x/week	37	350	920	151,3	0	5025	

One way ANOVA - Kruskal-Wallis test, sign level. 0.05

French fries, crisps and pop corn FFQ vs. 24- recall

	N	Mean	SD	Std. Error	MIN	MAX	P value
≤1 x/week	52	9	33	4,6	0	200	<0.001
2-3 x/week	29	18	35	6,6	0	120	
≥4 x/week	37	42	60	9,8	0	260	

One way ANOVA - Kruskal-Wallis test, sign level. 0.05

Prepared sandwiches and bakery goods FFQ vs. 24- recall

	N	Mean	SD	Std. Error	MIN	MAX	P value
≤1x/week	42	64	143	22,1	0	590	0.242
2-3 x/week	48	65	136	19,7	0	678	
≥4 x/week	28	144	231	43,6	0	740	

One way ANOVA - Kruskal-Wallis test, sign level. 0.05

Fast food consumption FFQ vs. 24- recall

	N	Mean	SD	Std. Error	MIN	MAX	P value
≤1x/week	51	84	145	20,3	0	600	0.023
2-3 x/week	49	175	215	30,8	0	900	
≥4 x/week	18	179	270	63,6	0	1085	

One way ANOVA - Kruskal-Wallis test, sign level. 0.05

Milk products* - combined FFQ vs. 24- recall

	N	Mean	SD	Std. Error	MIN	MAX	P value
≤1 x/week	19	297	287	65,9	0	946	0.103
2-5 x/week	88	643	566	60,4	0	3500	
≥6 x/week	11	938	468	141,0	200	1962	

One way ANOVA - Kruskal-Wallis test, sign level. 0.05

Milk, milk products and cheese.

Appendix 8

FFQ by protein supplement consumers

Crosstabs with chi-square test FFQ, sign. level 0.05

Protein supplement consumers		NC		OC		PC		P value
		n, %		n, %		n, %		
Bread ≥ 6 g fibre	< 1 x a week	21	29.2	5	25.0	15	36.6	0.663
	1-3 x a week	33	45.8	12	60.0	18	43.9	
	≥ 4 x a week	18	25.0	3	15.0	8	19.5	

Protein supplement consumers		NC		OC		PC		P value
		n, %		n, %		n, %		
Cereal rich in fibre	≤ 1x a week	49	66.2	11	55.0	21	51.2	0.257
	≥ 2 x week	25	33.8	9	45.0	20	48.8	

Protein supplement consumers		NC		OC		PC		P value
		n, %		n, %		n, %		
Brown pasta/ rice	Never	23	31 .1	1	5 .0	10	24 .4	0.329
	≤ 1x a week	17	23 .0	7	35 .0	13	34 .2	
	1 x/week	14	18 .9	5	25 .0	6	15 .8	
	≥ 2 x/week	20	27 .0	7	35 .0	9	23 .7	

Protein supplement consumers		NC		OC		PC		P value
		n, %		n, %		n, %		
Meet	≤ 1x a week	4	5.4	1	5.0	0	0.0	0.270
	2-3 x a week	21	28.4	7	35.0	12	29.3	
	4-5 x a week	27	36.5	9	45.0	11	26.8	
	≥ 6 x a week	22	29.7	3	15.0	18	43.9	

Protein supplement consumers		NC		OC		PC		P value
		n, %		n, %		n, %		
Fish	≤ 1x a week	40	54.1	6	30.0	17	41.5	0.320
	2-3 x a week	31	41.9	13	65.0	21	51.2	
	≥ 4 x a week	3	4.1	1	5.0	3	7.3	

Protein supplement consumers		NC		OC		PC		P value
		n, %		n, %		n, %		
Fish	≤ 1x a week	40	54.1	6	30.0	17	41.5	0.116
	≥ 2 x a week	34	45.9	14	70.0	24	58.5	

Protein supplement consumers		NC		OC		PC		P value
		n, %		n, %		n, %		
Average vegetable intake	≤ 1x a week	50	30.3	5	14.3	12	20.3	0.080
	2-3 x a week	33	20.0	14	40.0	21	35.6	
	4-5 x a week	51	30.9	11	31.4	16	27.1	
	≥ 6 x a week	31	18.8	5	14.3	10	16.9	

Protein supplement consumers		NC		OC		PC		P value
		n, %		n, %		n, %		
Vegetable or bean stew	Never	40	32.5	3	13.0	9	22.0	0.050
	< 1 x a week	44	35.8	14	60.9	13	31.7	
	1 x a week	39	31.7	6	26.1	19	46.3	

Protein supplement consumers		NC		OC		PC		P value
		n, %		n, %		n, %		
Fruits and berries	<1 a week	9	12.2	2	10.0	1	2.4	0.218
	1-3 x a week	24	32.4	8	40.0	12	29.3	
	4-5 x a week	27	36.5	6	30.0	12	29.3	
	≥ 6 x a week	14	18.9	4	20.0	16	39.0	

Protein supplement consumers		NC		OC		PC		P value
		n, %		n, %		n, %		
Sodas and drinks with sugar	≤ 1 x/week	21	28.4	4	20.0	14	34.1	0.502
	2-3 x/week	18	24.3	3	15.0	11	26.8	
	4-5 x/week	17	23.0	4	20.0	6	14.6	
	≥ 6 x/week	18	24.3	9	45.0	10	24.4	

Protein supplement consumers		NC		OC		PC		P value
		n, %		n, %		n, %		
Diet soda and drinks	≤ 1x/week	22	40.0	3	23.1	11	30.6	0.166
	1-3 x/week	22	40.0	4	30.8	19	52.8	
	≥4 x/week	11	20.0	6	46.2	6	16.7	

Protein supplement consumers		NC		OC		PC		P value
		n, %		n, %		n, %		
Carbonated water	≤ 1x/week	33	44.6	6	30.0	17	41.5	0.748
	1-3 x/week	19	25.7	8	40.0	12	29.3	
	≥4 x/week	22	29.7	6	30.0	12	29.3	

Protein supplement consumers		NC		OC		PC		P value
		n, %		n, %		n, %		
Tab water	<7 x/week	29	39.2	8	40.0	18	42.9	0.927
	Often per day	45	60.8	12	60.0	24	57.1	

Protein supplement consumers		NC		OC		PC		P value
		n, %		n, %		n, %		
Tab water	≤ 5x/week	18	24.3	2	10.0	4	9.5	0.069
	6-7 x/week	11	14.9	6	30.0	14	33.3	
	Often per day	45	60.8	12	60.0	24	57.1	

Protein supplement consumers		NC		OC		PC		P value
		n, %		n, %		n, %		
Candy. biscuits, cakes	≤ 1x/week	20	27.0	4	20.0	16	38.1	0.242
	2-3 x/week	31	41.9	6	30.0	16	38.1	
	4-5 x/week	14	18.9	6	30.0	9	21.4	
	≥ 6 x/week	9	12.2	4	20.0	1	2.4	

Protein supplement consumers		NC		OC		PC		P value
		n, %		n, %		n, %		
French fries, crisps and pop corn	≤ 1x/week	32	43.2	6	30.0	20	48.8	0.549
	2-3 x/week	18	24.3	8	40.0	9	22.0	
	≥ 4 x/week	24	32.4	6	30.0	12	29.3	

Protein supplement consumers		NC		OC		PC		P value
		n, %		n, %		n, %		
Readymade sandwiches and bakery goods	≤ 1x/week	29	39.2	5	25.0	14	34.1	0.641
	2-3 x/week	30	40.5	8	40.0	18	43.9	
	≥ 4 x/week	15	20.3	7	35.0	9	22.0	

Protein supplement consumers		NC		OC		PC		P value
		n, %		n, %		n, %		
Fast food	≤ 1x/week	31	41.9	7	35.0	20	48.8	0.441
	2-3 x/week	32	43.2	8	40.0	18	43.9	
	≥ 4 x/week	11	14.9	5	25.0	3	7.3	

Protein supplement consumers		NC		OC		PC		P value
		n, %		n, %		n, %		
All milk products	≤ 1x/week	18	24.7	1	10.0	4	15.4	0.055
	2-5 x/week	54	74.0	7	70.0	19	73.1	
	≥ 6 x/week	1	1.4	2	20.0	3	11.5	

Appendix 9

Blood pressure values categorized.

Category[121]	Systolic, mmHg	Diastolic, mmHg
Ideal	< 120	< 80
Normal	< 135	< 85
Edge of hypertension	135-139	85-89
Hypertension	≥140-160	>90-95

Appendix 10

Protein supplement consumption by FFQ

Frequency	n	%
Never	74	54,4
< 1 x a week	20	14,7
1 x a week	3	2,2
2-3x a week	11	8,1
4-5x a week	14	10,3
6-7x a week	6	4,4
Many times a day	8	5,9

Appendix 11

Questions from the knowledge part of the questionnaire about protein.

Icelanders do not eat enough protein.

	NC	OC	PC	P value
	n (%)	n (%)	n (%)	
Correct	18 (24.3)	5 (25.0)	16(38.1)	0.604
Wrong	30 (40.5)	9 (45.0)	16 (38.1)	
I don't know	25 (33.8)	5 (25.0)	9 (21.4)	
I don't want to answer	1 (1.4)	1 (5.0)	1 (2.4)	

Chi-Square test, sign level 0.05.

Protein is the most important nutrient for athletes.

	NC	OC	PC	P value
	n (%)	n (%)	n (%)	
Correct	32 (43.2)	8 (40.0)	17 (40.5)	0.735
Wrong	25 (33.8)	8 (40.0)	18 (42.9)	
I don't know	16 (21.6)	3 (15.0)	7 (16.7)	
I don't want to answer	1 (1.4)	1 (5.0)	0 (0.0)	

Chi-Square test, sign level 0.05.

It is difficult to fulfil RDS of protein with normal food.

	NC	OC	PC	P value
	n (%)	n (%)	n (%)	
Correct	9 (12.2)	7 (35.0)	9 (21.4)	0.291
Wrong	40 (54.1)	8 (40.0)	24 (57.1)	
I don't know	22 (29.7)	4 (20.0)	8 (19.0)	
I don't want to answer	3 (4.1)	1 (5.0)	1 (2.4)	

Chi-Square test, sign level 0.05.

Icelanders do not eat enough protein

	n	%
Correct	40	29,2
Wrong	55	40,1
I don't know	39	28,5
I don't want to answer	3	2,2

Protein is the most important nutrient for athletes

	n	%
Correct	57	41,6
Wrong	52	38,0
I don't know	26	19,0
I don't want to answer	2	1,5

It is difficult to fulfil RDS of protein with normal food

	n	%
Correct	25	18,2
Wrong	72	52,6
I don't know	35	25,5
I don't want to answer	5	3,6