Analysis of nutritional patterns in individuals at risk for the development of the metabolic syndrome assessed by a food frequency questionnaire

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Abbreviations

AACE	American Association of Clinical Endocrinology, American College of Endocrinology
BGS	Bundesgesundheitssurvey
BLS	Bundeslebensmittelschlüssel
BMI	Body Mass Index
BMR	Basal Metabolic Rate
BP	Blood pressure
BW	Body Weight
CI	Confidence Interval
CHD	Coronary Heart Disease
CVD	Cardiovascular Disease
DACH	Deutsche Akkreditierungsstelle Chemie
DGE	Deutsche Gesellschaft für Ernährung
DHA	Docosahexaenoic Acid
DNSG	Diabetes and Nutrition Study Group
EASD	European Association for the Study of Diabetes
EFQM	European Foundation for Quality Management
EGIR	European Group for the Study of Insulin Resistance
EI	Energy Intake
EPA	Eicosapentaenoic Acid
F	Female
FAO	Food and Agriculture Organisation
FFQ	Food Frequency Questionnaire
HDL	High-density Lipoprotein
IDF	International Diabetes Federation
LDL	Low-density Lipoprotein
Lp(a)	Lipoprotein (a)
LUPS	Lipid and Glucose under Prospective Surveillance
M	Male
MetS	Metabolic Syndrome
MUFA	Monounsaturated Fatty Acids
NARI	Nutritional Intake in Risk Groups

NCEP-ATP III	National Cholesterol Education Program's Adult Treatment Panel III
NVS	Nationale Verzehrsstudie
n-3 FA	Omega - 3 Fatty Acids
n-6 FA	Omega - 6 Fatty Acids
OR	Odds Ratio
PAL	Physical Activity Level
PUFA	Polyunsaturated Fatty Acids
r	Pearson Correlation Coefficient
RR	Relative Risk
SFA	Saturated Fatty Acids
SHIP	Study of Health in Pomerania
SSB	Sugar-sweetened Beverages
TG	Triglyceride
Trans FA	Trans-unsaturated Fatty Acids
T2D	Diabetes Mellitus Type 2
USDA	United States Department of Agriculture
WHO	World Health Organisation
WHR	Waist Hip Ratio

1. Introduction

The metabolic syndrome (MetS) is a worldwide growing phenomenon in industrial nations, having an enormous impact on public health in terms of an increased risk for diseases like type 2 diabetes (T2D) and cardiovascular diseases (CVD) [1,2]. Ever since the discussion of a worldwide accepted definition is on-going for decades, meanwhile there is more or less a worldwide accepted definition of the MetS by a cluster of at least three out of five of the following symptoms which are an elevated blood glucose, high triglycerides, a reduced HDL-cholesterol, an elevated blood pressure and an increased waist circumference [3-9].

Epidemiological data have shown an significant increased risk for T2D, CVD and all-cause mortality in patients having the MetS [1,2]. Until now a main research focus is to identify people at higher risk for these chronic diseases at a very early stage to cut down the alarming numbers of T2D and CVD. Beside of a still poorly understood genetic impact the MetS is caused by physical inactivity and high caloric diets leading to overweight and obesity [10]. In recent years several studies have shown that high fat diets, particularly saturated fatty acids, added sugar and other energy-dense foods as well as diets low in wholegrain products are associated with the increasing prevalence of obesity and MetS [11-23].

Regarding to this underlying link between nutritional intake and metabolic outcome I examined the habitual nutritional intake and dietary quality in a cohort of employees of a German company via a food frequency questionnaire.

1.1. Metabolic Syndrome

1.1.1. History of the Metabolic Syndrome

Back to the 17th century, N. Tulp, G.B. Morgagni, G.Maranon and E. Kylin identified an association of several risk factors like obesity, atherosclerosis, diabetes and hyperuricaemia [24,25]. In 1956 J. Vague [26] and in the mid-seventeens' P. Avogaro (1965) and J.P. Camus (1966) [27,28] figured out that the abdominal fat has somehow an influence on the development of type 2 diabetes, atherosclerosis, gout and uric calculus disease. In Germany, the term metabolic syndrome has been firstly used in 1969 by K. Jahnke and 1977 by H. Haller [29,30]. The description of the MetS in 1981 by M. Hanefeld and W. Leonhardt [31] defined the syndrome as a cluster of obesity, hyper- and dyslipoproteinemia, maturity-onset-Diabetes (Type2), hypertension and gout with an increased incidence of atherosclerosis, vascular disease, fatty liver and cholelithiasis accompanied by the individual genetic disposition and environmental factors. In his legendary Banting Lecture in 1988 G. Reaven established the MetS as Syndrome X [32]. Insulin resistance with the concomitant occurrence

of hypertension, reduced high-density lipoprotein (HDL) cholesterol and hypertriglyceridemia characterized the Syndrome X. The impact of the visceral adipose tissue, producing pro-inflammatory cytokines, insulin resistance, genetic pathways and psychosocial variables including depression as well as lifestyle factors like physical inactivity and dietary habits is still a major field of on-going research to detect the underlying pathophysiology of the MetS [33-44].

1.1.2. Definition of the Metabolic Syndrome

The WHO definition of the MetS, published in 1999 is still worldwide recommended. A diagnosis of the syndrome by the WHO criteria could be made on the basis of several indicators of insulin resistance levels plus 2 additional risk factors including obesity or an increased waist-hip ratio, raised blood pressure, raised triglycerides, reduced high-density lipoprotein (HDL) cholesterol or microalbuminuria [3]. Quite recently insulin resistance and abdominal obesity are better understood as risk factors in the development of CVD and T2D. Therefore at least half a dozen definitions of the MetS circle around, based on the same risk factors but varying in cut offs. Definitions of the following groups the European Group for the Study of Insulin Resistance (EGIR) 1999 [4], the National Cholesterol Education Program's Adult Treatment Panel III (ATPIII) 2001 [5], the American Association of Clinical Endocrinology, the American College of Endocrinology (AACE, 2003) [6], an update of the National Cholesterol Education Program NCEP – ATP III (2004) [7] and in 2005 the definition of the International Diabetes Federation (IDF) [8] have been published. In 2009 the International Diabetes Federation Task Force on Epidemiology and Prevention, the World Heart Federation, the International Atherosclerosis Society and the International Association for the Study of Obesity published a modified version of the NCEP – ATP III criteria including the presence of any 3 of the following 5 risk factors: 1. abdominal obesity (waist circumference: men ≥ 102 cm, women ≥ 88cm), 2. elevated triglycerides (TG) (≥ 150 mg/dl) or taking TG - lowering medication, 3. reduced high-density lipoprotein (HDL) cholesterol (men < 40 mg/dl, women < 50 mg/dl) or taking HDL - lowering medication, 4. elevated blood pressure (≥ 130/ ≥ 85 mm Hg) or taking antihypertensive drugs and 5. increased fasting blood glucose (≥ 100 mg/dl) or already medicated T2D [9]. In Table 1 the different definitions with cut offs are shown in detail.

Table 1: Summary of the most widely used definitions of the Metabolic Syndrome

Risk factors	WHO 1999 [3]	EGIR 1999 [4]	NCEP-ATP III 2001 [5]	AACE 2003 [6]	NCEP-ATP III 2004 [7]	IDF 2005 [8]	Joint Statement 2009 [9]
	Fasting glucose plus 2 of the following features had to be received	Hyper-insulinemia plus 2 of the following features had to be received	3 of the following 5 features had to be received	Fasting glucose plus 2 of the following features had to be received	3 of the following 5 features had to be received	Abdominal adiposity plus 2 of the following features had to be received	3 of the following 5 features had to be received

Fasting blood glucose	≥ 126 mg/dl or ≥ 110 - 126 mg/dl, Insulin resistance[#]	Only non-diabetic subjects, Hyper-insulinemia Fasting insulin > 75th percentile of the cohort	≥ 110 mg/dl or known diabetes	≥ 110 mg/dl < 126 mg/dl, not diabetes	≥ 100 mg/dl or diabetes	≥ 100 mg/dl or previously diagnosed diabetes type 2	≥ 100 mg/dl or diabetes or treatment with antidiabetic drugs
Abdominal obesity (BMI, waist, WHR)	BMI > 30 kg/m²	M ≥ 94 cm	M > 102 cm		M ≥ 102 cm	M ≥ 94 cm	M ≥ 102 cm
	and/ or WHR: M > 0.90 F > 0.85	F ≥ 80 cm	F > 88 cm		F ≥ 88 cm	F ≥ 80 cm or BMI ≥ 30 kg/m²	F ≥ 88 cm
Blood pressure	≥ 140/90 mm Hg		≥ 130/85 mm Hg	≥ 130/85 mm Hg	≥ 130/85 mm Hg	≥ 130/85 mm Hg or treatment of previously diagnosed hypertension	≥ 130/85 mm Hg or treatment with antihypertensive drugs
Triglycerides	≥ 150 mg/dl[§]	≥ 180 mg/dl or treatment for dyslipidemia	≥ 150 mg/dl	≥ 150 mg/dl	≥ 150 mg/dl	≥ 150 mg/dl or treatment for this lipid abnormality	≥ 150 mg/dl or treatment with TG lowering drugs
HDL cholesterol	M < 35 mg/dl	< 39 mg/dl	M < 40 mg/dl	M < 40 mg/dl	M < 40 mg/dl	M < 40mg/dl	M < 40 mg/dl
	F < 39 mg/dl		F < 50 mg/dl	F < 50 mg/dl	F < 50 mg/dl	F < 50 mg/dl or specific treatment for this lipid abnormality	F < 50 mg/dl or treatment for reduced HDL cholesterol
Others	Micro-albuminuria[$]						

[#] Insulin resistance measured under hyperinsulinemic, euglycemic conditions, glucose uptake below lowest quartile for background population under investigation.
M = male, F = female
[§] and or reduced HDL-cholesterol
[$] Urinary albumin excretion rate ≥ 20 µg/min or albumin:creatinine ratio ≥ 30 mg/g

1.1.3. Prevalence of the Metabolic Syndrome

The prevalence of the MetS in the German population is depending on the underlying definition between 19.8% and 23.8% [45-48]. Compared to the female population, there is a slightly higher risk for the MetS in the male population (male 22% to 27%, female 18% to 21%) [45-48]. The prevalence of the MetS is rising due to age up to 70 - 75 years and is higher in men than in women up to an age of 65 - 69 years [47,48]. Studies estimating the prevalence of the MetS in cohorts of Korea, China, Italy and France reported a lower prevalence ranging between 6.8 and 16.2% [49-53]. In Ireland and Oman [54,55] the prevalence of the MetS was comparable (20.7% – 21.0%) to that in the German population, whereas the prevalence reported for Iran [56], Great Britain [57], Greece [58] and the US population [59-61] was much higher than in the German population (23.6% – 34.1%). Consequences of the MetS are an increased risk for developing diabetes type 2, cardiovascular disease as well as all-

cause mortality [1,2,9]. Ford and colleagues reported in a meta-analysis that the incidence of T2D in patients with a MetS, depending on the definition, is associated with a relative risk (RR) of 3.5 – 5.2 [1]. Diagnosing 3 or more abnormal components of the MetS raised the incidence of diabetes. Therefore, the comparison of patients with any component of the MetS to patients fulfilling four or more factors of the MetS estimated a RR for T2D between 10.9 and 24.4 [1]. Even if the association between the metabolic syndrome and cardiovascular disease is less compared to the association between T2D and MetS, Mottillo et al. have shown in a 2010 published meta-analysis an increased risk for CVD mortality of 75% (RR: 1.75; 95% CI: 1.19 to 2.58), for myocardial infarct of 62% (RR: 1.62; 95% CI: 1.31 to 2.01) and for stroke an increased risk of 86% (RR: 1.86; 95% CI: 1.10 to 3.17). According to the current state of research the effect of the MetS on all-cause mortality is not quite clear (RR: 1.32; 95% CI: 0.65 to 2.67) [2]. Patients already having T2D and MetS do have as expected an even higher risk for CVD (RR: 2.35; 95% CI: 2.20 to 2.73), CVD mortality (RR: 2.40; 95% CI: 1.87 to 3.08), myocardial infarct (RR: 1.99; 95% CI: 1.61 to 2.46), stroke (RR: 2.27; 95% CI: 1.80 to 2.85) and all-cause mortality (RR: 1.58; 95% CI: 1.39 to 1.78) [2].

1.2. Recommendations for the nutritional management of the metabolic syndrome

From a scientist point of view there is no doubt about the huge influence of both dietary habits and lifestyle changes especially high calorie input combined with insufficient physical activity leading to the worldwide growing epidemic occurrence of chronic diseases like obesity, T2D and CVD [11,12,62-64]. These changes are reflected in shifting dietary patterns, for example towards the consumption of energy-dense diets with high fat, particular saturated fat (SFA), high sucrose or free sugars and foods with a high glycaemic index and low in wholegrain cereals [12,14,65,66]. These patterns are associated with declined energy expenditure due to an increasing sedentary lifestyle. Due to the fact that nutrition is a major factor, which can be modified to influence health and the development of chronic diseases a wide range of nutritional recommendations have been published to prevent and treat such diseases. Some of them are mentioned below more detailed.

1.2.1 Recommendations for energy and nutrient intake

The recommended individual nutritional intake of the population published by the German Society of Nutrition (Deutsche Gesellschaft für Ernährung, DGE) [62] is quite good comparable to the recommendations for chronic disease by the WHO/ FAO [63] as well as to the recommendations for the prevention of diabetes or cardiovascular disease [11,64] and the recommendations for the US population [12].

The daily energy intake is depending on age, gender, body weight and the daily physical activity level (PAL) [62]. Based on a low physical activity level of 1.4 at an age of 25 to 65 years a daily energy intake between 9.300 kJ – 10.200 kJ for male and 7.400 kJ – 7.800 kJ for female individuals is recommended. Because of its adverse effects on triglycerides, LDL-cholesterol, insulin sensitivity, blood pressure, atherosclerosis, obesity, coronary disease and the metabolic syndrome, total fat intake should not exceed 30 - 35% of total daily energy [12,13,62-64,67]. The adverse effects of saturated fatty acids (SFA) on particular coronary heart disease (CHD) by raising LDL-cholesterol levels and impairing insulin sensitivity as well as its pro-coagulate effects result in the recommendation of less than 10% of total daily energy for SFA [12,13,62-64,67]. Regarding to individuals with an increased risk for CVD, some studies identified an extra beneficial effect by an intake of SFA reduced to < 7% [12,14,62-64]. For monounsaturated fatty acids (MUFA) naturally occurring in olive oil, rapeseed oil or nuts an intake above 10% is recommended. The total daily energy intake of MUFA, calculated by the difference of total fat minus SFA plus PUFA and trans FA should ideally account between 10 – 20% [62-64]. The recommended intake for MUFAs is due to an alteration in serum lipid levels, particular to lower total cholesterol and LDL-cholesterol as well as an altered lipoprotein composition and increased insulin sensitivity [15,68]. Polyunsaturated fatty acids (PUFA) do have a beneficial effect on the MetS, CVD and coronary disease by improving lipid and lipoprotein profile and systemic inflammation [69]. Based on this effect, a ratio of omega - 6 fatty acids (n-6 FA) to omega - 3 fatty acids (n-3 FA) of 5:1 and a daily intake of these fatty acids of 6 – 10% of total energy intake is recommended [62,63,69]. The restriction to a maximum of 10% is due to potential adverse effects of PUFAs on lipid peroxidation. Trans-unsaturated fatty acids (trans FA), partially hydrogenated fats, produced during processing confectionary and commercially fried foods (e.g. biscuits, cakes and chocolate) and naturally occurring in margarine should be reduced to less than 1% as of their adverse effects on lipoprotein profile (increase of LDL-cholesterol, Lp(a), decrease of HDL-cholesterol) and CVD [12,14,62-64]. Assuming dietary cholesterol increase the risk of CVD the recommended intake should not exceed 300 mg/day and should be reduced strictly if LDL-cholesterol is above the upper limits [11,12,14,62-64].

The physiological demand of protein in healthy individuals is 0.8 g/kg BW and is equivalent to 9 to 11% of the daily energy intake [62]. The usual dietary protein intake evaluated in several studies ranged between 10 - 20% of daily energy intake. A widely used recommendation for dietary protein intake ranges between 10 – 20% of the daily energy intake [62-64], although recent guidelines from the US are recommending a protein intake up to 35% of the total daily energy intake [12]. These different recommendations are demonstrating a still on-going debate about the amount of protein in the diet. Some studies have shown a significant reduced risk for CHD, blood pressure and increased LDL-cholesterol for individuals with higher protein intake [70]. Additionally, high-protein diets have

shown to determine weight loss, improve glycaemia and triglyceride levels [71,72]. But the long-term effects on metabolic parameters are not quite well established nowadays. In contrast, major protein sources, for example, red meat and high-fat dairy products were significantly associated with an elevated risk of CHD and T2D [73,74].

The recommended carbohydrate intake is depending on the total fat and protein intake. For example, a recommendation of 30% total fat and 10 to 15% protein of daily energy intake, an intake of 55 to 60% carbohydrate is recommended [62]. The actual recommendations ranged from > 50% by the DGE [62], 45 – 60% for diabetic subjects [11,64], 45 – 65% by the USDA guidelines [13] and 55 – 75% by the WHO/FAO [63]. Analogous to the protein intake the carbohydrate intake is subject of a permanent debate. Some studies have shown an association of high carbohydrate intake and MetS (RR: 1.62 $p < 0.05$, OR: 2.7 $p < 0.01$) [75,76] reflected in increased triglyceride levels, reduced total cholesterol and LDL-cholesterol levels and reduced weight gain [16]. Liu S. and colleagues reported no coherence between high carbohydrate intake and the risk of T2D and CHD [77]. In addition there are no data showing an association between low or very low carbohydrate diet and risk of developing T2D [12,14,16,62-64]. Regarding to the recommended carbohydrate intake both quantity and source of carbohydrates having an impact on metabolism [16,17,77]. In particular high fibre foods with a rather low glycaemic load are known as the most valuable carbohydrate source. The German Society of Nutrition [62] suggested a dietary fibre intake of ≥ 30 g/day (women: 16 g/1000 kcal, men: 12.5 g/1000 kcal). The recommendation of the WHO/ FAO are down to > 25 g/day [50], the USDA guidelines propose 22 – 31 g/day [12] whereas patients already having T2D should ideally reach > 40 g/day of fibre according to the DNSG of the EASD nutritional guidelines [11,64]. Nutritional patterns containing high dietary fibre and wholegrain products are associated with a reduced risk of obesity, T2D, hypertension, colon cancer and CHD [17] as well as with a modest reduction in total and LDL-cholesterol [12,15,16,62-64]. Dietary fibre from fruits and vegetables mostly accompanied by large amounts of secondary plant sterols, vitamins and minerals may reduce CHD and T2D risk [77]. Additionally, dietary fibres promote satiety by slowing gastric emptying and nutrient uptake as well as by releasing satiety hormones, all leading to a decreased calorie intake [78,79]. Total free sugar should not exceed 10% of total daily energy [12,14,62-64].

Depending on the amount, consumed alcohol may have beneficial or harmful effects. Moderate alcohol consumption is associated with a lower cardiovascular risk and all-cause mortality [15]. However, excessive drinking provides many calories and is associated with increased body weight as well as an increase of all-cause mortality [80,81]. The nutrition societies, in line, are recommending a limited intake of alcohol to 20 g/d for men and 10 g/d for women, in case there is no contraindication because of special diseases [12-14,62,63]. These amounts are corresponding to a single drink a day

for women and for men not more than two drinks per day are appropriate [12,62,63]. For instance a 0.5 L bottle of German beer (0.5 L, 5.0 vol.-%) bears already 20 g alcohol.

A correlation of habitual dietary salt intake and blood pressure, stroke and CVD has been shown in many studies [82-84]. Furthermore, negative effects on left ventricular mass, arterial stiffness and renal function are known [82]. The recommendation of the DGE, WHO and USDA varied at most between 5 to 6 g/d for healthy individuals whereas the USDA guidelines recommend less than 3.75 g/d for subjects having hypertension, diabetes or chronic kidney disease [12,62,63].

1.2.2. Guidelines for the intake of different food groups

Corresponding to the recommendations for nutrient intake there are some guidelines for the consumption of different food groups. Diet should be rich in vegetables and fruits to lower the overall intake of energy-dense food and to ensure the intake of micronutrients, macronutrients and fibre leading to a lower risk of MetS and CVD [12,14,62,63,77,85]. According to the recommendation of the DGE cereal products should be consumed 4 times per day [49] at least half of it via wholegrain products. Generally, refined grains should be replaced by wholegrain products [12,14,63]. The intake of PUFA, n - 3 FA eicosapentaenoic acid (C20:5 n-3, EPA) and docosahexaenoic acid (C22:6 n-3, DHA), should be provided via an intake of preferable oily fish at least two times a week [12,14,62,63]. Fish consumption on a regular basis has been shown to be associated with a raised HDL-cholesterol, reduced TG levels and a reduced risk of coronary disease [15]. Furthermore, fish consumption can replace animal protein sources like red meat or whole-fat dairy products containing more saturated fatty acids [12,14,62,63,86]. Promoting healthy lipid profiles and insulin sensitivity the intake of 1 serving of nuts and seeds corresponding to 20 g per day is recommended [68]. To limit the intake of saturated fat, trans FA and cholesterol it is recommended to consume vegetable oil e.g. rapeseed or olive, lean meat like poultry or vegetable protein alternatives as well as skim or low – fat dairy products [12,14,62,63]. In general, dairy products are recommended to consume 3 times a day. Since the association of red meat and the development of MetS, T2D and coronary disease the German Society of Nutrition is recommending a limited intake of meat and meat products to 2 - 3 servings per week [13,18,73,74,85]. The intake of sweets, added sugar and sugar sweetened beverages (SSB) should be cut down to a minimum. Individuals consuming large amounts of SSB have an increased intake of calories with low effects on satiety. Thereby regularly drinking SSB increases the risk of weight gain and MetS [19,87,88]. Salt used for cooking or consumed via convenience food should also be minimized. Blood pressure may be lowered via reduced salt intake and accordingly the risk of cardiovascular disease, congestive heart failure and kidney disease [12,14,62,63,82-84].

Dietary patterns enable to analyse clusters of intake to estimate the diet-disease relation. Nutritional patterns including food like nuts, legumes, fish (oily fish), wholegrain cereals, oil, wine, fruits and

vegetables are inversely associated with hyperglycaemia, hypertension and prevalence of the MetS, T2D, CVD and CHD [13,15,18,20-23,87,89]. In contrast, dietary patterns mostly containing meat, processed meat, fried food, whole-fat dairy products, refined grains, sugar sweetened beverages and sweets are positively associated with the prevalence of the MetS, T2D, CVD and CHD [13,18,23-23,87,89]. The negative effect of the so-called “Western dietary patterns” may be due to a lower amount of beneficial food and nutrients as well as to a higher intake of SFA, trans FA, added sugars and refined grains [22].

2. Objectives

The aim of the *Lipid and glucose under prospective surveillance (LUPS)* study, a prospective examination of a cohort of 1.962 employees of a company in Hamburg, Germany, is to identify the impact of nutritional factors in the development of the MetS at an early stage. Nutritional intake and dietary quality were assessed via using a standardized food frequency questionnaire.

The present study is an analysis (a first step of a planned 3 – annually follow-up project) of reported energy, nutrient and food intake either sex, classified into different age groups of the total LUPS cohort. Furthermore, the habitual nutritional intake of the cohort was compared to actual evidence – based nutritional recommendations for the general population and for individuals at risk for the MetS. Identified unsound dietary patterns and their hazardous role in the development of the MetS were discussed. Therefore the baseline nutritional LUPS data were compared to the results of comparable German studies like the *Nationale Verzehrsstudie (NVS) 2006* and the *Bundesgesundheitssurvey (BGS) 1998* and projects published recently.

3. Methodology

Nutritional intake presented in this manuscript is part of the ***L**ipid and Gl**u**cose under **P**rospective **S**urveillance (LUPS)* project. LUPS is a joint research project between the university hospital Hamburg - Eppendorf and the Asklepios Kliniken Hamburg GmbH, initiated and headed during the first cross sectional observation of which data are used in this nutritional analysis by Prof. Dr. Ulrike Beisiegel (former Director of the Department of Molecular Cell Biology II, University Medical Center Hamburg-Eppendorf), Prof. Dr. Dirk Müller-Wieland (Director of the Department of General Internal Medicine, Asklepios Clinic St. Georg, Asklepios Campus Hamburg, Medical Faculty of Semmelweis University), Prof. Dr. Karl Wegscheider (Director of the Department of Medical Biometry and Epidemiology, University Hospital Hamburg-Eppendorf) and Prof. Dr. Bernd Löwe (Director of the Department of Psychosomatic Medicine and Psychotherapy, University Medical Center Hamburg-Eppendorf and Schön Klinik Hamburg-Eilbek) in collaboration with Dr. Monika Toeller (Department of Endocrinology, Diabetology and Rheumatology, University Hospital Düsseldorf, Heinrich-Heine-University). This prospective observational study carried out in Hamburg, Germany, is regarding to the development of the Metabolic Syndrome (MetS) and Type 2 Diabetes (T2D) in terms of risk factors like smoking, physical activity, psychosocial variables and nutrition with a particular emphasis on very early changes in the lipid and glucose metabolism.

3.1. Population and sampling

The prospective LUPS trial is planned to take at least ten years with a three year follow-up interval. Baseline examination took place from November 2008 to June 2010, at site of Lufthansa Technik GmbH in Hamburg, Germany. Overall, 1.962 individuals, aged 25 – 60 years, were recruited within the first examination. Individuals already diagnosed with diabetes or respectively have taken antidiabetic drugs or rather have had missing data were excluded from the analysis (n = 75).

Baseline examination was based on a comprehensive study operational procedure established by the LUPS Steering committee. Anyone involved in the study examination was trained to follow the standardized procedures. In brief the following analyses were done, venous blood samples were taken for biochemical measurements, after an overnight fasting (10h). All routine laboratory analyses were processed within 6 hours of blood collection by Medilys, Asklepios Hamburg GmbH, Institut für Labormedizin, Mikrobiologie und Krankenhaushygiene, certified and accredited by EFQM (European Foundation for Quality Management) and DACH (Deutsche Akkreditierungsstelle Chemie GmbH),

Germany. Anthropometric measurements comprised height without shoes, weight with light clothing, waist circumference (midway between the lowest rib and the iliac crest), hip circumference (maximal circumference between the iliac crest and the thigh region) and blood pressure in the sitting position after 5 minutes rest. Within standardized interviews information about the medical conditions and medical history, including family history as well as hormonal status particular in women were assessed in the total cohort. A comprehensive health and lifestyle questionnaire was used to evaluate demographic data, psychosocial status, smoking habits, physical activity and diet.

The study was acknowledged by the ethic committee of Hamburg and informed consent was obtained from all participants. The registration of the study is supplied in clinical trials register, NCT01313156.

3.2. Dietary intake assessment

Nutritional habits of the cohort have been assessed via, the dietary questionnaire NARI (**n**utritional int**a**ke in **ri**sk groups) [90]. NARI comprises a self-administered semi-quantitative food frequency questionnaire with 85 food items (FFQ85) representing present national food intake. The 85 possible food items are presented in Table 8.

In addition 17 questions have been used to assess the intake of supplements, sweeteners, dietetic food and to obtain detailed information on food which may have a specific influence on the lipid and glucose metabolism. Moreover, individuals were asked, if they have taken any vitamin, mineral, poly-supplements, artificial sweeteners, sugar substitutes, dietetic food or low-caloric food. Those who reported to have taken supplements were asked to tell the label of the supplements for further details. In terms of duration and dosage of supplement intake no information was assessed. Regarding to food specifically influencing the lipid metabolism individuals were asked in detail for the use and type of consumed oils, nuts, fish and margarines.

In addition the FFQ85 allows participants to give up to 7 further food items they usually eat, but which are not described in the 85 items of the FFQ. As appropriate additional reported food items were matched to one of the 85 established food codes and the predefined portion sizes of the FFQ85 respectively they were newly coded at the time dietary intake data were calculated.

Either, the 85 food items as well as the added food items were allotted to predefined food groups, based on the similarity of nutrient profiles according to the food groups of the German National Nutrition Survey II (Nationale Verzehrsstudie, NVS II) [65] and modified to the goals of the target population of the study (Table 2).

Table 2: Classification of food items into food groups

Foods or food groups	Food items
Refined grains	Wheat bread, rolls, rye-wheat bread, white rice (basmati, parboiled), pasta, noodles (egg), muesli, cornflakes, other refined cereal products
Wholemeal products	Wholemeal bread or rolls, crisp bread, brown rice (whole grain, natural), pasta (durum wheat, whole-grain), other wholemeal cereal products
Pastries	Pies, cake (pound or yeast), croissant, pancakes, cookies (butter), cookies with chocolate, puff pastries
Fast Food and convenience	Hamburger, hot dog, cheeseburger, pizza, fast food, toast hawaii, Croque, wraps, falafel, frozen foods, convenience products
Vegetables	Raw and cooked vegetables, herbals, vegetable juice
Legumes	Green peas, green beans, lentils, soybeans
Processed plant products	Processed plant products, vegetable salad
Potatoes	Salted potatoes, jacket potatoes
Potato products	French fries, fried potatoes, dumplings, mashed potatoes, potato salad, potato fritters, croquettes
Fruits	Fresh fruits
Nuts and seeds	Nuts and seeds, walnuts, sunflower seeds, linseed
Butter	Butter, low-fat butter as spread and for food preparation
Margarine	Margarine, low-fat margarine as spread and for food preparation
Oil	Oils
Other fat	Solid vegetable fat, bacon, mayonnaise
Low-fat dairy products	Skim or low-fat milk or yoghurt or soured milk (< 1,5% fat), low-fat curd cheese, buttermilk, whey beverage (fruits)
Low-fat cheese	Low-fat cheese
High-fat dairy products	Whole-fat milk or yoghurt or soured milk (> 1,5% fat), high-fat curd cheese, creamer, condensed milk, sour crème, crème fraiche
High-fat cheese	Whole-fat cheese
Eggs	Boiled, fried and scrambled eggs, omelette
Red and processed meat products	Meat (liver, lamb, beef, pig, venison), high-fat processed sausage and sausage products, high-fat processed meat, innards
Low-fat meat products	Low-fat processed sausage and sausage products, low-fat processed meat
Fish	Fish, smoked fish
Fish products and seafood	Canned fish, seafood and crustaceans, fish salad
Soups and stews	Vegetable or potato stew, vegetable soup, soup with meat or fish, broth or thickened
Sauces and condiments	Brown and white sauce, ketchup, mustard, vinegar, Maggi, Worchester sauce, spices
Sweets	Chocolate and chocolate bars, ice cream, water-ice, jam, honey, fruit gum, candies, chocolate spread, canned fruits, dried fruits
Salty snacks	Potato chips, peanut puffs or other salty snacks, popcorn
Added sugar	Sugar
Sweeteners	Artificial sweeteners
Vegetarian products	Vegetarian products
Beer	Beer
Spirits	Spirits, Liqueur
Wine	Wine (red or white), champagne
Free-energy beverages	Tap water, mineral water, tea (black or green), tea (fruit or herbal)
Low-energy beverages	Fruit juice spritzer, light soft drinks
High-energy beverages	Soft drinks (e.g. cola, fanta or red bull), fruit nectar, beer (alcohol-free)
Fruit juice	Fruit juice (e.g. apple or orange)
Coffee	Coffee, Cafe Latte, espresso

For each of the semi-quantitative 85 food items the FFQ is providing a choice out of 3 portion sizes (small, medium or large), based on defined regional and target population specific empirical values. Moreover, individuals had to report their usual frequency of consumption of the foods over the past 4 weeks by marking one of six possible frequency categories ranging from “never or extremely rare” to “several times a day”. A period of 4 weeks was chosen to report usual food intake by the FFQ,

taking into account that longer periods would decrease the memory of the study participants and thereby reduce the precision to report what they consumed over the last range of time.
At LUPS baseline examination the NARI, included in the health and lifestyle questionnaire, was re-checked for completeness and plausibility.

3.2.1. Coding and calculation procedures

To calculate reported energy and nutrient intakes for each study participant, in the first instance reported portions of all foods were transferred to the gram amounts or millilitres using predefined lists of portion sizes prepared by skilled dieticians and nutritionists. Calculating the intakes per day the reported gram and millilitre amounts were multiplied with factors derived from the reported frequency of consumption (Table 3).

Table 3: Factors for the assessing of the amounts of the daily intake

				Factors	**x 0**	**x 0,07**	**x 0,21**	**x 0,64**	**x 1**	**x 2,5**
				Consumption frequency	**(1=never)**	**(2=1-3x/m)**	**(3=1-2x/w)**	**(4=3-6x/w)**	**(5=1x/d)**	**(6=several/d)**
Item number	**Food** ***PRODI-Code***	**Portion size gram**	**size**		**0**	**0,07**	**0,21**	**0,64**	**1**	**2,5**
2	**Poultry**	100	small		0	7	21	64	100	250
	Code: V 410 111	200	medium		0	14	42	128	200	500
		300	large		0	21	63	192	300	750
35	**Oil**	10	small		0	0.7	2.1	6.4	10	25
	Code: Q 100 000	20	medium		0	1.4	4.2	12.8	20	50
		30	large		0	2.1	6.3	19.2	30	75
41	**Fresh fruits**	100	small		0	7	21	64	100	250
	Code: F 000 111	150	medium		0	10.5	31.5	96	150	375
		200	large		0	14	42	128	200	500
70	**Water**	200	small		0	14	42	128	200	500
	Code: N 100 000	600	medium		0	42	126	384	600	1500
		1000	large		0	70	210	640	1000	2500

M = month, w = week, d = day

The semi-quantitative calculation of daily energy and nutrient intake is based on food amounts reported in the FFQ85 using a list of prepared Code – Numbers (Code) matching best with the food ingredients from the German Food Analysis System (Bundeslebensmittelschlüssel, BLS) [91] comprising data of nearly 15.000 food items. We used the computer software program PRODI®expert [92] to calculate the nutrient contents of the food items. Total energy intake was calculated using the physiological caloric value of the foods considering the Atwater factors 37 kJ per 1g fat, 17 kJ per 1g protein, 17 kJ per 1g carbohydrate and 29 kJ per 1g alcohol [93].
The FFQ85 was validated in a randomly selected subgroup, 115 male versus 117 female study participants, aged 25 to 60 years, 1 year after baseline examination. Pearson correlation coefficients

(r) for nutrient intake compared baseline to subgroup assessment of the FFQ ranged from 0.39 for polyunsaturated fat (E%) to 0.71 for alcohol (g/d) in men and from 0.44 for monounsaturated fat (E%) to 0.73 for polyunsaturated fat (g/d) in women. It was shown that the FFQ85 is an instrument with a high degree of reproducibility. This fact was previously reported in subjects with diabetes and in non-diabetic controls using a slightly shorter version of the food frequency questionnaire 85 [94-96].

3.3. Statistical analysis

The characteristic of the study population is described using means ± standard deviation (SD) for continuous variables and frequencies for categorical variables (Table 4).

Due to gender specific differences in dietary intake patterns, all analyses (Tables 7-13 and Figures 1-12) are presented separately for male and female study participants.

Since dietary habits change due to age or vary between age groups, nutritional data were subdivided into different age groups or were age-adjusted (Tables 7-9, 11 and Figures 2-5).

Average daily energy and nutrient intake are shown as the arithmetic mean in grams per day respectively as % of total energy intake. Age-adjusted values for daily mean intake of energy and nutrients as well as for single food items and food groups are presented as means with 95% confidence interval (CI). Age-adjustment was performed for the median age of male and female individuals. A two-sided students't-test was conducted in order to compare mean daily intake of male and female study participants. Statistical significance was assumed at $P < 0.05$ (Table 7-9). The percentage intake of total energy intake for protein, carbohydrates, total fat, SFA, MUFA and PUFA as well as the intake of dietary fibre and cholesterol were compared to nutritional recommendations of the German Society of Nutrition [62] (Figure 1).

Plots, shown in figure 2 and 5 were calculated to demonstrate gender specific variations of energy, macronutrient and food intake in 3 different age groups. Accordingly, mean dietary intake of the age groups was adjusted for 28 years corresponding to 5^{th} percentile of age (male n=70, female n=62), 43 years corresponding to median age (male n=1142, female n=529) and 56 years corresponding to the 95^{th} percentile of age (male n=62, female n=22) of the study participants. Analysis of covariance (ANCOVA) with Bonferroni correction was used to examine the effects of age and gender on the reported mean daily energy and nutrient intake.

The mean daily intake of food groups (g/d) and beverages (ml/d) for male and female study participants are described via vertical bar graphs. Bars are sorted in an ascending order (Figure 3 and 4).

Estimating the frequency of intake for the different food items the six categories of frequency used in the FFQ85 were summarized to 3 categories of consumption frequency. The frequencies “never or extremely rare” and “1-3 times a month” are summarized to the group “never to 3 times a month”. The category “1-2 times per week” is sustained whereas the categories “3-6 times a week”, “once a day” and “several times a day” were combined to the group “3 times a week to several times a day”. A logistic regression model was used to describe possible significant ($p < 0.05$) differences of the frequency of gender related intakes (Table 10).

The percentages of reported use of supplements, artificial sweetener, sugar substitute, dietetic food and specific food known to have an impact on lipid metabolism were calculated, separately for male and female study participants. A logistic regression model was applied to examine the association between both sexes, non-users provided as reference category. Odd ratios determine probabilities of use of supplements in male versus female study participants (Table 12,13). Assuming the use of supplement vary in different age groups, mean percentage of the use of these supplements as well as of foods influencing the lipid metabolism a calculation of four age groups (< 30 years, 31 – 40 years, 41 – 50 years, 51 – 60 years; Figures 6-12) was done.

4. Results

4.1. Characteristics of the study population

A total of 1.962 individuals were recruited in the LUPS project to study the development of the MetS. 75 individuals did not fulfil the inclusion criteria either of already had diabetes or have taken antidiabetic drugs (n = 22) or any missing data like missing blood pressure values (n= 15), missing blood sampling (n = 3), age outside inclusion range (n = 28) or missing nutritional data (n=7). Overall, the present cohort comprised 1274 male and 613 female study participants. The mean age at study entry was 42.4 ± 8.8 years in male and 41.9 ± 8.9 years in female participants. Mean and percentage values for anthropometric parameters, blood sampling, smoking status, education level and MetS risk factors are presented in Table 4. Average BMI and waist circumference were 26.3 ± 3.6 kg/m² and 92.0 ± 12.1 cm (26.6 ± 3.5 kg/m² and 95.4 ± 10.1 cm in men; 25.0 ± 4.2 kg/m² and 85.0 ± 11.4 cm in women). Mean diastolic blood pressure was 83.1 ± 9.6 mmHg and systolic blood pressure 126.9 ± 16.9 mmHg.

The prevalence of the metabolic syndrome was 20.4% in men and 11.8% in women. Blood pressure (BP) was the most prevalent MetS risk factor in men (66.7%) and in women (43%), followed by triglycerides (TG) (26.4%) and waist circumference (25%) in men and waist circumference (36.6%) and HDL-cholesterol (15.5%) in women. Elevated blood glucose levels were shown by 11.9% male and 6.2% female study participants.

Table 4: Baseline characteristics of the study population

Characteristics	**Men (n=1274)**	**Women (n=613)**
	Mean ± SD	
Age (years)	42.4 ± 8.8	41.9 ± 8.9
Height (cm)	181.3 ± 6.9	168.2 ± 6.5
Weight (kg)	88.8 ± 12.8	70.8 ± 12.9
Waist circumference (cm)	95.4 ± 10.1	85.0 ± 11.4
Systolic BP (mm Hg)	129.3 ± 16.1	121.7 ± 17.6
Diastolic BP (mm Hg)	84.8 ± 9.0	79.5 ± 10.0
BMI (kg/m²)	26.6 ± 3.5	25.0 ± 4.2
Blood samples		
Fasting glucose (mg/dl)	90.4 ± 12.4	87.3 ± 8.7
HbA1c (%)	5.5 ± 0.4	5.5 ± 0.3
Triglyceride (mg/dl)	128.4 ± 97.5	95.0 ± 102.8
Cholesterol (mg/dl)	206.0 ± 39.6	201.4 ± 36.0
HDL - cholesterol (mg/dl)	49.5 ± 12.1	65.1 ± 16.3
Non - HDL (mg/dl)	156.5 ± 40.9	136.3 ± 36.6
LDL - cholesterol (mg/dl)	135.5 ± 35.2	122.5 ± 34.3
Smoking status	**% (n)**	
Never	43.3 (559)	44.1 (273)
Former	34.1 (441)	31.1 (193)
Current	21.7 (281)	23.7 (147)

School years	% (n)	
< 10 years	16.4 (212)	8.5 (53)
10 years	30.5 (395)	33.2 (206)
> 10 years	49.7 (642)	54.2 (336)
Prevalence of MetS and its components[§]	**%**	
Metabolic syndrome	20.4	11.8
Waist risk	25.0	36.6
TG risk	26.4	9.6
HDL risk	21.0	15.5
BP risk	66.7	43.0
Glucose risk	11.9	6.2

[§] Prevalence of metabolic syndrome and its components are calculated by the Joint Statement criteria 2009 [31] (Risk: values outside the recommended levels)

4.2. Extra-Coding of the individualized FFQ items

As far as possible additional food items were allotted to one of the previously defined 85 codes and portion sizes prepared for the FFQ85 or even got an own code. In total, 134 additional food items not already listed in the FFQ85 were reported by the study participants. Out of these, 40 food items were assigned to already defined food codes and their portion sizes (Table 5). Further, 94 food items had to be newly coded using data from the BLS and were assigned to common portion sizes (Table 6). The 5 most frequently reported additional food items were Liquorice (n=31), Nutella (n=23), Tofu (n=18), chocolate (n=12) and protein shake (n=12). Energy and nutrient contents of these food items were also calculated using their physiological caloric value with the considering Atwater factors and the computer software program PRODI®expert [92]. The surplus energy content from these foods was 68.7 kJ/d in male and 103.4 kJ/d in female participants. This energy and calculated nutrient intakes were added to the sum obtained from the 85 FFQ items. To guarantee the correct assignment of all reported foods and to achieve high quality standards for the nutrition assessment, all foods were coded individually by trained nutritionists using standardized procedures, which were regularly checked by nutrition experts.

Table 5: Added foods (free-write in items) assigned to already defined food or food group codes

E – Nb. of NARI	Foods	BLS-Code	Portion size (g) small/ medium/ large
67	Wholemeal bread, spelt bread	B 191000	30/60/90
66	Leavened bread	B 271000	30/60/90
65	White bread, rolls, pretzel roll	B 304000	25/50/75
69	Muesli, Cornflakes	C 512011	20/40/80
23	Cinnamon roll	D 450000	30/60/90
63	Pasta (spelt)	E 604022	80/160/240
41	Fruits (e.g. Banana, apple)	F 000111	100/150/200
49	Cooked vegetables (e.g. Cauliflower, Spinach)	G 000111	100/200/300

78	Carrot juice	G 090600	100/200/300
50	Raw vegetables (e.g. Tomato, sweet pepper)	G 100111	100/200/300
29	Walnuts, sunflower seeds, linseed	H 100000	25/50/100
52	Soybeans, beans, peas	H 700011	60/120/180
54	Potatoes	K 110021	80/160/240
30	Chips, salty snacks	K 280111	15/30/45
30	Popcorn	K 280111	20/30/50
14	Lactose-free yogurt, milk, sheep and goat milk or yogurt	M 110300	100/150/250
18	Condensed milk	M 174711	20/50/100
11	Low-fat cheese	M 402400	20/30/40
12	High-fat cheese, sheep or goat cheese, Camembert	M 402700	20/30/40
15	Cottage cheese	M 713100	50/100/200
75	Apple juice and other NFC juices (not from concentrate)	N 200000	100/200/300
79	Red Bull, Eistee, Iso-Star	N 310000	200/400/600
76	Bionade, Wellness-beverages, Apple spritzer	N 310300	200/400/600
71	Espresso	N 410100	50/100/150
72	Rooibos Tea	N 600100	125/250/500
35	Olive oil	Q 100000	10/20/30
33	Margarine with Olive oil	Q 420000	5/10/20
34	Low-fat margarine with plant sterols	Q 450000	5/10/20
44	Jam, honey, sugar-beet molasses	S 131000	10/25/40
46	Water-ice	S 220000	50/100/200
3	Fresh fish (e.g. Salmon, mackerel), smoked fish	T 000111	80/150/250
4	Canned fish	T 102902	50/100/150
5	Crabs	T 750011	80/150/250
1	Red unprocessed meat	U 000111	80/150/250
2	Poultry	V 410111	100/200/300
8	High-fat sausage products	W 232000	20/30/40
38	Soups	X 425003	200/300/400
42	Red berry compote, canned fruits	Y 855051	100/200/300
37	Fast food	Y 911061	200/350/600

Table 6: Added foods (free-write in items), newly coded

Nb.	Food	BLS-Code	Portion size (g) small/ medium/ large
1	Cereal products (e.g. bulgur, millet)	C 393011	50/100/150
2	Other cooked breakfast cereals	C 492011	50/100/150
3	Waffles (egg)	D 621000	100/200/250
4	Zwieback	D 630411	15/50/100
5	Spaetzle	E 430022	200/380/500
6	Wraps/ Falafel, tortillas	E 621211	150/200/250
7	Smoothie	F 000311	100/200/300
8	Sweet soups	X 491341	200/300/400
9	Avocado	F 502000	120/200/250
10	Pepperoni	G 554111	10/15/20
11	Mixed pickles	G 880611	50/80/120
12	Coconut milk	H 151011	100/150/250
13	Canned olive	H 510000	15/30/60
14	Sprouts and germs	H 620021	100/200/300
15	Soy products	J 200000	100/150/200

16	Soy cream	J 300011	20/50/100
17	Soy milk, Soy yogurt	J 370011	100/150/250
18	Tofu, Seitan	J 381011	50/100/150
19	Soy roast	J 451000	100/200/400
20	Vegetarian spreads	J 500000	20/30/40
21	Vegetarian pasties	J 510000	20/30/40
22	Peanut squish or other nut squish	J 587000	10/25/40
23	Fruit bar	J 620000	15/25/40
24	Soy sauce	J 721000	15/30/45
25	Yeast	J 737711	15/30/45
26	Vegetarian spreads based on yeast	J 740000	20/30/40
27	Vegetarian convenience food	J 900000	200/300/400
28	Soy sausage	J 945000	20/30/40
29	Mushrooms	K 700021	100/200/300
30	Gluten free flour	L 131111	30/60/90
31	Inulin	L 310011	5/10/15
32	Chewing gum (sugar free)	L 380011	2/3/5
33	Artificial sweeteners	L 410011	1/2/4
34	Cellagon Aurum	L 571211	20/30/50
35	Juice, whey beverage	M 160000	125/250/400
36	Carbohydrate shake	M 200200	100/150/200
37	Actimel	M 240000	50/100/200
38	Whey beverage (fruits)	M 262011	125/250/400
39	Protein shake	M 890011	100/150/200
40	Cappuccino, Latte Macchiato	N 410200	125/250/500
41	Malt beer	P 121000	200/300/500
42	Mayonnaise	Q 993011	15/30/50
43	Salt	R 114000	1/2/3
44	Mustard	R 130000	5/10/20
45	Ketchup	R 141100	20/30/50
46	Maggi	R 149111	2/4/6
47	Worchester sauce	R 149211	2/4/6
48	Tomato paste	R 160000	5/10/20
49	Spices	R 280011	2/4/6
50	Broth	R 810000	5/10/15
51	Mixed spices	R 910000	30/45/60
52	Vinegar	R120000	2/4/6
53	Sweets	S 000000	30/80/150
54	Dextrose	S 115111	5/10/15
55	Sugar substitutes	S 118000	5/10/15
56	Crystallized fruits	S 310000	30/50/100
57	Chewing gum	S 390000	2/3/5
58	Liquorice	S 410000	20/50/80
59	Marzipan	S 420000	20/50/100
60	Chocolate spread, Peanut-butter	S 500000	10/25/40
61	Nuts (coated with chocolate)	S 500000	30/50/100
62	Chocolate sprinkles	S 590000	10/20/30
63	Protein bar	S 830011	15/25/40
64	Carbohydrate bar	S 830011	15/25/40
65	Fish paste	T 800021	20/30/40
66	Veal sausage (Bavarian)	W 232000	100/200/350
67	Croque	X 060060 (6)	250/300/500
68	Hawaii Toast	X 081742	150/300/450

69	Salads prepared with mayonnaise	X 191302	60/125/200
70	Farmer-salad	X 203142	60/125/200
71	Anti Pasta	X 254261	50/80/120
72	Potato-salad	X 280000	150/200/300
73	Sushi	X 286052	200/300/400
74	Sausage-salad	X 290762	60/125/200
75	Poultry-salad	X 293142	60/125/200
76	Trout-salad	X 294751	60/125/200
77	Crab-salad	X 297161	50/100/150
78	Canteen food	X 554331	200/300/400
79	Labskaus	X 693412	250/380/500
80	Noodles (Chinese, roasted)	X 700002	100/200/300
81	Lasagne	X 730033	200/400/600
82	Soufflés	X 730033	200/400/600
83	Rice pudding	X 810111	125/250/500
84	Frozen foods, convenience products	X 891131	250/380/500
85	Oatmeal	X 900002	50/100/150
86	Oat milk	X 900002	100/150/250
87	Polenta	X 986161	125/250/375
88	Couscous	X 992161	90/180/270
89	Chicken fricassee	Y 564112 (1)	200/300/400
90	Fish sticks	Y 695112	90/150/210
91	Potatoes with mustard sauce	Y 740451	150/200/300
92	Pudding	Y 870252	100/150/250
93	Rice crackers	C 532011	20/30/50
94	Puffed rice (sweetened)	C 532611	20/30/50

4.3. Nutrient and energy intake of the study population

Both, crude and age-adjusted daily mean intakes and 95% confidence intervals of the reported energy and nutrients for male and female study participants are presented in Table 7. Differences in energy and nutrient intake between men and women were tested and p-values are showing significance levels.

Reported daily mean energy intake in males was significantly higher than in female participants (7191.4 kJ vs. 5976.8 kJ). Men have reported significantly higher nutrient intakes compared to women for protein, total fat, SFA, dietary cholesterol, alcohol and NaCl (18.2 E% vs. 17.4 E% for protein; 35.3 E% vs. 34.5 E% for total fat; 14.9 E% vs. 14.4 E% for SFA; 167.5 mg/1000kcal vs. 151.5 mg/1000kcal and 278.1mg/d vs. 209.6 mg/d for dietary cholesterol; 6.9 g/d vs. 3.5 g/d for alcohol and 3.3 g/d vs. 2.6 g/d for NaCl). The intake of monounsaturated fatty acids, polyunsaturated fatty acids and dietary fibre (g/d) were not statistically different between male and female study participants (13.5 E% vs. 13.3 E%; 4.5 E% vs. 4.4 E%; 16.5 g/d vs. 16.4 g/d). However, reported intake of carbohydrate and dietary fibre (g/1000kcal) were significantly higher in women than in men (43.5 E% vs. 46.2 E% for carbohydrate; 9.9 g/1000kcal vs. 11.9 g/1000kcal for dietary fibre). Although, male

individuals have reported a predominantly higher daily intake than females; often larger confidence intervals were shown in women. This effect was seen as well by the standard errors of the age-adjusted mean daily intakes (data not shown) representing larger interindividual variations of the reported intake in females.

Table 7: Reported energy and nutrient intakes per day of male and female study participants

	Male (n=1274)			Female (n=613)			P–Value[§]
	Crude means	Age-adjusted means	(95% CI)	Crude means	Age-adjusted means	(95% CI)	
Energy (kJ/d)	7224.9	7191.4	(7033.1 7349.7)	6020.3	5976.8	(5747.3 6206.3)	< 0.001
Protein (E%)	18.3	18.2	(18.0 18.5)	17.4	17.4	(17.1 17.8)	< 0.001
Carbohydrate (E%)	43.4	43.5	(43.0 43.9)	46.3	46.2	(45.5 46.9)	< 0.001
Dietary fibre (g/1000kcal)	9.9	9.9	(9.7 10.1)	11.9	11.9	(11.6 12.3)	< 0.001
Dietary fibre (g/d)	16.5	16.5	(16.1 17.0)	16.4	16.4	(15.7 17.1)	n.s.
Fat (E%)	35.4	35.3	(35.0 35.7)	34.5	34.5	(34.0 35.0)	< 0.05
Saturated FA (E%)	15.0	14.9	(14.7 15.1)	14.4	14.4	(14.1 14.6)	< 0.05
Monounsaturated FA (E%)	13.6	13.5	(13.4 13.7)	13.3	13.3	(13.0 13.5)	n.s.
Polyunsaturated FA (E%)	4.5	4.5	(4.4 4.5)	4.4	4.4	(4.3 4.5)	n.s.
Dietary cholesterol (mg/1000kcal)	167.9	167.5	(164.3 170.7)	151.3	151.5	(146.9 156.2)	< 0.001
Dietary cholesterol (mg/d)	280.2	278.1	(270.9 285.3)	210.7	209.6	(199.1 220.0)	< 0.001
Alcohol (g/d)	6.8	6.9	(6.5 7.3)	3.5	3.5	(3.0 4.1)	< 0.001
NaCl (g/d)	3.3	3.3	(3.2 3.4)	2.7	2.6	(2.5 2.8)	< 0.001

[§] P-values comparing differences between age-adjusted mean daily intakes of male and female study participants using a two-sided t-test (P<0.05).
FA fatty acids; n.s. not significant

Compared to the recommended energy intake of 9.300 kJ/d to 10.200 kJ/d for male and 7.400 kJ/d to 7.800 kJ/d for female individuals at the age of 25 to 65 years with a low activity level (physical activity level, PAL) of 1.4, male and female study participants reported energy intakes below these levels (Table 7). The mean daily reported intake of protein in both sexes was lying above the recommendations of the German Society of Nutrition. The upper limit of 30% for total fat of the daily energy intake is not adhered by men and women. Recommendations for saturated fatty acids (≤ 10% of daily energy intake) and polyunsaturated fatty acids (7 – 10% of daily energy intake) were not reached in both genders (Figure 1). Reported dietary cholesterol intake in men (278.1 mg/d) and women (209.6 mg/d) was within the recommendations up to a maximum of 300 mg/d (Table 7). The recommended mean daily intake of carbohydrates of 50% at minimum of the daily energy was not reached (Figure 1). In addition the daily intake of dietary fibre, in both genders was about half of the recommended 30 g/d. The recommended limits for daily intakes of alcohol (10 g/d for females and 20 g/d for males) and salt intake (6g/d) were not exceeded by men and women [62].

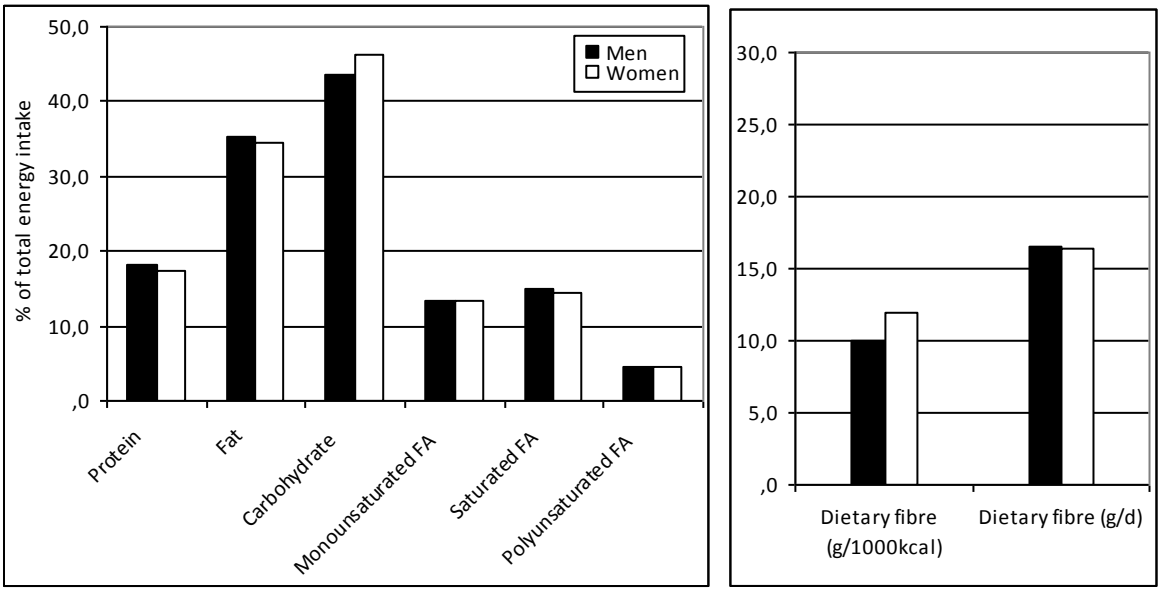


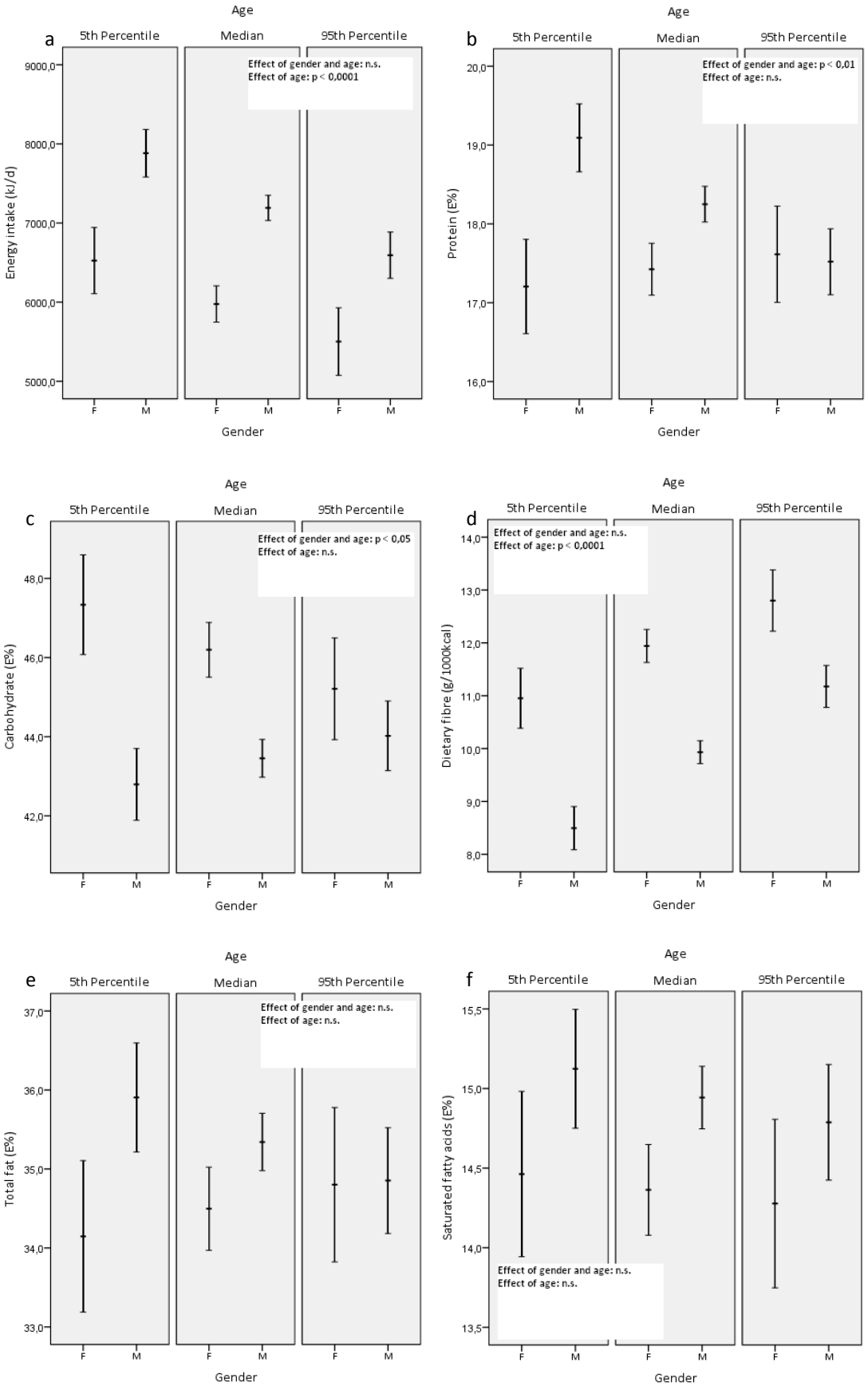
Figure 1: Reported age-adjusted mean daily nutrient intakes of male and female study participants.

4.3.1. Nutrient and energy intake in different age groups

To describe energy and nutrient intake in different age groups, reported mean daily intakes were plotted against age, within 3 age groups. The differences for male and female study participants are shown in Figure 2 (a-j).

In male and female study participants daily energy intake (Figure 2a) decreased significantly ($p < 0.001$) in the older age groups (-1.289 kJ/d for men; -1.024 kJ/d for women). In all age related groups, a gender specific difference in the daily protein intake was shown. In women the daily intake was slightly higher (+ 0.4 E%) and in men the daily intake of protein was lower (-1.6 E%) in the older age groups. The differences of daily carbohydrate intake within the 3 age groups were significantly different ($p < 0.05$) between men and women. Reported daily carbohydrate intake increased in men (+ 1.2 E%) and decreased in women (-2.1 E%) in the older age groups. Regarding daily dietary fibre intake (Figure 2d), the intake within the 3 age groups was significantly ($p < 0.001$) different between male (+ 2.7 g/1000kcal) and female (+ 1.8 g/1000kcal) study participants. For the intake of total fat (2e), saturated fatty acids (2f) and polyunsaturated fatty acids (2h) no significant differences between the age groups were seen, in both genders. Figure 2g shows a significant different intake of MUFAs in the 3 age groups between men and women ($p < 0.05$). In the older age group mean daily intake of MUFA was higher (+ 0.5 E%) in women and lower (-0.7 E%) in men compared to men and women in the age group of the 5^{th} percentile. The reported intake of dietary cholesterol did not differ significantly in the 3 age groups. However, the daily cholesterol intake differs significantly ($p< 0.01$) between genders. In men, intake of dietary cholesterol was lower (-17.2 g/1000kcal) and in women the intake was higher (+4.5 g/1000kcal) in the older age groups. The intake of alcohol was

significantly higher in the age group of the 95th percentile, however not significantly different between men and women.



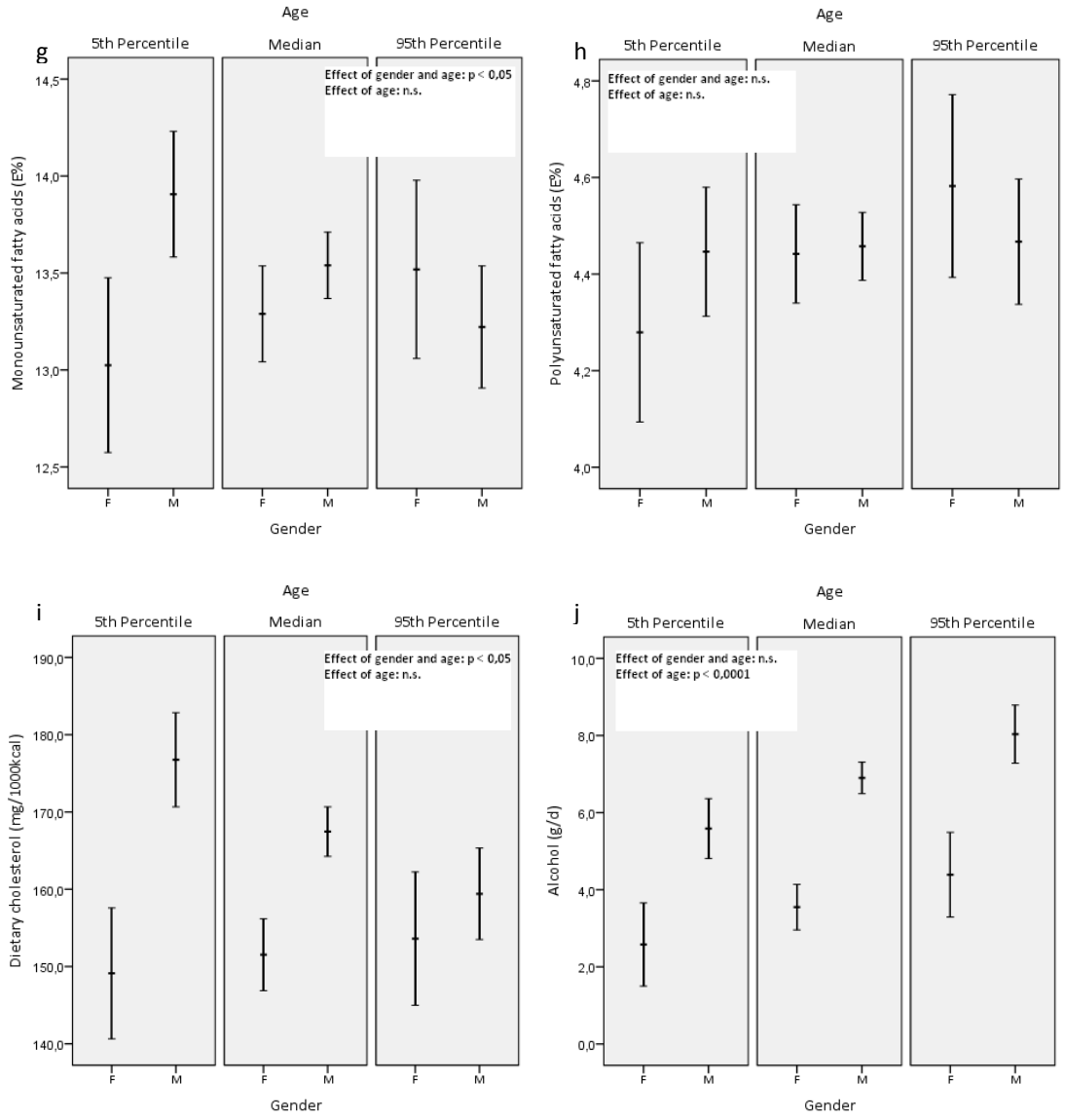


Figure 2: Differences of reported energy and nutrient intakes (a-j) in 3 age groups, stratified by gender (F = female, M= male).
Values are means and 95% CI. The 3 age groups are describing the mean intakes adjusted for 28 years corresponding to 5th percentile of age (male n=70, female n=62), 43 years corresponding to median age (male n=1142, female n=529) and 56 years corresponding to the 95th percentile of age (male n=62, female n=22) of the study subjects. Test of effects (p-values) resulting from ANCOVA, using Bonferroni`s correction for each variable p <0.05.
n.s. not significant

4.4. Food choices and amounts of intakes

Reported mean daily food intakes regarding the 85 food items assessed with the FFQ are shown in Table 8. Because of expected differences between men and women, age-adjusted means and 95% confidence intervals are separately presented for male and female study participants. Differences between both were tested by a two-sided t-test.

The reported daily intakes in male subjects were mostly higher compared to those of females. In men, the reported food intake of unprocessed meat, poultry, unprocessed fish, canned fish, eggs, low-fat processed sausage products, high-fat processed sausage products, low-fat processed meat, high-fat processed meat, whole-fat milk, yoghurt, soured milk; cream, condensed milk, sour cream, crème fraiche; ice-cream; pies; cake (yeast); croissant; puff pastries; butter; margarine; solid vegetable fat, bacon; fast food; stew; sauce; jam and honey; sugar; legumes; salted potatoes; dumplings; croquettes; fried potatoes; French fries; white rice (basmati, parboiled); brown rice (natural, whole-grain); noodles (egg); wheat bread, rolls; rye-wheat bread; coffee; fruit juice; fruit nectar; soft drinks; beer; beer alcohol-free and spirits were significantly higher than in women. For the remaining food items we observed lower or equal intakes in men compared to women. Thereby, the intakes of skim or low-fat milk, yogurt, soured milk; chocolate, chocolate bars; oil; fresh fruits; cooked vegetables; raw vegetables; herbals; jacket potatoes; crisp bread; water (tap and mineral); and fruit or herbal tea were significantly lower in men than in women.

Table 8: Reported mean daily food choices (g/d or ml/d) for male and female study participants by the 85 items of the Food Frequency Questionnaire (FFQ85).

Items in FFQ85	Food choices g/d or ml/d	Male (n = 1274)		Female (n = 613)		P-value[§]
		Mean[$]	(95% CI)	Mean[$]	(95% CI)	
1	Meat, unprocessed	85.1	(81.36; 88.91)	45.8	(40.37; 51.32)	< 0.001
2	Poultry	54.7	(52.10; 57.29)	42.9	(39.13; 46.66)	< 0.001
3	Fish, unprocessed	20.0	(18.91; 21.12)	17.7	(16.12; 19.33)	< 0.05
4	Canned fish	2.1	(1.87; 2.40)	1.1	(0.75; 1.53)	< 0.001
5	Seafood and crustaceans	4.9	(4.44; 5.36)	5.7	(5.00; 6.33)	n.s.
6	Eggs	16.3	(15.45; 17.20)	13.6	(12.37; 14.91)	< 0.01
7	Low-fat processed sausage products	11.4	(10.82; 12.06)	8.0	(7.14; 8.94)	< 0.001
8	High-fat processed sausage products	7.2	(6.69; 7.68)	3.2	(2.48; 3.93)	< 0.001
9	Low-fat processed meat	5.8	(5.42; 6.22)	3.8	(3.20; 4.35)	< 0.001
10	High-fat processed meat	3.5	(3.20; 3.85)	1.5	(0.99; 1.93)	< 0.001
11	Low-fat cheese	6.2	(5.65; 6.69)	6.9	(6.11; 7.63)	n.s.
12	Whole-fat cheese	8.2	(7.59; 8.76)	8.7	(7.82; 9.52)	n.s.
13	Skim or low-fat milk, yogurt, soured milk	52.1	(47.04; 57.09)	74.8	(67.50; 82.08)	< 0.001
14	Whole-fat milk, yogurt, soured milk	53.9	(49.68; 58.06)	44.1	(38.00; 50.16)	< 0.01
15	Low-fat quark	4.8	(3.94; 5.76)	6.3	(5.01; 7.65)	n.s.
16	Cream quark	4.0	(3.08; 4.85)	4.3	(3.04; 5.62)	n.s.
17	Buttermilk	8.7	(6.87; 10.50)	7.9	(5.23; 10.50)	n.s.
18	Cream, condensed milk, sour cream, crème fraiche	11.1	(9.91; 12.23)	5.8	(4.09; 7.45)	< 0.001
19	Ice-cream	6.5	(5.91; 7.08)	4.7	(3.88; 5.58)	< 0.01
20	Chocolate, chocolate bars	16.6	(15.02; 18.09)	19.6	(17.35; 21.81)	< 0.05
21	Pies	3.8	(3.36; 4.22)	2.3	(1.70; 2.94)	< 0.001
22	Cake, pound	3.8	(3.29; 4.23)	3.3	(2.65; 4.00)	n.s.

23	Cake, yeast	1.9	(1.72; 2.16)	1.2	(0.88; 1.52)	< 0.001
24	Croissant	1.3	(1.13; 1.46)	0.8	(0.54; 1.03)	< 0.01
25	Puff pastries	1.1	(0.93; 1.33)	0.6	(0.30; 0.89)	< 0.01
26	Pancakes	4.7	(4.26; 5.15)	4.3	(3.62; 4.91)	n.s.
27	Cookies, butter	5.3	(4.69; 5.96)	5.3	(4.42; 6.25)	n.s.
28	Cookies with chocolate	2.9	(2.47; 3.40)	2.4	(1.71; 3.06)	n.s.
29	Nuts and seeds	4.7	(4.16; 5.24)	5.5	(4.73; 6.30)	n.s.
30	Potato chips, peanut puffs or other salty snacks	2.4	(2.15; 2.62)	2.1	(1.82; 2.48)	n.s.
31	Butter	3.0	(2.76; 3.31)	2.2	(1.83; 2.63)	< 0.01
32	Low-fat butter	0.4	(0.31; 0.52)	0.5	(0.35; 0.64)	n.s.
33	Margarine	2.1	(1.84; 2.29)	1.2	(0.90; 1.56)	< 0.001
34	Low-fat margarine	2.1	(1.88; 2.34)	1.8	(1.45; 2.12)	n.s.
35	Oil	4.3	(4.04; 4.61)	5.5	(5.06; 5.88)	< 0.001
36	Solid vegetable fat, Bacon	0.5	(0.39; 0.52)	0.2	(0.10; 0.29)	< 0.001
37	Fast Food	23.8	(21.78; 25.76)	13.9	(11.00; 16.78)	< 0.001
38	Soup, broth or thickened	23.0	(21.03; 24.97)	25.7	(22.83; 28.55)	n.s.
39	Stew	27.2	(25.48; 28.83)	21.1	(18.64; 23.51)	< 0.001
40	Sauce	10.7	(10.10; 11.33)	7.5	(6.57; 8.35)	< 0.001
41	Fresh fruits	108.5	(101.81; 115.10)	150.4	(140.78; 160.05)	< 0.001
42	Canned fruits	5.9	(5.06; 6.69)	5.0	(3.80; 6.16)	n.s.
43	Dried fruits	1.5	(1.20; 1.71)	1.4	(1.08; 1.81)	n.s.
44	Jam, honey	6.3	(5.82; 6.76)	5.0	(4.37; 5.72)	< 0.01
45	Sugar	3.7	(3.33; 3.98)	2.9	(2.40; 3.34)	< 0.01
46	Water-ice	2.7	(2.37; 3.04)	2.1	(1.63; 2.60)	n.s.
47	Fruit gum	4.4	(3.59; 5.19)	5.2	(4.08; 6.40)	n.s.
48	Candies	1.0	(0.83; 1.19)	1.2	(0.89; 1.41)	n.s.
49	Vegetables, cooked	80.8	(76.94; 84.76)	94.5	(88.87; 100.21)	< 0.001
50	Vegetables, raw	68.7	(64.31; 73.17)	97.5	(91.10; 103.95)	< 0.001
51	Herbals	1.6	(1.45; 1.72)	2.0	(1.84; 2.23)	< 0.001
52	Legumes	9.8	(9.03; 10.59)	7.8	(6.67; 8.94)	< 0.01
53	Jacket potatoes	12.1	(11.03; 13.18)	16.3	(14.76; 17.87)	< 0.001
54	Salted potatoes	33.1	(31.23; 35.06)	25.6	(22.82; 28.38)	< 0.001
55	Mashed potatoes	11.0	(9.96; 12.04)	10.1	(8.58; 11.59)	n.s.
56	Dumplings (potatoes)	2.3	(2.00; 2.50)	1.3	(0.98; 1.71)	< 0.001
57	Croquettes (potato)	3.2	(2.89; 3.53)	1.4	(0.90; 1.83)	< 0.001
58	Fried potatoes	11.4	(10.74; 12.01)	6.3	(5.34; 7.17)	< 0.001
59	French fries	12.3	(11.56; 13.08)	5.9	(4.82; 7.03)	< 0.001
60	Potato fritters	1.1	(0.95; 1.28)	0.8	(0.61; 1.08)	n.s.
61	White rice (Basmati, parboiled)	34.3	(32.32; 36.21)	26.9	(24.04; 29.68)	< 0.001
62	Brown rice (whole-grain, natural)	13.1	(11.74; 14.44)	8.1	(6.13; 10.05)	< 0.001
63	Pasta (durum wheat, whole-grain)	26.4	(24.43; 28.36)	26.5	(23.64; 29.34)	n.s.
64	Noodles (egg)	20.0	(18.55; 21.41)	14.9	(12.79; 16.94)	< 0.001
65	Wheat bread, rolls	19.0	(17.95; 20.08)	12.1	(10.54; 13.63)	< 0.001
66	Rye-wheat bread	20.3	(18.91; 21.75)	14.2	(12.19; 16.31)	< 0.001
67	Wholemeal bread, rolls	29.8	(28.05; 31.65)	31.0	(28.35; 33.57)	n.s.
68	Crisp bread	1.0	(0.77; 1.25)	1.6	(1.28; 1.97)	< 0.01
69	Muesli and cornflakes	8.2	(7.36; 9.00)	7.3	(6.10; 8.48)	n.s.
70	Water (tap, mineral)	1292.7	(1247.12. 1338.25)	1538.1	(1472.05; 1604.23)	< 0.001

71	Coffee	620.6	(593.82; 647.33)	548.9	(510.05; 587.66)	< 0.01
72	Tea (black, green)	92.5	(79.86; 105.20)	112.3	(93.93; 130.68)	n.s.
73	Tea (fruit, herbal)	203.0	(170.60; 235.39)	549.0	(502.04; 596.02)	< 0.001
74	Hot chocolate	14.5	(11.72; 17.29)	11.2	(7.14; 15.22)	n.s.
75	Fruit juice	51.2	(46.25; 56.08)	36.8	(29.65; 43.91)	< 0.01
76	Fruit juice spritzer	171.9	(154.24; 189.57)	183.2	(157.53; 208.78)	n.s.
77	Fruit nectar	31.5	(28.07; 34.93)	15.1	(10.09; 20.04)	< 0.001
78	Vegetable juice	4.2	(3.26; 5.11)	2.8	(1.44; 4.12)	n.s.
79	Soft drinks	67.9	(59.86; 76.00)	26.2	(14.52; 37.93)	< 0.001
80	Light soft drinks	51.5	(41.75; 61.20)	53.9	(39.81; 68.02)	n.s.
81	Beer	107.1	(99.29; 114.95)	24.5	(13.11; 35.82)	< 0.001
82	Beer (alcohol-free)	17.8	(15.05; 20.59)	7.8	(3.73; 11.77)	< 0.001
83	Wine	23.8	(21.56; 26.14)	26.4	(23.03; 29.67)	n.s.
84	Liqueur	0.3	(0.20; 0.32)	0.3	(0.17; 0.34)	n.s.
85	Spirits	1.3	(1.12; 1.43)	0.5	(0.29; 0.72)	< 0.001

[$] Mean daily intakes were adjusted for age
[§] P-values comparing the differences of mean food choices between male and female study participants using a two-sided t-test (P<0.05).
n.s. not significant

To assess the intake on a food group level and to compare intakes with the recommendations of the German Society of Nutrition, the 85 food items of the FFQ including the individual specified items mentioned above were classified in 39 food groups (see chapter 3.2., Table 2). Table 9 shows data of 37 food groups. Data of two food groups were reported by tiny number of study participants (processed plant products by 5 men and 2 women; sweeteners by 1 man and 2 women). Therefore, we did not include these results in Table 9. Table 9 presents age-adjusted means, 95% confidence intervals and p-values from the comparison between genders.

Significantly ($p < 0.05$) higher intakes for males compared to females were obtained for refined grains, baked goods, fast food and convenience products, legumes, potatoes, potato products, margarine, butter, other fats, high-fat dairy products, eggs, red and processed meat, low-fat meat products, fish, sauces and condiments, added sugar, beer, spirits, coffee, high-energy beverages and fruit juice. For the remaining food groups men reported lower daily intakes compared to women. Significant ($p < 0.05$) lower values in male subjects were only observed for vegetables, fruits, oil, low-fat dairy products and free-energy beverages.

Table 9: Reported mean daily intakes (g/d or ml/d) of specific food groups in male and female study participants

Food groups g/d or ml/d	**Male (n = 1274)**		**Female (n = 613)**		
	Mean[$]	**(95% CI)**	**Mean[$]**	**(95% CI)**	**P – Value[§]**
Refined grains	102.2	(98.71; 105.60)	76	(70.99; 80.98)	<0.001
Wholemeal products	71	(67.70; 74.29)	67.5	(62.73; 72.29)	n.s
Baked goods	24.9	(23.22; 26.61)	20.2	(17.79; 22.70)	<0.01
Fast Food and conveniences	24	(21.73; 26.30)	15.8	(12.52; 19.15)	<0.001
Vegetables	152.4	(145.52; 159.25)	196.7	(186.74; 206.65)	<0.001

Legumes	9.9	(9.07; 10.64)	7.8	(6.71; 8.99)	<0.01
Potatoes	58.5	(55.68; 61.41)	53.3	(49.18; 57.49)	<0.05
Potato products	28	(26.73; 29.31)	14.4	(12.55; 16.29)	<0.001
Fruits	109.2	(102.53; 115.91)	151	(141.27; 160.68)	<0.001
Nuts and seeds	4.7	(4.18; 5.27)	5.6	(4.83; 6.41)	n.s
Margarine	4.2	(3.87; 4.53)	3	(2.54; 3.49)	<0.001
Butter	3.5	(3.17; 3.75)	2.7	(2.30; 3.15)	<0.01
Oil	4.4	(4.06; 4.64)	5.5	(5.05; 5.88)	<0.001
Other fats	0.5	(0.39; 0.52)	0.2	(0.10; 0.29)	<0.001
Low-fat dairy products	65.6	(59.73; 71.51)	89.2	(80.65; 97.74)	<0.001
Low-fat cheese	6.2	(5.64; 6.70)	7	(6.26; 7.79)	n.s
High-fat dairy products	84	(78.14; 89.95)	67.5	(58.93; 76.07)	<0.01
High-fat cheese	8.3	(7.67; 8.86)	8.8	(7.98; 9.71)	n.s
Eggs	16.3	(15.45; 17.21)	13.6	(12.37; 14.91)	0.001
Red and processed meat products	96.2	(92.16; 100.26)	51.1	(45.25; 56.99)	<0.001
Low-fat meat products	72	(69.10; 74.84)	54.7	(50.55; 58.87)	<0.001
Fish	20.1	(18.95; 21.17)	17.7	(16.12; 19.33)	<0.05
Fish products and seafood	7.2	(6.62; 7.78)	6.9	(6.01; 7.70)	n.s
Soups and stews	50.2	(47.17; 53.28)	47.7	(43.25; 52.11)	n.s
Sauces and condiments	10.8	(10.17; 11.41)	7.5	(6.63; 8.41)	<0.001
Sweets	45.7	(43.02; 48.29)	46.3	(42.44; 50.07)	n.s
Salty snacks	48.1	(45.38; 50.73)	48.4	(44.56; 52.31)	n.s
Added sugar	3.7	(3.33; 3.98)	2.9	(2.40; 3.34)	<0.01
Vegetarian products	1.5	(0.80; 2.28)	1	(-0.07; 2.08)	n.s
Beer	108.7	(100.82; 116.54)	25.2	(13.81; 36.62)	<0.001
Spirits	1.5	(1.36; 1.71)	0.8	(0.51; 1.00)	<0.001
Wine	23.8	(21.56; 26.14)	26.4	(23.07; 29.71)	n.s
Free-energy beverages	1589.7	(1530.60; 1648.81)	2199.5	(2113.75; 2285.20)	<0.001
Low-energy beverages	224.5	(204.12; 244.97)	239.1	(209.47; 268.72)	n.s
Coffee	623.3	(596.44; 650.21)	550.4	(511.43; 589.41)	<0.01
High-energy beverages	118.4	(108.96; 127.77)	49	(35.41; 62.68)	<0.001
Fruit juice	55.6	(50.56; 60.70)	39.7	(32.32; 47.03)	<0.001

[$] Mean values were adjusted for age

[§] P-values show the level for significance of the differences of mean daily intakes between male and female study participants by using a two-sided t-test ($p < 0.05$).

n.s. not significant

4.4.1. Dietary patterns of male and female study participants

Figure 3 and 4 are illustrating dietary patterns for foods and beverages of both genders. Because of a very low daily intake of both following food groups, other fats and vegetarian products, we did not include these in the figures. The vegetable and fruit groups reached the highest levels of consumed food, 261.6 g/d in men and 347.7 g/d in women. In male individuals refined grains, red and processed meat and high-fat dairy products (altogether 272.4 g/d) were in the second order of frequently consumed food groups. Foods of the following five frequently consumed food groups in

men were low-fat meat products, wholemeal products, low-fat dairy products, potatoes and soups and stews.

In descending order female individuals consumed vegetables and fruits most frequently (overall 212.7 g/d) followed by low-fat dairy products, refined grains and wholemeal products. In addition the next following five frequently consumed food groups in women were high-fat dairy products, low-fat meat products, potatoes, red and processed meat products and salty snacks.

The five mostly assessed beverages in male study participants (2664.6 ml/d) were in descending order free-energy beverages, coffee, low-energy beverages, high-energy beverages and beer. Female study participants mostly consumed free-energy beverages, coffee, low-energy beverages, high-energy beverages and fruit juice (altogether 3077.7 ml per day) in a descending order. More detailed, the most frequently consumed beverage in men was water followed by coffee, tea (fruit, herbal), fruit juice spritzer and beer. In women the mostly consumed beverage was also water followed by tea (fruit, herbal), coffee, fruit juice spritzer and tea (black, green) (Table 8).

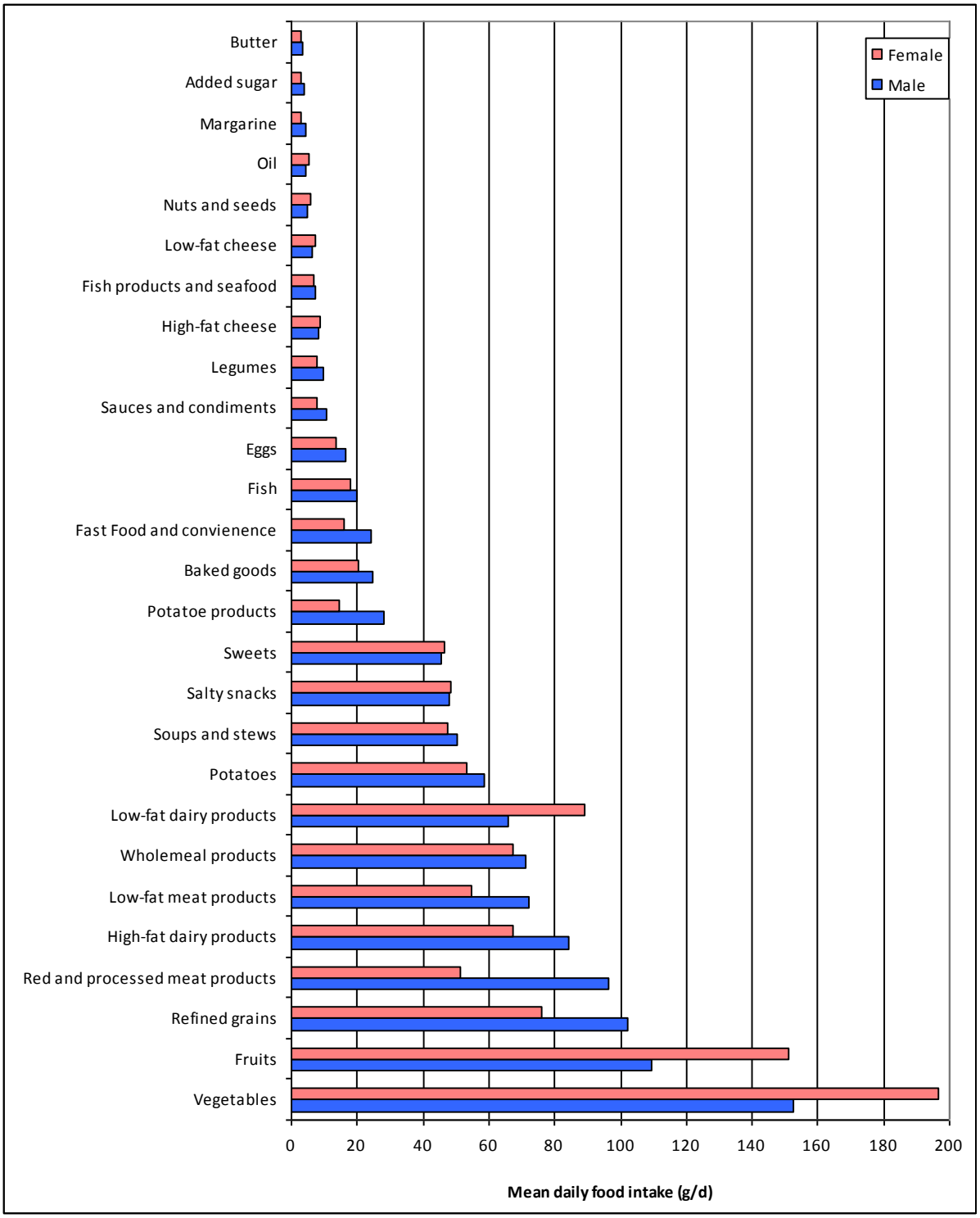


Figure 3: Reported mean daily intake of foods (g/d) for male (n=1274) and female (n=613) study participants.

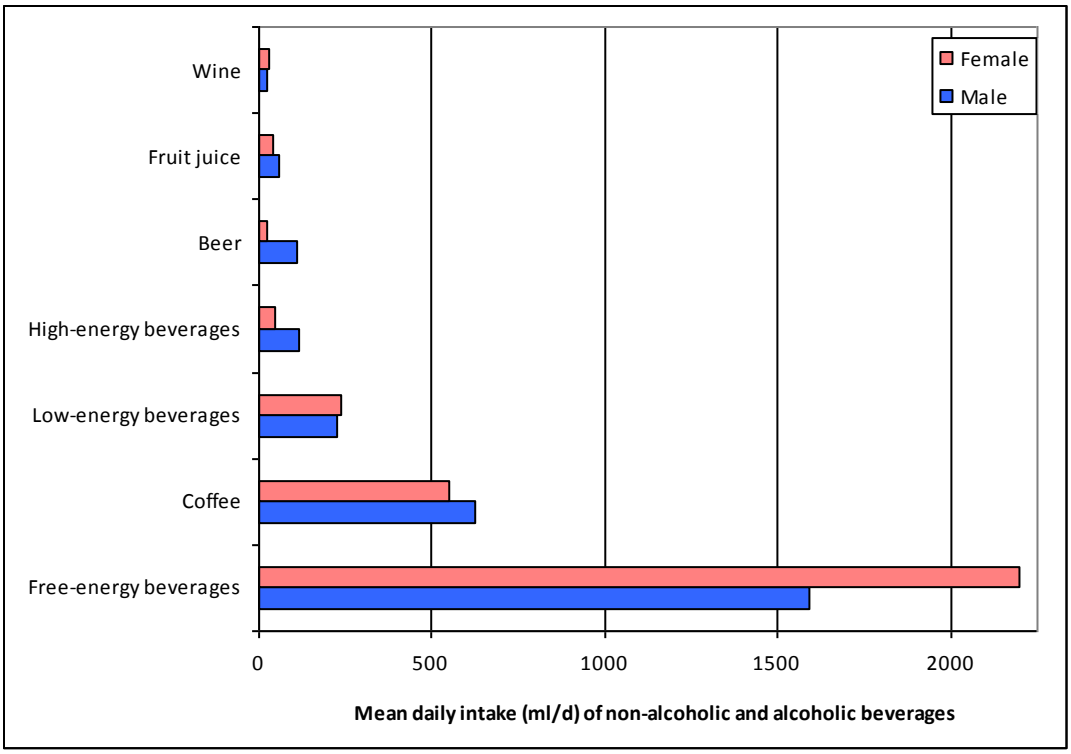


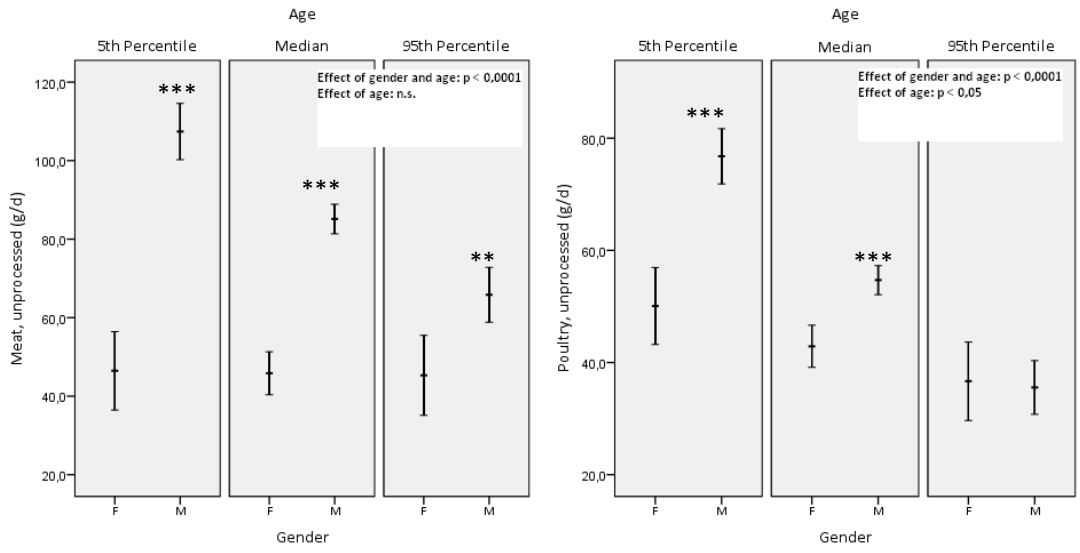
Figure 4: Reported mean daily intake of beverages (ml/d) of male (n=1274) and female (n=613) study participants.

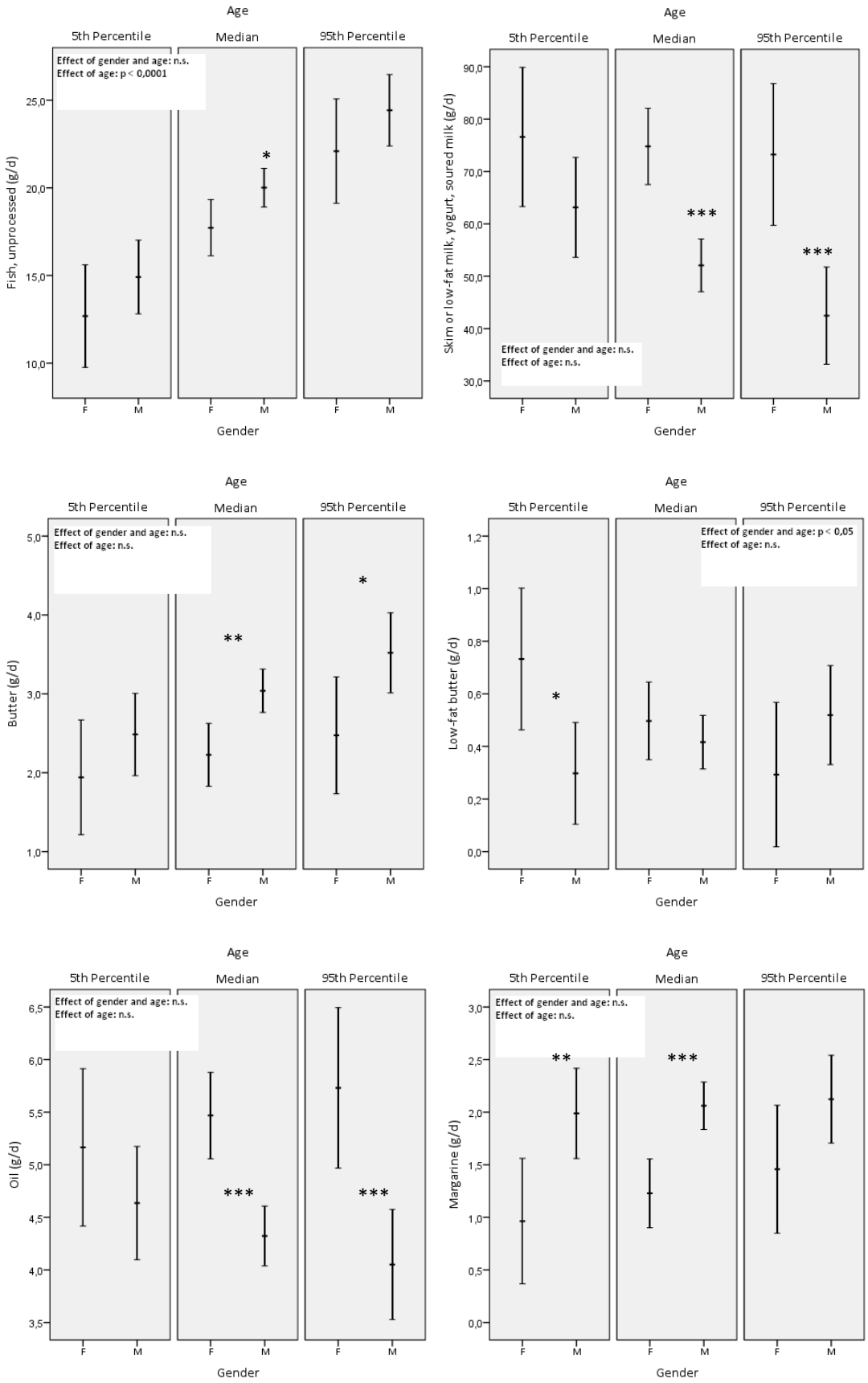
4.4.2. Food intake in different age groups

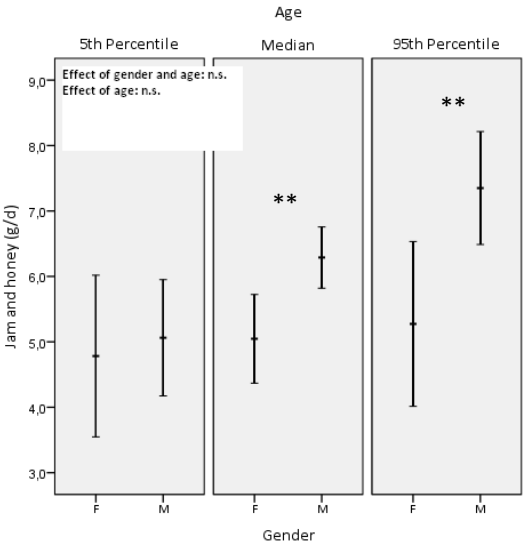
Figure 5 shows mean daily intakes and 95% CI for some typical foods of male and female study participants within three age groups. Effects of gender and age were calculated and included in the figures.

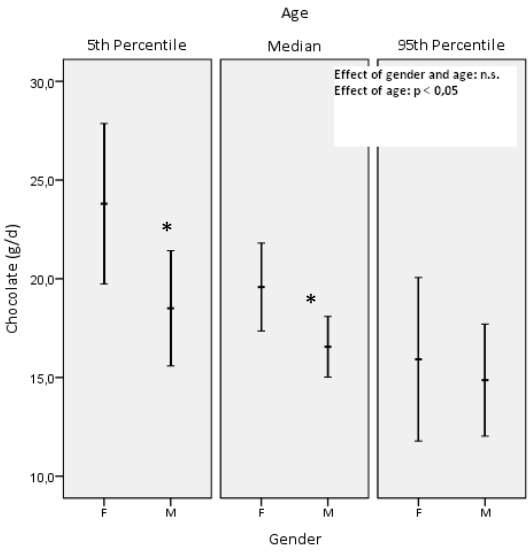
Reported intake of unprocessed meat was significantly different between male and female study participants in the age groups. In women the mean daily intake was similar in the 3 age groups, whereas in men the intake varied significantly (- 41.6 g/d) between the 3 age groups. The reported intake of poultry was lowest in the oldest age group. Additionally, the differences between age groups differed significantly between men and women (men: -41.2 g/d; women: -13.4 g/d). Men and women higher at age consumed more likely fish than the younger group of men and women (+9.5 g/d in male and +9.4 g/d in female). The reported daily intake of skim or low-fat milk, yoghurt and soured milk did not vary in age. Between men and women of the median and 95th percentile age group significant differences of the reported intake of skim or low-fat milk, yoghurt and soured milk were reported (men: -20.3 g/d; women: -3.4 g/d). For both genders, the reported intake of low-fat butter was significantly different in all age groups. Men higher at age consumed larger (+ 0,2 g/d) and women at higher age consumed lower quantities (- 0.4 g/d) compared to those of the youngest age group. Chocolate was less likely consumed by male and female study participants higher at age compared the participants of the 5th percentile (men: -3.6 g/d; women: -7.9 g/d). The consumption of

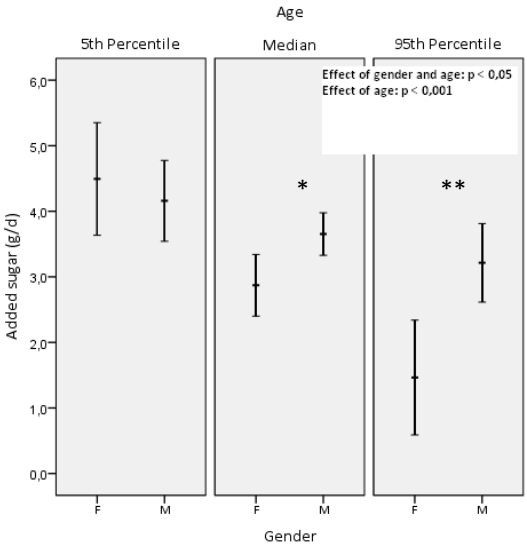
added sugar was significantly lower in men and women higher at age compared to the youngest (men: -1.0 g/d; women: -3.0 g/d). Compared to men reported daily intake of fresh fruits was higher in females in all age groups and largest quantities were consumed in the oldest groups (men: +43.6 g/d; women: +51.7 g/d). Compared to the youngest age group women higher at age consumed less (-2.6 g/d) and men consumed more (+2.8 g/d) legumes a day. Mean daily intake of jacket potatoes were significantly different between the age groups in men and women. While male study participants showed similar intakes in the age groups, female study participants were more likely to consume jacket potatoes (+12.9 g/d) higher at age. Men and women higher at age consumed less French fries than those of the younger age groups (men: -11.0 g/d; women: -7.2 g/d). Younger study participants consumed more white rice (basmati, parboiled) than older participants (men: +11.6 g/d; women: +17.2 g/d). The intake of water (mineral and tap) showed significant differences for male and female individuals between the age groups. In female study participants only small differences between the age groups were assessed, whereas for male study participants a difference of – 422.4 ml/d between the youngest and the highest age group were reported. For both genders the reported consumption of coffee was largest in the highest age group compared to the age group of the 5th percentile (men: + 150.6 ml/d; women: + 207.9 ml/d). Male and female study participants higher at age were less likely to consume soft drinks than the younger participants (men: -82.2 ml/d; women: -48.7 ml/d). For the remaining food groups no significant differences between age groups were documented.

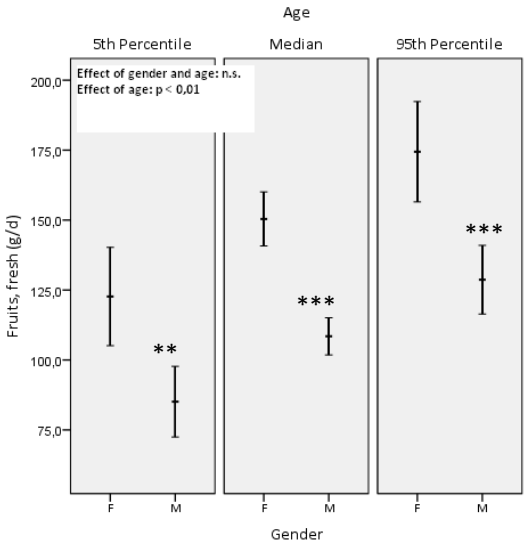


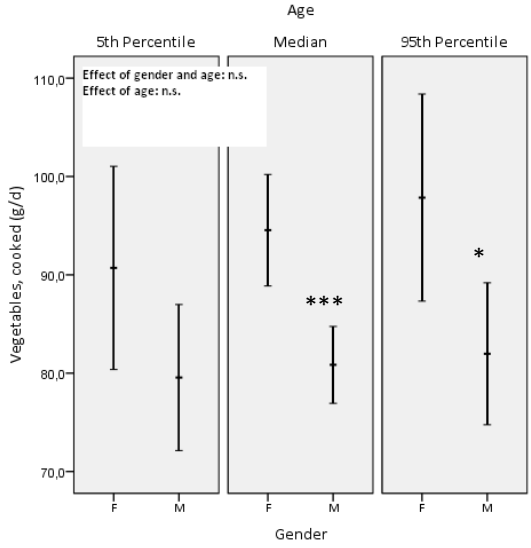

Age
5th Percentile
Median
95th Percentile
Effect of gender and age: n.s.
Effect of age: p < 0,0001
Fish, unprocessed (g/d)
25,0
20,0
15,0
10,0
*
F
M
Gender
Skim or low-fat milk, yogurt, soured milk (g/d)
90,0
80,0
70,0
60,0
50,0
40,0
30,0
***
***
Effect of gender and age: n.s.
Effect of age: n.s.
Butter (g/d)
5,0
4,0
3,0
2,0
1,0
**
*
Effect of gender and age: n.s.
Effect of age: n.s.
Low-fat butter (g/d)
1,2
1,0
0,8
0,6
0,4
0,2
0,0
*
Effect of gender and age: p < 0,05
Effect of age: n.s.
Oil (g/d)
6,5
6,0
5,5
5,0
4,5
4,0
3,5
***
***
Effect of gender and age: n.s.
Effect of age: n.s.
Margarine (g/d)
3,0
2,5
2,0
1,5
1,0
0,5
0,0
**
***
Effect of gender and age: n.s.
Effect of age: n.s.

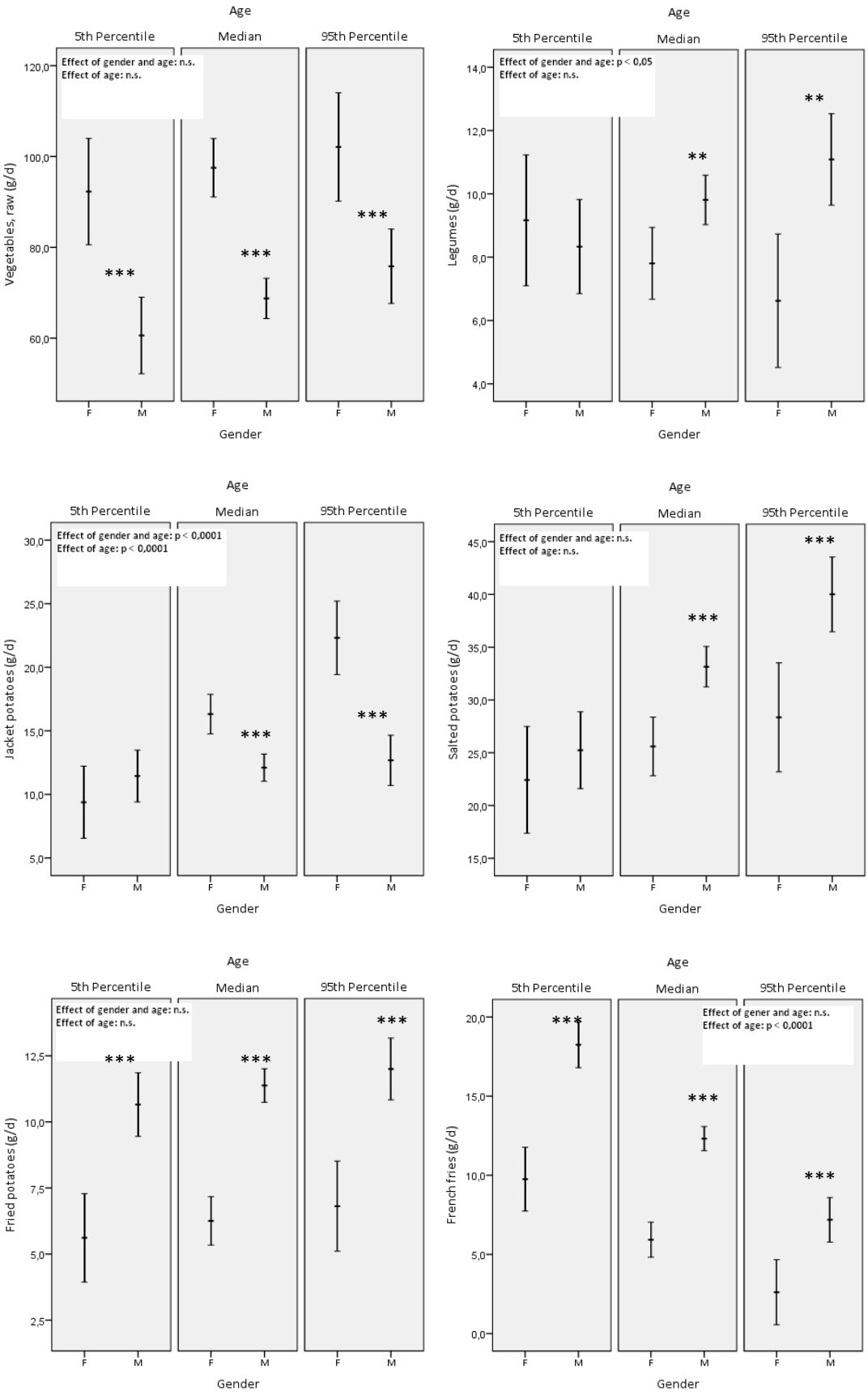

Age
5th Percentile
Median
95th Percentile
Effect of gender and age: n.s.
Effect of age: n.s.
Jam and honey (g/d)
9,0
8,0
7,0
6,0
5,0
4,0
3,0
**
**
F
M
Gender

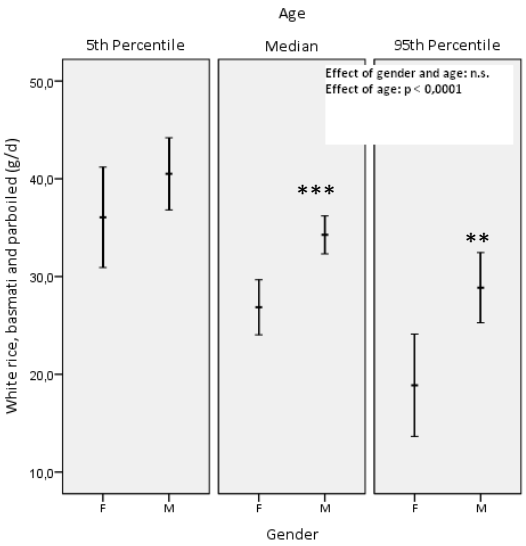

Age
5th Percentile
Median
95th Percentile
Effect of gender and age: n.s.
Effect of age: p < 0,05
Chocolate (g/d)
30,0
25,0
20,0
15,0
10,0
*
*
F
M
Gender

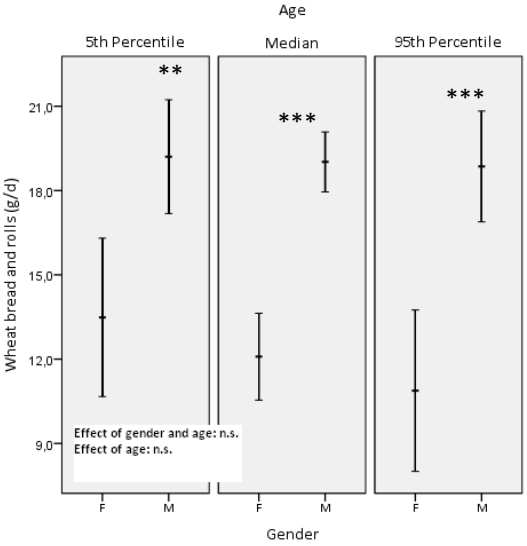

Age
5th Percentile
Median
95th Percentile
Effect of gender and age: p < 0,05
Effect of age: p < 0,001
Added sugar (g/d)
6,0
5,0
4,0
3,0
2,0
1,0
0,0
*
**
F
M
Gender

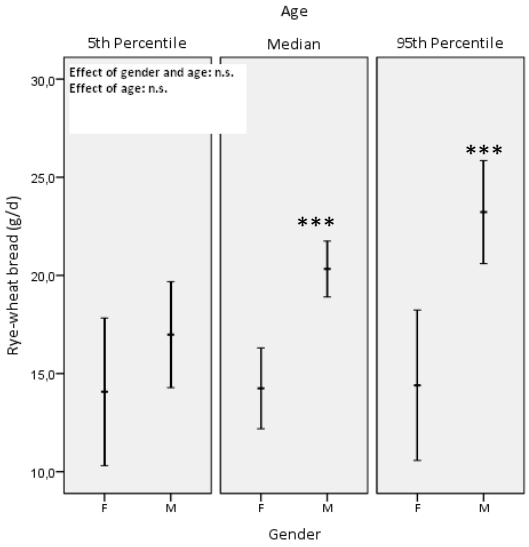

Age
5th Percentile
Median
95th Percentile
Effect of gender and age: n.s.
Effect of age: p < 0,01
Fruits, fresh (g/d)
200,0
175,0
150,0
125,0
100,0
75,0
**
***
***
F
M
Gender

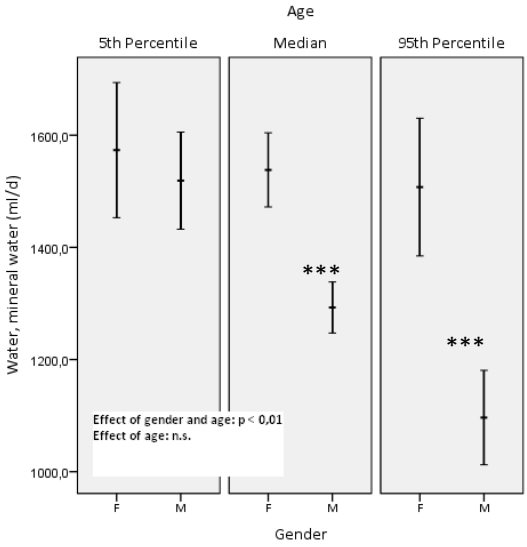

Age
5th Percentile
Median
95th Percentile
Effect of gender and age: n.s.
Effect of age: n.s.
Vegetables, cooked (g/d)
110,0
100,0
90,0
80,0
70,0
***
*
F
M
Gender

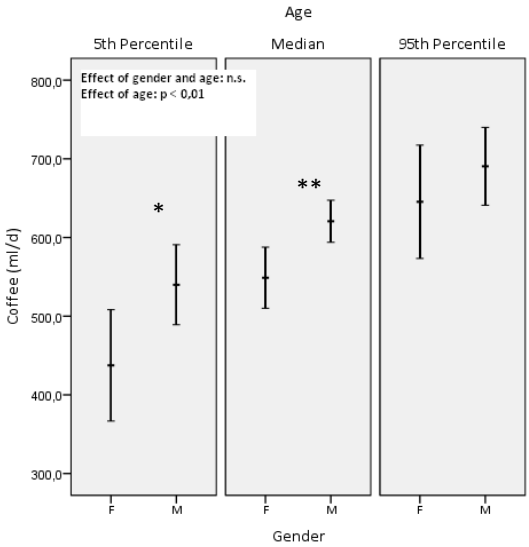

Age
5th Percentile
Median
95th Percentile
Effect of gender and age: n.s.
Effect of age: n.s.
Vegetables, raw (g/d)
120,0
100,0
80,0
60,0
***
***
***
F
M
Gender
Effect of gender and age: p < 0,05
Effect of age: n.s.
Legumes (g/d)
14,0
12,0
10,0
8,0
6,0
4,0
**
**
Effect of gender and age: p < 0,0001
Effect of age: p < 0,0001
Jacket potatoes (g/d)
30,0
25,0
20,0
15,0
10,0
5,0
Effect of gender and age: n.s.
Effect of age: n.s.
Salted potatoes (g/d)
45,0
40,0
35,0
30,0
25,0
20,0
15,0
Effect of gender and age: n.s.
Effect of age: n.s.
Fried potatoes (g/d)
12,5
10,0
7,5
5,0
2,5
Effect of gener and age: n.s.
Effect of age: p < 0,0001
French fries (g/d)
20,0
15,0
10,0
5,0
0,0

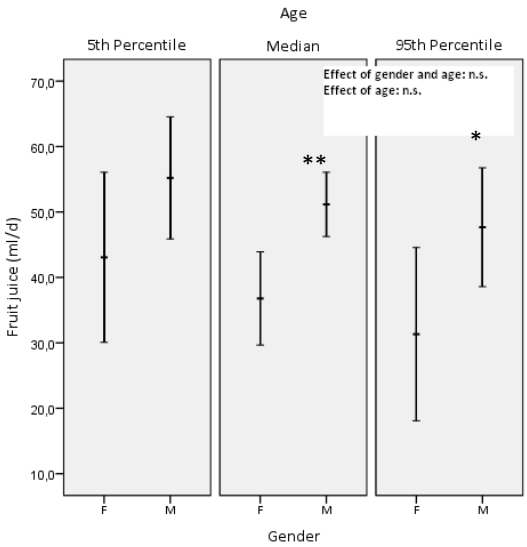

Age
5th Percentile
Median
95th Percentile
White rice, basmati and parboiled (g/d)
Effect of gender and age: n.s.
Effect of age: p < 0,0001
Gender


Age
5th Percentile
Median
95th Percentile
Wheat bread and rolls (g/d)
Effect of gender and age: n.s.
Effect of age: n.s.
Gender


Age
5th Percentile
Median
95th Percentile
Rye-wheat bread (g/d)
Effect of gender and age: n.s.
Effect of age: n.s.
Gender


Age
5th Percentile
Median
95th Percentile
Water, mineral water (ml/d)
Effect of gender and age: p < 0,01
Effect of age: n.s.
Gender


Age
5th Percentile
Median
95th Percentile
Coffee (ml/d)
Effect of gender and age: n.s.
Effect of age: p < 0,01
Gender


Age
5th Percentile
Median
95th Percentile
Fruit juice (ml/d)
Effect of gender and age: n.s.
Effect of age: n.s.
Gender

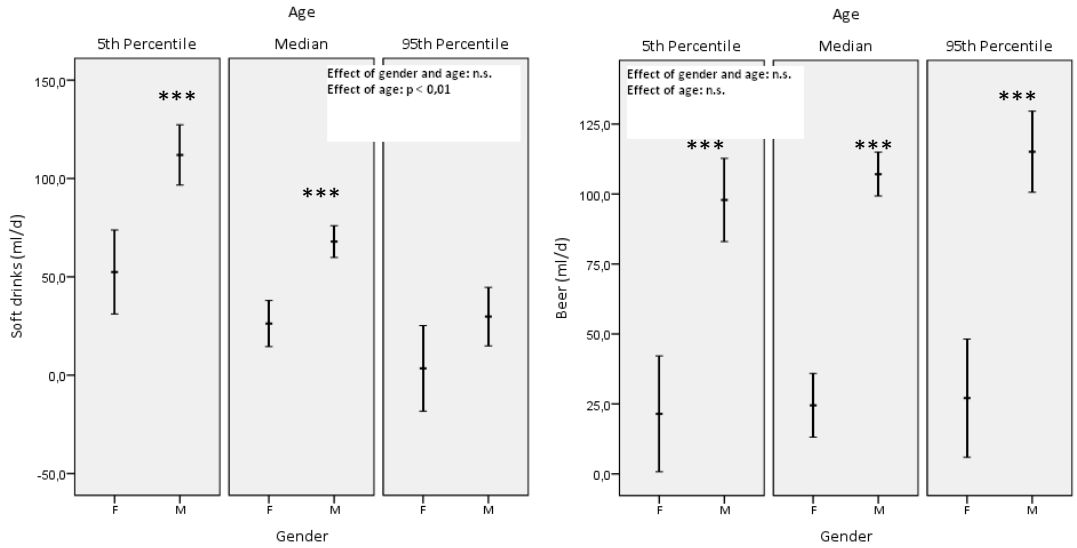


Figure 5: Differences for some regional reported food and beverage intakes within 3 age groups of male (M) and female (F) study participants.
Values are means and 95% CI. The 3 age groups describe the mean intakes adjusted for 28 years corresponding to 5th percentile of age (male n=70, female n=62), 43 years corresponding to median age (male n=1142, female n=529) and 56 years corresponding to the 95th percentile of age (male n=62, female n=22) of the study participants.
Test of effects (p-values) resulting from ANCOVA, using Bonferroni`s correction for each variable.
Two-sided t-tests were used to compare means for each age group and to identify significant differences (* < 0.05, ** < 0.01, *** < 0.001, n.s. not significant) across male and female study participants.

4.5. Frequency of food intake in male and female study participants

To describe the frequency of intake for the 85 food items of the FFQ we classified the six frequency categories used in the FFQ in 3 groups; never up to 3 times a month (less frequently), 1 – 2 times a week (moderately) and 3 times a day up to several times a day (most frequently). Table 10 shows the results separately for male and female study participants with P values for significant differences between genders.

The ten most frequently consumed foods in males were fresh fruits (64.8%), unprocessed meat (62.7%), cooked vegetables (53.1%), wholemeal bread and rolls (51.8%), low-fat processed sausage products (47.8%), wheat bread and rolls (41.9%), chocolate and chocolate bars (41.3%), raw vegetables (39.9%), added sugar (39.1%) and whole-fat milk, yoghurt and soured milk (38.3%). In females the ten most frequently consumed foods were fresh fruits (76.3%), cooked vegetables (57.8%), wholemeal bread and rolls (56.9%), raw vegetable (55.2%), oil (49.3%), chocolate and chocolate bars (49.3%), skim or low-fat milk, yogurt and soured milk (47.9%), low-fat processed sausage products (36.7%), whole-fat cheese (34.4%) and added sugar (33.4). Regarding to the beverage items, water (90.5%), coffee (82.5%), fruit juice spritzer (30.7%), fruit juice (24.2%) and fruit or herbal tea (23.1%) were the most frequently consumed beverages in men. In women the most

frequently consumed beverages were water (94.1%), coffee (83.4%), fruit or herbal tea (51.6%), fruit juice spritzer (31.6%) and black or green tea (27.9%). The less frequently reported food consumption in men and women was reported for potato fritters (0.6% vs. 0.5%), dumplings (1.0% vs. 0.5%), croquettes (1.9% vs. 0.5%), pancakes (0.7% vs. 1.5%) and puffed pastries (3.6% vs. 1.5%). Significant differences of the frequency of intake between male and female study participants were obtained for unprocessed meat, poultry, canned fish, eggs, high-fat processed sausage products, high-fat processed meat, chocolate and chocolate bars, margarine, mashed potatoes, wheat bread and rolls, tea (fruit and herbal) and beer. Thereby, men showed a higher consumption frequency for unprocessed meat, canned fish, eggs, high-fat sausage products, high-fat processed meat, margarine, mashed potatoes, wheat bread and rolls and beer compared to women. The consumption frequencies of poultry, chocolate and chocolate bars and tea (fruit and herbal) were higher in women compared to men.

Table 10: Reported consumption frequencies of the 85 food items in the Food Frequency Questionnaire (FFQ85) for male (M) and female (F) study participants.

FFQ 85		Frequency of intake						
Item number	**Food item**	**Never to 3 times a month**		**1-2 times per week**		**3-times per week to several times a day**		**P - value for trend[$]**
		M	**F**	**M**	**F**	**M**	**F**	
1	Meat, unprocessed	8.5	25.7	28.8	41.5	62.7	32.8	< 0.0001
2	Poultry	21.4	30.0	54.6	50.9	24.0	19.1	< 0.0001
3	Fish, unprocessed	57.3	59.4	39.7	38.8	3.1	1.8	0.789
4	Canned fish	95.1	97.4	4.2	2.5	0.6	0.2	< 0.05
5	Seafood and crustaceans	93.3	91.3	6.4	8.2	0.3	0.5	0.599
6	Eggs	22.2	27.4	49.9	50.1	27.8	22.5	< 0.05
7	Low-fat processed sausage products	29.3	35.5	23.0	27.8	47.8	36.7	0.355
8	High-fat processed sausage products	45.8	68.9	28.6	22.1	25.5	9.0	< 0.05
9	Low-fat processed meat	48.5	59.2	29.7	28.9	21.7	11.9	0.408
10	High-fat processed meat	69.6	85.9	19.5	11.0	10.9	3.1	< 0.01
11	Low-fat cheese	49.6	49.2	26.1	24.2	24.3	26.6	0.625
12	Whole-fat cheese	37.0	37.2	30.8	28.5	32.2	34.4	0.909
13	Skim or low-fat milk, yogurt, soured milk	49.1	36.4	16.5	15.7	34.4	47.9	0.547
14	Whole-fat milk, yogurt, soured milk	40.6	49.3	21.1	20.7	38.3	30.0	0.088
15	Low-fat quark	88.3	82.3	7.7	12.8	4.0	4.9	0.499
16	Cream quark	91.0	88.0	6.7	9.0	2.3	3.0	0.861
17	Buttermilk	94.1	93.5	3.0	3.6	2.9	2.9	0.698
18	Cream, condensed milk, sour cream, crème fraiche	64.2	72.7	11.2	15.5	24.5	11.8	0.235
19	Ice-cream	82.3	87.3	15.3	11.9	2.4	0.8	0.450
20	Chocolate, chocolate bars	28.2	25.1	30.4	25.6	41.3	49.3	< 0.05
21	Pies	90.5	94.4	8.4	4.9	1.1	0.7	0.073
22	Cake, pound	90.2	92.8	8.7	6.5	1.1	0.7	0.569
23	Cake, yeast	95.8	97.4	4.0	2.6	0.2	0.0	0.810
24	Croissant	89.8	94.8	8.1	4.6	2.1	0.7	0.080

25	Puffed pastries	96.4	98.5	3.5	1.3	0.2	0.2	0.122
26	Pancakes	99.3	98.5	0.6	1.5	0.1	0.0	0.533
27	Cookies, butter	58.4	60.1	29.6	27.3	12.0	12.6	0.541
28	Cookies with chocolate	76.3	81.4	18.8	14.2	4.9	4.4	0.800
29	Nuts and seeds	73.1	70.9	18.3	17.3	8.7	11.8	0.773
30	Potato chips, peanut puffs or other salty snacks	76.4	77.8	19.7	17.8	3.9	4.4	0.488
31	Butter	51.6	59.5	12.8	13.2	35.6	27.3	0.068
32	Low-fat butter	90.8	89.2	3.0	3.4	6.2	7.4	0.323
33	Margarine	68.7	76.8	6.3	7.1	25.0	16.1	< 0.05
34	Low-fat margarine	67.7	69.1	5.0	7.2	27.4	23.7	0.752
35	Oil	28.9	17.5	35.3	33.2	35.8	49.3	0.481
36	Solid vegetable fat, Bacon	92.3	97.7	6.1	1.8	1.7	0.5	0.076
37	Fast Food	81.5	90.2	16.6	9.5	1.9	0.3	0.378
38	Soup, broth or thickened	81.3	77.5	15.8	19.3	2.9	3.3	0.368
39	Stew	86.4	90.4	12.9	9.6	0.8	0.0	0.295
40	Sauce	38.7	50.4	31.0	30.5	30.2	19.1	0.979
41	Fresh fruits	12.9	7.2	22.4	16.5	64.8	76.3	0.107
42	Canned fruits	93.1	93.5	5.6	4.9	1.3	1.6	0.796
43	Dried fruits	91.3	88.9	4.3	7.4	4.4	3.8	0.706
44	Jam, honey	32.7	37.0	31.8	31.1	35.5	31.9	0.740
45	Sugar	46.4	49.5	14.5	17.1	39.1	33.4	0.425
46	Water-ice	94.2	94.9	5.3	4.1	0.5	1.0	0.058
47	Fruit gum	70.8	67.7	20.9	21.0	8.3	11.3	0.752
48	Candies	76.6	72.9	15.6	16.8	7.8	10.3	0.068
49	Vegetables, cooked	11.6	8.7	35.3	33.6	53.1	57.8	0.812
50	Vegetables, raw	20.8	11.3	39.3	33.6	39.9	55.2	0.085
51	Herbals	41.8	35.4	36.3	36.0	21.9	28.6	0.623
52	Legumes	72.6	78.0	23.1	18.8	4.3	3.3	0.087
53	Jacket potatoes	80.8	72.9	17.1	22.9	2.1	4.2	0.050
54	Salted potatoes	40.3	49.6	42.0	38.5	17.7	11.9	0.899
55	Mashed potatoes	88.5	90.2	10.7	9.2	0.8	0.7	< 0.01
56	Dumplings (potatoes)	99.0	99.5	1.0	0.5	0.0	0.0	0.364
57	Croquettes (potato)	98.1	99.5	1.7	0.5	0.2	0.0	0.833
58	Fried potatoes	90.4	97.1	9.5	2.8	0.1	0.2	0.560
59	French fries	75.4	89.1	22.5	10.5	2.0	0.5	0.153
60	Potato fritters	99.4	99.5	0.5	0.5	0.1	0.0	0.602
61	White rice (basmati, parboiled)	41.2	50.1	46.4	41.7	12.4	8.2	0.724
62	Brown rice (whole-grain, natural)	82.8	87.2	14.1	11.8	3.1	1.0	0.592
63	Pasta (durum wheat, whole-grain)	52.4	49.5	37.8	40.8	9.8	9.7	0.247
64	Noodles (egg)	62.2	68.6	32.0	26.8	5.8	4.6	0.901
65	Wheat bread, rolls	21.2	36.6	37.0	39.0	41.9	24.4	< 0.05
66	Rye-wheat bread	37.4	52.1	25.9	21.7	36.7	26.2	0.563
67	Wholemeal bread, rolls	18.7	16.5	29.6	26.6	51.8	56.9	0.071
68	Crisp bread	89.7	83.5	6.0	8.2	4.2	8.3	0.127
69	Muesli and cornflakes	65.4	65.0	14.4	12.9	20.1	22.1	0.925
70	Water (tap, mineral)	5.3	3.3	4.2	2.6	90.5	94.1	0.226
71	Coffee	14.1	13.2	3.4	3.4	82.5	83.4	0.171
72	Tea (black, green)	66.6	60.8	11.5	11.3	21.9	27.9	0.202
73	Tea (fruit, herbal)	63.1	36.4	13.8	11.9	23.1	51.6	< 0.0001
74	Hot chocolate	88.2	91.5	6.7	4.4	5.1	4.1	0.813
75	Fruit juice	53.7	60.9	22.2	22.1	24.2	17.0	0.696
76	Fruit juice spritzer	51.4	46.0	18.0	22.3	30.7	31.6	0.450

77	Fruit nectar	65.6	81.7	20.3	11.9	14.1	6.4	0.621
78	Vegetable juice	96.1	96.4	2.6	2.4	1.3	1.1	0.753
79	Soft drinks	69.5	85.9	14.6	8.2	15.9	5.9	0.571
80	Light soft drinks	82.5	80.1	7.2	8.7	10.3	11.3	0.633
81	Beer	47.9	84.3	32.8	13.2	19.2	2.5	< 0.01
82	Beer (alcohol-free)	91.4	96.1	5.9	2.8	2.7	1.1	0.096
83	Wine	69.7	60.1	21.2	27.1	9.1	12.7	0.087
84	Liqueur	98.4	98.2	1.4	1.8	0.2	0.0	0.384
85	Spirits	90.7	97.1	8.1	2.8	1.2	0.2	0.329

[$] Data were analysed with an ordinal regression model.

4.6. Food intake amounts and frequency of intake compared to the national nutritional recommendations [62]

4.6.1. Foods rich in carbohydrates

This food group contains bread and rolls, cereal products, rice and pasta as well as potatoes and potato products like French fries or mashed potatoes. The recommendation by the German Society of Nutrition of 4 servings a day from this food group was achieved by a minority of 1.3 – 5.8% women and 1.4 – 4.3% men, calculated only by item numbers 65-67 of the FFQ85 (data not shown). The reported mean consumption of 70.1 g/d in men and 48.9 g/d in women for bread (items 65-67) were far below the recommendation of 200-300 g bread a day. Assuming a standard weight of 50g for one slice of bread men consumed just 1.5 and women only one slice of bread per day. Intakes of 180.3 g/d in men and 139.1 g/d in women for potatoes, potato products, rice, pasta or other cereal products also were below the recommended intakes of 200 – 250 g/d (Table 8).

4.6.2. Fruits and vegetables

Legumes, mushrooms, cooked and raw vegetables, processed plant products as well as fresh fruits belonging to the group of fruits and vegetables. 23.5% of female and 12.9% of male study participants consumed several times per day one serving of fresh fruits (data not shown), coming up to a mean daily intake of 151.0 g/d for females and 109.2 g/d for males (Table 9). The recommendations of either 2 fruit portion per day or at minimum 250g fruits per day were not reached.

The reported mean intakes for vegetables of 162.4 g/d for men and 204.7 g/d for women (calculated by the food groups vegetables, legumes and processed plant products; Table 9) and consumption frequencies for several times a day of 0.2 – 2.9% in men and women (data not shown) were below the recommended intakes of the German Society of Nutrition with at minimum 400 g/d or 3 portions a day. 42.3% of men and 47.6% of women reported naturally raw vegetables on a daily basis (Table 8).

4.6.3. Milk, dairy products and cheese

This group contains skim and whole fat milk and dairy products like yogurt, curd cheese and soured milk as well as skim or low-fat and whole fat cheese, buttermilk, creamer, condensed milk and sour cream. The German Society of Nutrition [62] is recommending 3 servings a day of this food group. Only 0.2-8.1% of female and 0.1-4.2% of male study participants have reached this target considering the FFQ items 11-18 (data not shown). The reported mean daily intake of milk, dairy products and cheese of 164.1 g/d in men and 172.5 g/d in women were below the recommended 250 – 310 g milk and dairy products a day by the Nutrition Society (Table 9). Around half of the study population (44 – 56%) consumed the recommended low-fat milk products (Table 9).

4.6.4. Meat and meat products, fish and eggs

The group of meat and meat products is containing all kinds of red meat (lamb, beef and pork), innards, white meat from poultry, as well as low and high fat sausage products. Regarding to all these foods, a daily intake of 168.2 g/d for men and 105.8 g/d for women was reported (Table 9) is exceeding the weekly recommendation of 300 – 600g meat and meat products (43 – 85 g/d) of the German Society of Nutrition. In particular, male individuals reported almost twice as much as recommended; 1177g meat per week for men and 740.6 g meat per week for women. 42.8% of male and 51.7% of female study participants reported an intake of low fat or white meat.

Fish, canned fish, seafood and crustaceans, fish salad as well as fish dishes were also assessed, summarized to the group of fish. 16% of male and 13% of female study participants did not consume fish within the 4-week time range of reporting (Table 13). Almost corresponding to the recommended quantity of 150 -200 g fish per week (21 - 29 g/d) the mean daily intake of fish was assessed at 27.8 g/d in men and 24.6 g/d in women (Table 9). Men and women preferred most likely to consume pollack or tuna. Oily fish like herring, mackerel or salmon was reported by 52.9% of male and 37.6% of female study participants (Table 13).

Boiled, fried and scrambled eggs were pooled to the group of eggs. Mean reported daily intake of eggs was 16.3 g/d in men and 13.6 g/d in women (Table 9). Assuming a standard weight of 60g for a single egg, men consumed about 2 eggs and women 1.5 eggs a week. However, the calculation of the overall intake of egg did not take into account that many products like for example cake, cookies, pies and fresh pasta are containing eggs. For this reason results according to the egg intake are rather underestimated.

4.6.5. Fats

The reported mean daily intake for spreadable fat (butter and margarine) in men and women was 7.7 g/d respectively 5.7 g/d. Daily intake of oils was 4.4 g/d in men and 5.5 g/d in women. It has to be

considered that fat which was used for the preparation of meals was not assessed separately and therefore did not account in the calculation.

Nuts botanically classified as fruits but due to their high amount of fat, evaluated in the group of fats. One serving a day (20g) is recommended by the German Nutrition Society. Only a tiny percentage of participants (2.5% of male vs. 4.2% of female) reported one serving nuts a day (data not shown). The average daily intake of nuts was done to only 4.7 g/d in men and 5.6 g/d in women (Table 9).

4.6.6. Beverages

A daily intake of at least 1.5 L preferably free-energy or low-energy beverages is highly recommended by the DGE. In average male study participants consumed 2.6 L and female study participants 3.1 L alcohol-free beverages per day (Table 9). The mean daily water intake was almost half of the overall liquid intake for both genders. Consumed coffee was up to 28.3% of the overall beverage intake in male versus 17.8% in female study participants (Table 8).

The average intake of alcoholic beverages was 134.0 ml/d in men and 52.4 ml/d in women (Table 9). Calculating the mean daily alcohol intake men consumed 6.9 g and women 3.5 g alcohol per day (Table 5). The intake in both genders was below the upper limits for daily alcohol intake of 20g in male and 10g in female individuals according to the above mentioned guidelines.

4.6.7. Dietary patterns

The reported foods were classified to the recommended food groups of the DGE guidelines in order to survey the reported LUPS dietary patterns compared to the DGE recommendations on a daily basis. Table 11 shows the recommended food groups arranged in descending order: carbohydrate rich foods, vegetables, milk and milk products, fruits, meat and meat products. The reported dietary patterns of female individuals did fit to the recommendations of the DGE, whereas for male individuals the reported intake of meat and meat products was above and the intake of vegetables was below the DGE guidelines.

Table 11: Daily dietary patterns of male and female study participants in comparison to the recommendations of the German Society of Nutrition (DGE) [62]

	Recommendations of the DGE [62]	**Male[$] (n=1274)**	**Female[$] (n=613)**
Carbohydrate rich foods	400 - 550 g/d 200-300g bread and 200-250 potatoes or pasta or 150 -180g rice	259	211
Vegetables	≥ 400 g/d 300g cooked + 100g raw vegetable or 200g cooked + 200g raw vegetable	162	205

Milk and milk products	300 g/d 200 - 250g milk or dairy products and 50g cheese	164	173
Fruits	≥ 250g/d	109	151
Meat and meat products	per week: 300-600g (43- 85g/d)	168	106
Fish	per week: 150 - 200g (21 - 29g/d)	27	25
Eggs	per week: 1-3 eggs	2.0	1.5
Free-energy beverages	1500 ml/d	2612	3078

[$] Mean daily intake in g/d or ml/d

4.7. Use of dietary supplements, sweeteners, dietetic foods and specific foods influencing lipid and glucose metabolism

4.7.1. Use of dietary supplements, sweeteners and dietetic foods in male and female study participants

In Table 12 numbers of supplement use, use of sweeteners and dietetic food are presented. The use of dietary supplements, sweeteners and dietetic food was significantly higher in women than in men. 25.3% of male individuals reported mineral supplement use, composed of 72% use of magnesium, 16% use of calcium, 9% use of zinc and 10% use of multi-mineral supplements. Female individuals reported a 32.5% use of mineral supplements. Women were taken predominantly magnesium (59%), followed by calcium (26%), multi-mineral-supplements (13%) and zinc (6%). Vitamin supplement use was reported by 13% of male and 15.8 of female study participants. The highest contribution of vitamin supplementation among men and women was reported for vitamin C (42% and 33%) and multi-vitamin supplements (39% and 40%). Poly supplementation (including minerals and vitamins) was reported by 10% of male and 13.4% of female individuals of the LUPS cohort. In men, the probability for the use of mineral and poly-supplements was significantly lower than in women (OR 0.70 (95% CI 0.57; 0.87) for mineral supplements and OR 0.72 (95% CI 0.53; 0.97) for poly-supplements, whereas for vitamin use no significant difference was shown between men and women.

The use of artificial sweeteners was reported by 11.5% male and 20.9% female study participants. Predominantly saccharin was used (men 41%; women 40%) followed by cyclamate (men 26%; women 21%) and aspartame (men 8%; women 9%). The use of sugar substitutes reported 1.2% male and 2.5% female study participants. The most frequently reported sugar substitute was fructose (n=6). Four study participants reported the use of agave syrup to replace sucrose. Compared to female study participants male study participants showed a significant lower probability for the use of artificial sweeteners (OR 0.49 (95% CI 0.37; 0.63)) and sugar substitutes (OR 0.48 (95% CI 0.23; 0.99)).

The use of dietetic food was reported by 2.4% of men and 4.6% of women. The use of low-calorie food (light - products) was reported more frequently. Among men, 36% and among women 52.5% reported low-calorie food use. The probability of dietetic food and low-calorie food use in men is significantly lower compared to women (OR 0.52 (95% CI 0.31; 0.87)) for dietetic foods and (OR 0.51 (95% CI 0.42; 0.62)) low-calorie foods.

Table 12: Use of supplements, artificial sweeteners, sugar substitutes and dietetic foods in male and female study participants.

	Men[#] (n=1274)	Women[#] (n=613)	P-Value[§]	OR[$]
Use of mineral supplements [e.g. magnesium, calcium, selenium]	25.3	32.5	< 0.01	0.702
Use of vitamin supplements	13.0	15.8	n.s.	0.797
Use of poly supplements (including minerals and vitamins)	10.0	13.4	< 0.05	0.72
Use of artificial sweeteners	11.5	20.9	< 0.0001	0.485
Use of sugar substitutes	1.2	2.5	< 0.05	0.481
Use of dietetic foods	2.4	4.6	< 0.05	0.515
Use of low-calorie foods (light-products)	36.0	52.5	< 0.0001	0.511

[#] Percentages of population are given for dichotomous variables
[§] Differences were analysed with a logistic regression model.
[$] OR (odds ratio) describe the probability for the use of supplements, artificial sweeteners, sugar substitutes and dietetic foods by male compared to female study participants.
n.s. not significant

4.7.2. Use of specific foods influencing lipid and glucose metabolism in males and females of the study

The proportion of individuals consuming foods like oils, nuts, fish and margarines which may – depending on quantities and consumption frequencies - influence lipid and/or glucose metabolism negatively or positively are presented in Table 13.

Male individuals were more likely to have no use of oil (OR 2.35 (95% CI 1.09; 5.08)). In both sexes, the three most used oils were olive oil (men 83.7%; women 86.5%) followed by sunflower oil (men 56.9%; women 55.3%) and rapeseed oil (men 24.5%; women 35.1%). The probability for the use of rapeseed oil and other kinds of oils was significantly lower in men compared to women (OR 0.59 (95% CI 0.48; 0.73) for rapeseed oil and OR 0.66 (95% CI 0.45; 0.97) for other oils). Further kinds of oils used by the study participants were pumpkin seed oil (2.0%), sesame oil (1.3%) and walnut oil (1%) in men and pumpkin seed oil (3.9%), linseed oil (1.6%) and sesame oil (1.3%) in women.

The percentage of study participants who did not consume nuts was higher in men than in women (16.6% vs. 12.2%). In men the highest consumption was reported for peanuts (55.7%), followed by cashews (45.5%) and walnuts (36.9%). Among women the highest consumption was reported for

cashews (53.7%), walnuts (43.7%) and peanuts (42.6%). Further kinds of nuts reported by the study participants were macadamia (4.5%), almonds (3.5%) and pistachios (2.5%) in male and almonds (8.8%), macadamia (7%) and brazil nuts (3.5%) in female individuals. In men the probability for the consumption of cashews, walnuts and other nuts was significantly lower compared to women (OR 0.59 (95% CI 0.59; 0.90) for cashews, OR 0.74 (95% CI 0.61; 0.91) for walnuts and OR 0.59 (95% CI 0.45; 0.76) for other nuts), whereas the probability for the consumption of peanuts was significantly higher compared to women (OR 1.70 (95% 1.41; 2.10)).

7.4% of male and 6.2% of female individuals reported to eat no fish at all. In men the most reported kinds of fish were Pollack (62.9%), tuna (42.1%) and herring (31.6%). Women reported also the highest consume for Pollack (63.6%) and tuna (42.7%) followed by redfish (35.6%). Other reported fish in men and women were salmon (8.9% vs. 11.1%), plaice (3.0% vs. 5.1%) as well as cod (2.8%) in men and gilthead (3.9%) in women. Significantly different probabilities for the consumption between men and women were shown for herring (OR 2.11 (95% CI 1.66; 2.68), mackerel (OR 1.45 (95% CI 1.05; 2.01), redfish (OR 0.72 (95% CI 0.59; 0.89) and zander (OR 0.62 (95% CI 0.48; 0.81).

Of the study cohort 37.6% men and 39.5% women did not use margarine. In individuals using margarine the most frequently consumption was seen for soft margarines (men 37.9%; women 28.7%), margarines including polyunsaturated fatty acids (men 16.1%; women 18.8%) or dietetic margarines (men 16%; women 17.1%). In men, the probability for the use of soft margarine was significantly higher compared to women (OR 1.52 (95% CI 1.23; 1.87)). Other kinds of margarines consumed by the study participants were low-fat margarines (men 1.2%; women 2.6%), *Lätta*® (men 1.2%; women 2.4%) and *Becel*® (men 1.1%; women 1.8%).

Table 13: Use of specific foods influencing the lipid and glucose metabolism in male and female study participants**.**

Food items	**Men (n=1274)[#]**	**Women (n=613)[#]**	**P-Value[§]**	**OR[$]**
Consumption of oils				
No Oil	3.0	1.3	< 0.05	2.35
Thistle oil	6.0	7.3	n.s.	0.78
Peanut oil	3.2	4.2	n.s.	0.76
Germ oil	7.2	6.0	n.s.	1.21
Olive oil	83.7	86.5	n.s.	0.80
Rapeseed oil	24.5	35.1	< 0.0001	0.59
Soya oil	2.3	2.3	n.s.	0.99
Sunflower oil	56.9	55.3	n.s.	1.07
Other oils	5.3	7.8	< 0.05	0.66
Which other oils do you use?	Pumpkin seed oil (2.0%) Sesame oill (1.3%) Walnut oil (1.0%)	Pumpkin seed oil (3.9%) Linseed oil (1.6%) Sesame oil (1.3%)		
Consumption of nuts				
No Nuts	16.6	12.2	n.s.	1.45
Cashew	45.5	53.7	< 0.01	0.72
Peanuts	55.7	42.6	< 0.0001	1.70

Hazelnut	25.4	23.0	n.s.	1.14
Walnuts	36.9	43.7	< 0.01	0.74
Other nuts Which other nuts do you use?	11.7 Macadamia (4.5%) Almonds (3.5%) Pistachios (2.5%)	18.4 Almonds (8.8%) Macadamia (7.0%) Brazil nuts (3.5%)	< 0.0001	0.59
Consumption of fish				
No fish	7.4	6.2	n.s.	1.25
Trout	28.4	26.4	n.s.	1.09
Herring	31.6	17.9	< 0.0001	2.11
Carp	1.6	2.4	n.s.	0.64
Mackerel	12.4	8.8	< 0.05	1.45
Redfish	28.9	35.6	< 0.01	0.72
Pollack	62.9	63.6	n.s.	0.97
Tuna	42.2	42.7	n.s.	0.98
Zander	12.4	18.4	< 0.0001	0.62
Other fish Which other fish species do you use?	17.6 Salmon (8.9%) Plaice (3.0%) Cod (2.8%)	18.8 Salmon (11.1%) Plaice (5.1%) Gilthead (3.9%)	n.s.	0.92
Consumption of margarines				
No margarine	37.6	39.5	n.s.	0.93
Use of hard margarine (not immediately spreadable)	3.6	2.9	n.s.	1.24
Use of soft margarine (immediately spreadable)	37.9	28.7	< 0.0001	1.52
Use of margarine fortified with polyunsaturated fatty acids	16.1	18.8	n.s.	0.82
Use of margarine fortified with olive oil	8.9	10.9	n.s.	0.79
Use of dietetic margarine	16.0	17.1	n.s.	0.92
Use of other kinds of margarines Which other margarines do you use?	5.3 Low-fat margarine (1.2%) Lätta® (1.2%) Becel® (1.1%)	6.4 Low-fat margarine (2.6%) Lätta® (2.4%) Becel® (1.8%)	n.s.	0.81

[#] Percentages of population are given for dichotomous variables
[§] Differences were analysed with a logistic regression model.
[$] OR (odds ratio) describe the probability for the use of these specific foods by male compared to female study participants.
n.s. not significant

4.7.3. Use of supplements, sweeteners and sugar substitutes, dietetic foods and specific foods influencing lipid and glucose metabolism in different age groups

To analyse the use of supplements and specific foods in different age groups we subdivided the study participants in four age ranges, first ≤ 30 years (145 males and 94 females), second 31 - 40 years (364 males and 158 females), thirty 41 – 50 years (520 males and 246 females) and fourth 51 – 60 years (245 males and 115 females). The use of vitamin or poly supplements in men was decreased by age, whereas mineral supplements showed a slightly increase (Figure 6). The highest use of poly supplements in women was reported in the second range between 31 – 40 years (18.6%), the highest use of mineral and vitamin supplements was reported between 51 – 60 years.

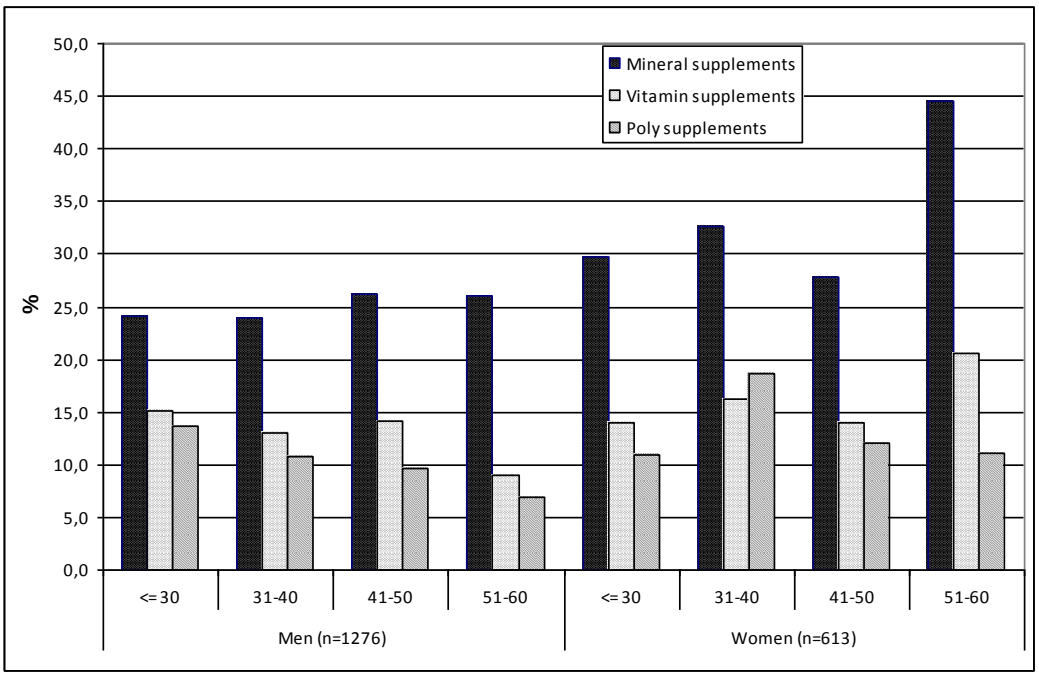


Figure 6: Use of supplements within four age groups, stratified by gender.

Reported intake of artificial sweeteners was increased in male (≤ 30 years 8.3%; 51-60 years 12.7%) and female (≤ 30 years 16.3%; 51-60 years 19.8%) study participants by age. Women used higher amounts of sweeteners compared to men. The highest use of sweeteners in men was reported for the age range between 51-60 years (12.7%) and in women between 41-50 years (24.8%). Reported use of sugar substitutes was lower compared to the use of sweeteners and decreased age based (Figure 7).

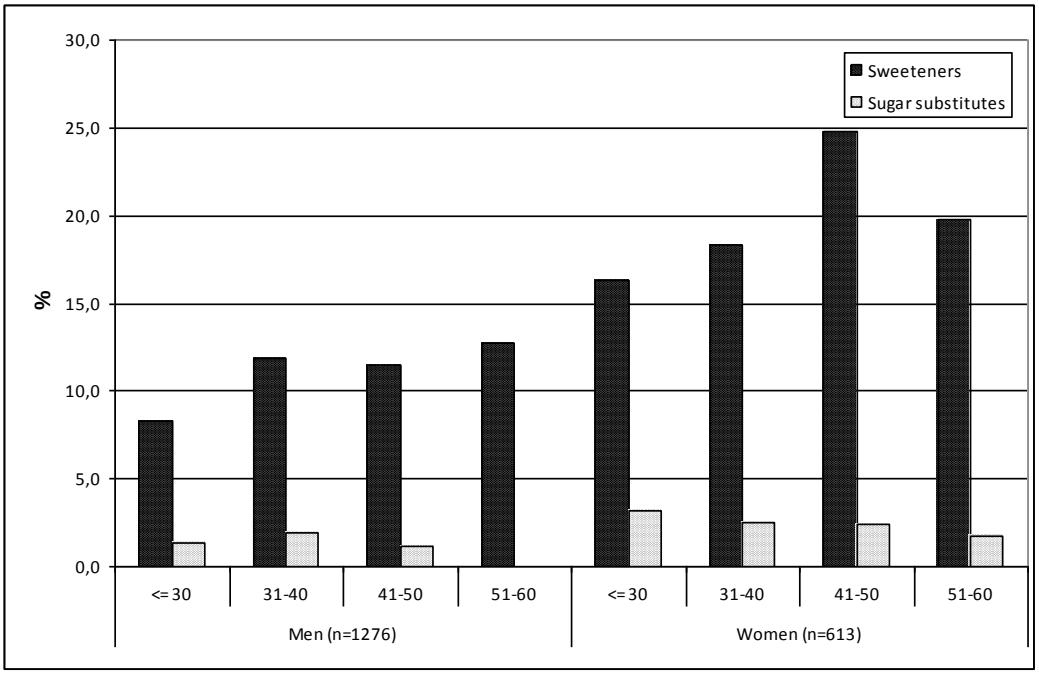


Figure 7: Use of artificial sweeteners and sugar substitutes within four age groups, stratified by gender.

Reported consumption of dietetic foods (Figure 8) in men and women was marginal observing a small increase in older men (≤ 30 years 2.7%; 51-60 years 4.1%). In women reported intake (≤ 30 years 3.3%; 51-60 years 3.5%) showed the highest consumption in the range between 41-50 years (7.3%). Reported intake of low-calorie foods was higher in women than in men. In men and women the highest intake was reported in the age group ≤ 30 years (41.4% for male and 63.0% for female study participants). Among both genders the reported intakes were lowest in the age group 51 – 60 years (men: ≤ 30 years 41.4%; 51-60 years 31.7% and women: ≤ 30 years 63.0%; 51-60 years 41.8%).

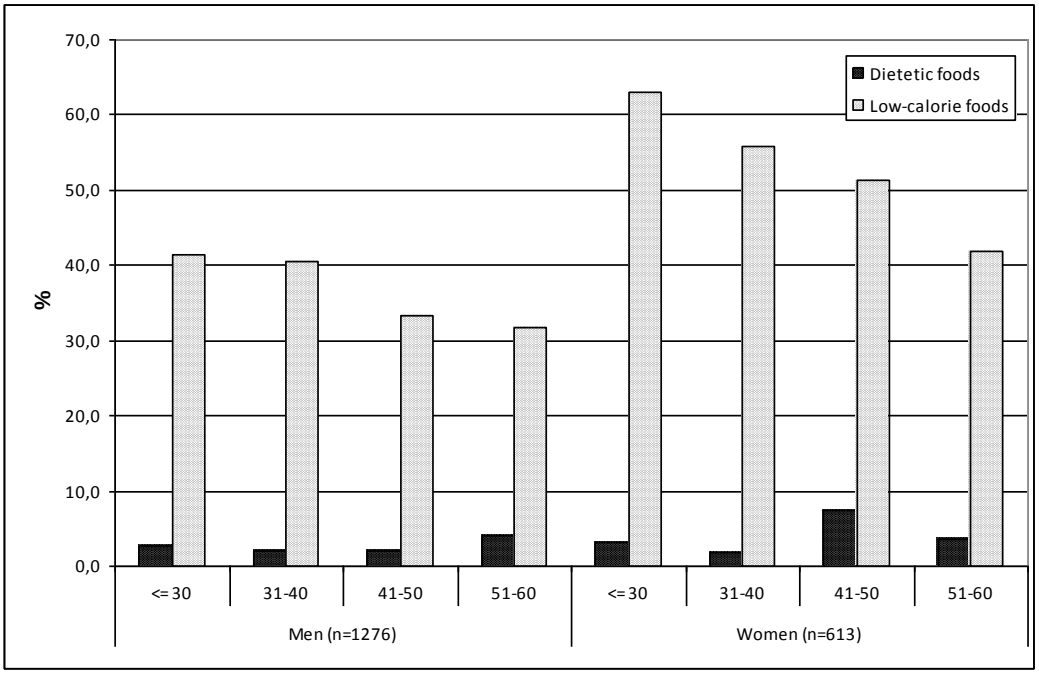


Figure 8: Use of dietetic and low-caloric foods within four age groups, stratified by gender.

The three most consumed oils were olive oil, sunflower oil and rapeseed oil. No definite differences for the consumed oils except for rapeseed oil were seen between age groups (Figure 9). The highest use of rapeseed oil in men was reported in the age group of 31-40 years (27.5%). In women the reported consumption of rapeseed oil was increased by age, with the highest reported use in the age range between 41-50 years (39.4%). The highest intake of thistle oil in male and female individuals was reported in the age group of 51 – 60 years with 12.2% in male and 11.3% in female study participants.

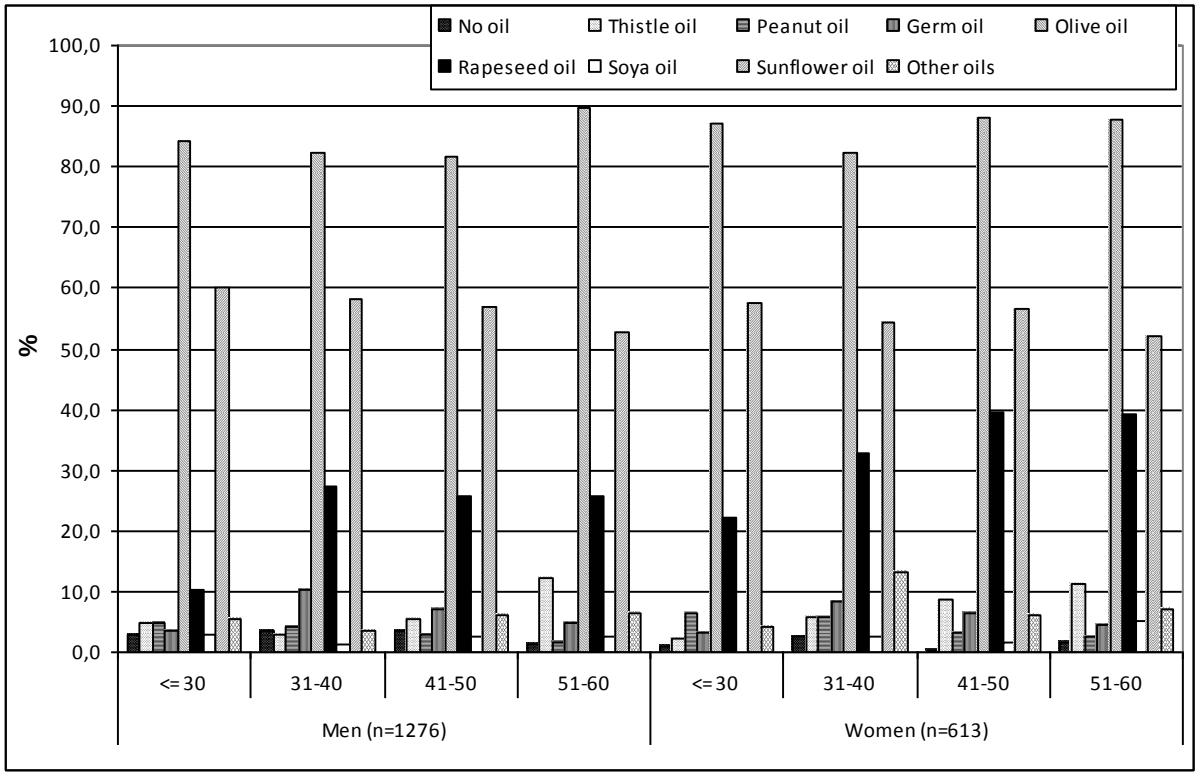


Figure 9: Reported consumption of different oils within four age groups, stratified by gender.

Mostly peanuts, cashews and walnuts were reported in descending order by male individuals. Female individuals reported preferably cashews, followed by walnuts and peanuts. In men, the reported intake of cashews and hazelnuts were highest in the age range between 51 – 60 years (cashews: ≤ 30 years 41.8% and 51-60 years 50.8%; hazelnuts: ≤ 30 years 21.9% and 51-60 years 31.3%), women reported an almost consistent intake in the different age groups (cashews: ≤ 30 years 55.3% and 51-60 years 56.3%; hazelnuts: ≤ 30 years 25.5% and 51-60 years 21.7%). In men the consumption of peanuts increased by age (≤ 30 years 47.9% and 51-60 years 53.7%) and was highest in the age range between 41 – 50 years (59.6%). The highest intake of peanuts in women was reported by 50.0% in the age group of ≤ 30 years. In men and women the intake of walnuts was highest in the age range between 51 – 60 years (men 47.2%; women 54.8%), however female study participants reported a high intake already at age ≤ 30 years (46.8%).

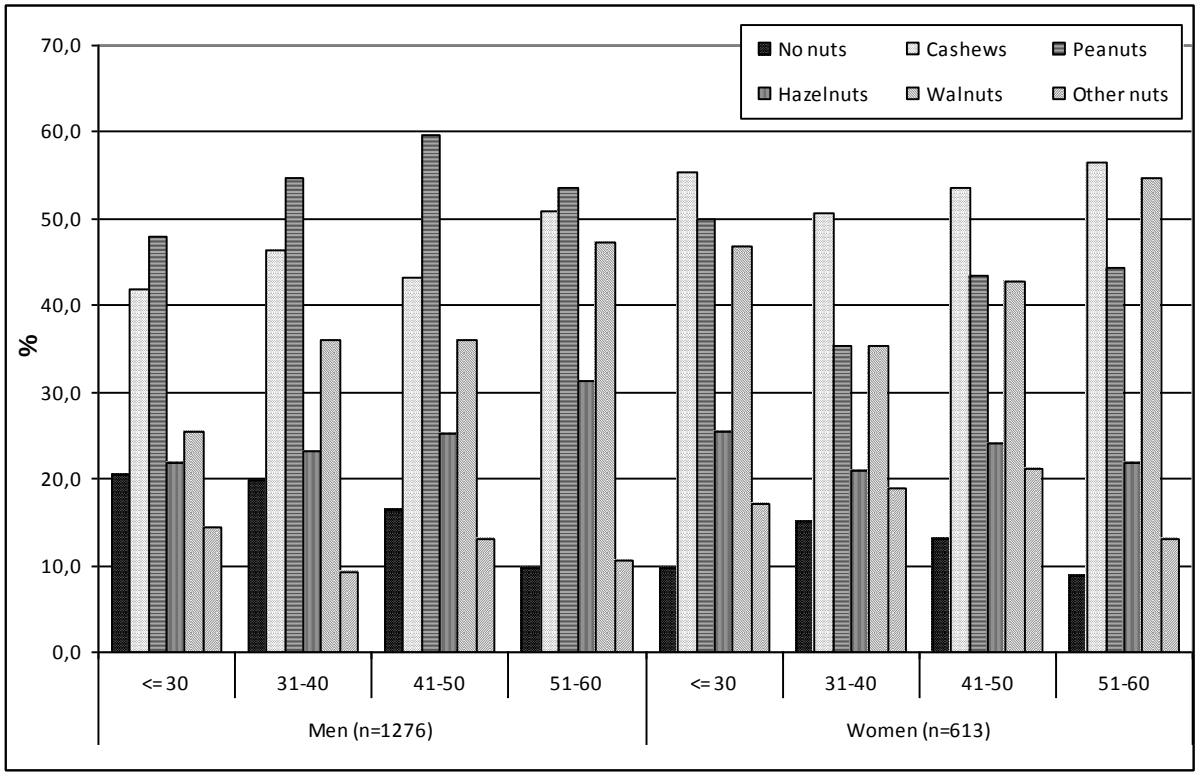


Figure 10: Reported consumption of different nuts divided into four age groups, stratified by gender.

In general, the reported patterns of fish consumption were similar in male and female study participants (Figure 11). The percentage of individuals consuming no fish was highest in the youngest age between 25 to 30 years for both genders (men 8.2%; women 8.5%). In men and women reported consumption of trout, herring and redfish was highest in the age range between 51 – 60 years. Reported intake of pollack was high compared to the other kinds of fish, but was slightly lower in the age between 51 – 60 years, in both gender (≤ 30 years 65.8% and 51-60 years 59.3% for men, ≤ 30 years 71.3% and 51-60 years 60.0% for women). In all age groups tuna was reported in a similar range in male and female study participants (≤ 30 years 44.5% and 51-60 years 39.0% for men, ≤ 30 years 43.6% and 51-60 years 41.7% for women).

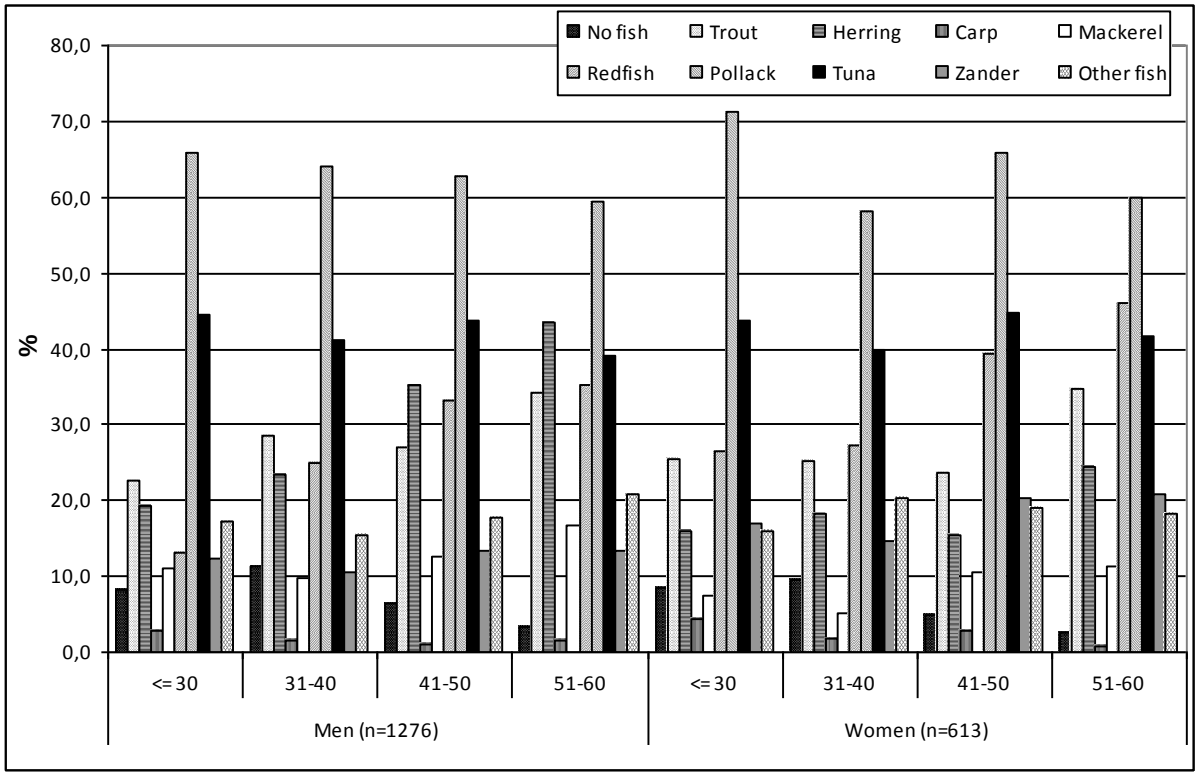


Figure 11: Reported consumption of different fish species within four age groups, stratified by gender.

The percentage amount of study participants who reported to consume no margarine was high with a slight decrease in the older age groups, in both genders (Figure 12). Soft margarine was - except for women between 51 – 60 years – the most reported kind of margarine in both genders. The consumption of margarine fortified with PUFAs was highest in the age range between 51 – 60 years, in both genders (≤ 30 years 10.3% and 51-60 years 22.8% for men, ≤ 30 years 12.8% and 51-60 years 27.8% for women). Further, the consumption of soft, dietetic and other kinds of margarine was increased in the higher age groups in male study participants (≤ 30 years 33.6% and 51-60 years 35.4% for soft margarine; ≤ 30 years 17.1% and 51-60 years 22.0% for dietetic margarine; ≤ 30 years 5.5% and 51-60 years 7.7% for other kinds of margarine). In women, the intake of soft margarine was lowest in the age range between 51 – 60 years (≤ 30 years 37.2% and 51-60 years 26.1%). In the higher age groups, reported consumption of hard margarine was lower in male (≤ 30 years 6.8% and 51-60 years 2.0%) and higher in female (≤ 30 years 1.1% and 51-60 years 5.2%) study participants.

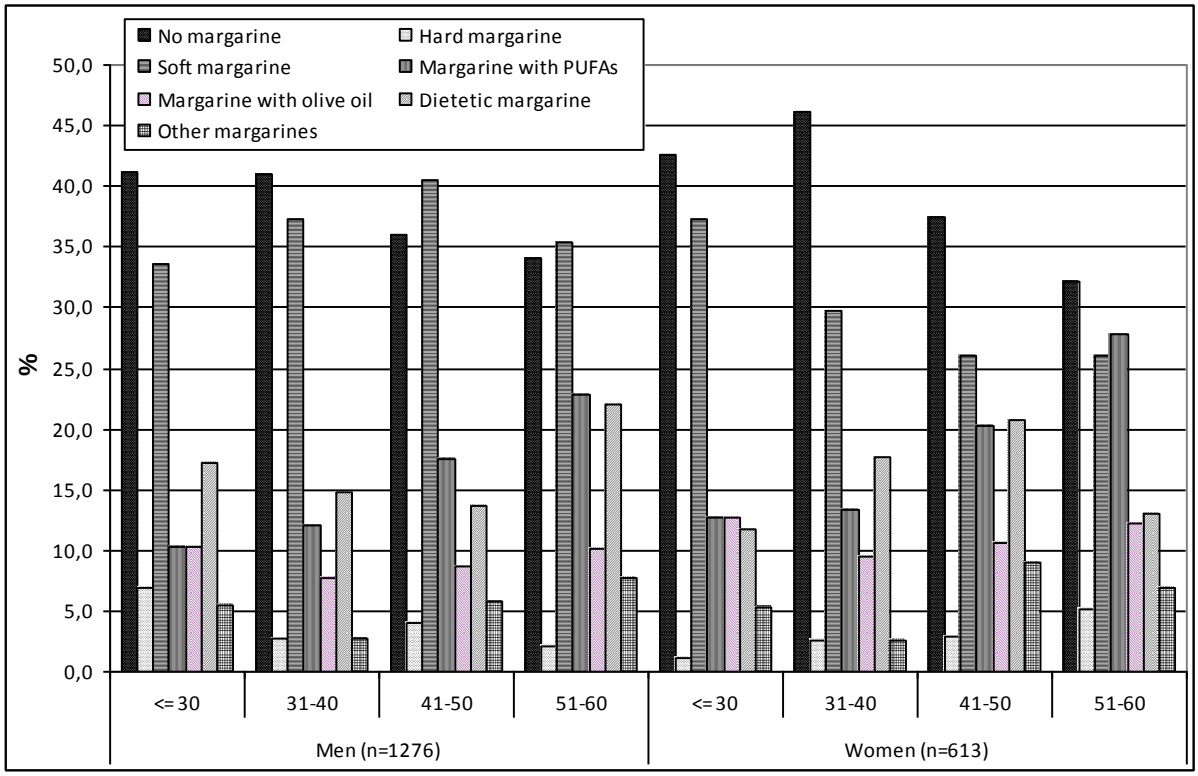


Figure 12: Reported consumption of different margarines within four age groups, stratified by gender.

5. Discussion

Only a few prospective observational studies evaluated the quality of dietary intake in a so called healthy workers cohort regarding to the development of the MetS. The present examination assessed energy and nutrient intake in 1.962 individuals recruited in Hamburg, Germany. Between November 2008 and June 2012 data on dietary patterns, the use of supplements and specific foods which may have an influence on the glucose and lipid metabolism were collected.

Nutrition is a major factor either in prevention or in the treatment of the MetS, its single components and secondary diseases [11,12,63,64]. In addition to an energy-balanced diet, an adequate intake of carbohydrates and fibres and a limited intake of fats, particular saturated and trans fatty acids is recommended by national and international nutritional societies [11,12,62-64]. A vegetable rich diet reduced in animal based products is recommended by several nutrition organisations for the prevention and treatment of the MetS and its secondary diseases like T2D and CVD [11,12,62-64]. In order to achieve an accurate baseline data set we used a self-administered food frequency questionnaire. Certain food and beverage items as well as portions sizes of every single item were reported by each study participant over a time range of the previous four weeks. FFQs are established instruments to assess habitual dietary patterns and trends within the nutritional intake in prospective studies. The FFQ85 used in our study enables a semi-quantitative assessment of the habitual dietary pattern within a defined time interval. Due to missing nutritional data only 23 (1,2%) of the FFQs obtained from our study participants have been excluded from the analysis. This result is demonstrating high compliance in completing the questionnaire. Feasibility of the FFQ was analysed in previous studies [94-96].

The distribution of male and female study participants in our cohort consisted of 67.7% male individuals and is not representative for the German population (49% men) [97]. Study participants were recruited from the predominantly male staff of the Lufthansa Technik Company. Mean age of 42.4 years in male versus 41.9 years in female study participants and the age distribution is matching quite well to the National Nutrition Survey II (NVS) and the *Mikrozensus* 2011 data sets in Germany [65,97]. In our cohort, the prevalence of the MetS according to the Joint Statement definition [9], was 20.4% in male and 11.8% in female individuals. Compared to previous German surveys the prevalence of the MetS in the here discussed data set is ranking below [45,47,48]. However, some studies have shown similar results. Moebus et al. published a regional prevalence of the MetS around 20.0% for male and 14.3% female individuals [46] and Balkau et al. described a prevalence of 18% for

men and 14% for women in a French population [98]. As mentioned above, the prevalence of the MetS is largely affected by the underlying definition. Continents, countries and even various regions in these countries have shown regarding to their population, huge differences for the prevalence of the MetS. This effect is influenced by age and sex distribution as well as the social economic status of the individuals [50,98-101]. Compared to former German studies we measured a rather high prevalence of elevated blood pressure, triglycerides and waist circumference in male individuals and increased blood pressure, waist circumference and reduced HDL cholesterol in female individuals. Compared to the German SHIP study, the distribution of the single components of the MetS was similar to our cohort, though at a lower range [48]. The high prevalence of elevated blood pressure levels, mentioned above was documented in previous studies [99,101]. Regarding to all five components of the MetS fasting glucose has shown an overall lowest prevalence in our cohort. This is in line with results observed in SHIP [48], yet not matching to data of other European data sets, which measured the lowest prevalence for low HDL cholesterol or high triglycerides, particularly in women [46,98].

5.1. Nutritional patterns of the LUPS cohort compared to results from national nutrition surveys in Germany

5.1.1. Energy intake

An energy balanced diet is highly recommended to individuals at risk for MetS. To avoid weight gain, energy intake should be adjusted to the individual energy expenditure. For this reason, not merely the amount of food intake but also the composition of the diet has an enormous impact on outcome criteria like e.g. weight or lipid levels.

Previous nutrition surveys, the German Bundesgesundheitssurvey 1998 (BGS) [66] and the National Nutrition Survey 2006 [65] showed higher levels of daily energy intake ranging from 10.5 to 10.9 MJ/d in men and 7.5 to 7.7 MJ/d in women, whereas reported energy intake in our cohort ranged from 7.19 MJ/ d in men to 5.98 MJ/d in women. To better understand these results we have performed further analysis regarding on portion sizes and the frequency of food intake. Study participants could choose the portion sizes small, medium or large for each food item. More than 90% of the cohort reported either the serving size “small” or “medium”. We detected a positive correlation of serving size to energy intake, BMI and waist circumference (data not shown). Considering total food intake also includes frequency of food consumption we have analysed the eating frequency of some basic food items [102]. With regard to the frequency of intake of bread, rolls or muesli, only 9.4 to 19.4% of male and 8.3 to 24% of female study participants consumed at least once a day these foods. A daily consumption of vegetables and fruits was reported by 7.9 – 36.6

% of men and 13.9 – 53.7% of women only. The eating frequency of butter and margarine for at least once a day was reported by 10.3 – 23.3 % of our cohort and for unprocessed meat only by 6.5 – 15.7% of the study participants. Based on these facts we came to the conclusion, that study participants tended to underestimate portion size and eating frequency. Further analysis were done to identify reasons for low energy values, calculating the ratio of energy intake/ basal metabolic rate (EI:BMR ratio) [103,104]. Thereby > 80% of the cohort can be classified as under-reporters according to the Goldberg cut-off of EI:BMR ratio 1.14 [103]. No associations between EI:BMR ratio and BMI or waist circumference were observed in the present data set as also reported in other studies [105-107].

The quality of assessment of habitual dietary intake via a FFQ is depending on many aspects. Characteristics of the study population, the number of food items included in the selected FFQ, the given time frame asking about intake (e.g. 4 weeks up to 1 year), the kind of administration (self- or interviewer-administered) and the method to describe portion sizes [e.g. food photographs), they all have an impact on the resulting data [106-110]. There are no fixed rules about the number of items of a FFQ. Though the more detailed questionnaire is used, the more overestimating of intake is observed. The selection of food items depends on what should be assessed. For instance assessment of vitamin and mineral intake, FFQ items can be limited to foods which supply these micronutrients [106-110]. In case the whole habitual nutritional pattern should be evaluated the FFQ items should cover a broad spectrum of foods and food groups usually consumed in the region by comparable individuals [111,112]. The average number of items used in FFQs is 88 [113]. The FFQ85 implemented in our cohort is taking into account typical German food and food groups and additionally gives the opportunity to report food items which are not included in the FFQ85.

Memory lacks may play a role within all retrospective dietary assessments [108,110]. To reduce memory lacks we choose a time period of 4 weeks. To avoid possible incompleteness of answers in the self-administered FFQ trained nutrition experts checked each FFQ for completeness and plausibility. An incorrect estimation of consumed portion sizes is the most frequent measurement error in almost every dietary assessment method [108]. Although several types of portion size measurement assistances like for example food images of typical serving sizes presenting a small, medium or large portion or, household measures, food photographs or rather food models do exist, the reported estimated portion size tend to be imprecise [108,110,113]. In our cohort, we offered to include portion sizes for all foods and beverages (small, medium or large) to simplify the completion of the FFQ85 and therefore reduce respondent burden and to analyse the reporting pattern [90,102,108,109]. Interestingly we found conclusive patterns of reporting. On average, men reported more frequently greater portion sizes than women. Male and female participants at higher age have reported to choose more frequently smaller portion sizes than participants of younger age groups.

Moreover, individuals having a higher BMI and a higher waist circumference reported larger serving sizes than individuals with lower BMI and lower waist circumference. Thus, study participants who are female, at higher age and reduced weight reported more frequently small portion sizes and study participants who are male, at younger age and overweight reported more often large portion sizes. This is in accordance with the reported daily energy intake in our cohort, but does not reflect results of other studies [105-107].

In general, the strength of a semi-quantitative FFQ is more likely to assess dietary patterns and nutritional changes in follow-up trials within large prospective epidemiological studies than the absolute estimates of total energy intake. The relatively low energy intake reported in our cohort is either showing limitations of the dietary assessment method or reveals an attitude of the employees at Lufthansa Technik Company aiming to report socially desired dietary intakes. Despite that, the estimated dietary pattern of the cohort indicates plausibility and is in accordance with the nutritional patterns assessed in the NVS II. To adjust for total energy intake statistical procedures with simple factor corrections can be applied [90].

5.1.2. Intake of nutrients

The role of a high carbohydrate intake for the prevention of the metabolic syndrome and its risk factors is subject to a permanent controversial discussion [16,75,76]. The present study showed a higher intake of carbohydrates and dietary fibre in women than in men. This fact has also been observed in other previous German studies (men: 44% in BGS vs. 45% in NVS II vs. 44% in LUPS; women: 47% in BGS vs. 49% in NVS II vs. 46% in LUPS). Although the consumption of carbohydrates and dietary fibre in women was higher than in men and increased in both genders at higher age, it did not reach the recommendations of the German Society of Nutrition [62]. The higher intake of carbohydrates and dietary fibre in women was accompanied by a lower intake of meat, meat products and beer and a higher intake of fruits and vegetables as well as of cereal products, especially wholegrain products.

In comparison to former studies in Germany we observed an increase of reported protein intake by + 4.2% in men and + 3.4% in women (men: 15.3% in BGS vs. 14% in NVS II vs. 18.2% in LUPS; women: 15.3% in BGS vs. 14% in NVS II vs. 17.4% in LUPS). Detriments to health by a diet rich in proteins are actually not known for healthy individuals. However, a diet rich in proteins mostly goes in line with an increased intake of animal protein and thereby with a higher intake of fat and cholesterol which may increase the risk for T2D, CHD and CVD [73,74,114]. Studies evaluating methods to lose weight recently showed beneficial effects also for diets high in protein [71,72,115,116] and some public magazines or media advertised diets rich in proteins to reduce overweight. However, most of the diets named “low-carbohydrate” or “protein-rich” varied in the composition of nutrients and were

therefore in some cases not comparable. Yet studies did not show long-term effects of weight loss [71,72,116]. In addition long-term results and their effects on renal function, especially in persons with diabetes are not fully understood. Further research is requested [72,117].

The reported intake of total fat in our cohort was similar to results observed in the NVS II and the BGS. It exceeded the recommended upper-limit of 30% of total daily energy intake (men: 34% in BGS vs. 36% in NVS II vs. 35% in LUPS; women: 34% in BGS vs. 35% in NVS II vs. 35% in LUPS). Moreover the reported consumption of saturated fatty acids (SFA) in our study was comparable to the results of previous German surveys. It was lying above the recommended upper-limit of 10% total energy intake and higher than the recommendations for people at higher risk for CVD (< 7% of total energy intake). For the reported intake of monounsaturated fatty acids (MUFA) we observed a somehow higher intake than in the NVS II and the BGS. In particular, these results may positively affect lipid levels, total cholesterol and LDL cholesterol as well as lipoprotein composition and insulin sensitivity. In contrast to male individuals, the reported intake of MUFA in elderly female individuals was higher. We can only assume that the increase of MUFA content in the diet can be attributed to a higher considering for beneficial vegetable oils, particular of olive and rapeseed oil, especially in female individuals. Polyunsaturated fatty acid (PUFA) intake in our study was similar to that determined in national nutrition surveys in 1998 and 2006. Despite of the recommendation of the German Society of Nutrition to consume at least one portion oily fish a week and one portion of nuts a day to raise the intake of n-3 FA, the recommended amount of 6 – 10 E% PUFA per day was not met. This was also continued by the results that pollack and tuna were the most consumed kinds of fish within the cohort whereas oily fish like herring or mackerel were only consumed by 25% and 11% of the study participants. The reported intake of nuts and seeds, however, seemed to be too low to have an impact on n-3 fatty acid intake.

In general, the intake of dietary cholesterol was within the recommended 300 mg per day. However, in contrast to the last nationwide nutritional survey the dietary cholesterol (mg/1000kcal) intake in our cohort was increased (men: 150 mg/1000kcal in BGS vs. 146 mg/1000kcal in NVS II vs. 168 mg/1000kcal in LUPS; women: 156 mg/1000kcal in BGS vs. 136 mg/1000kcal in NVS II vs. 152 mg/1000kcal in LUPS). This increase was in line to the increased intake of protein and can be attributed to the higher consumption of animal products like eggs, meat, sausages as well as milk and dairy products. Reduction of the dietary cholesterol intake may help to maintain normal blood cholesterol levels. In the higher age groups the reported intakes of protein, total fat and cholesterol were lower in male and higher in female study participants. This may be attributable to a higher intake of animal products in women and lower intakes of these foods in men. Male individuals of the study reported lower consumptions of meat, meat products, chocolate and fast food with higher age.

In contrast, women showed a nearly constant consumption of meat, meat products and chocolate but a lower consumption of fast food. In both genders the intake of fish, nuts and seeds was higher in higher age. A different consumption between men and women at the higher age groups was reported for oil (+9% for women and -12% for men). Thereby, the intake of MUFA was increased in women.

The estimation of alcohol consumption within a dietary assessment is often critical [118]. Two studies estimating the alcohol intake with two different assessment methods showed that underreporting increased with increasing alcohol intake [80,81]. In our cohort, men consumed less alcohol (6.5 g/d vs. 9 – 11.5 g/d) and women consumed more alcohol (3.5 g/d vs. 2 - 2.4 g/d) compared to former studies in the German population [65,66]. To compare the reported daily alcohol consumption of individuals in our cohort with data from the NVS 2006 and the BGS 1998 we calculated the proportion of alcohol (1g alcohol = 7kcal) of daily energy intake. Male study participants reported similar intakes compared to the surveys from 1998 and 2006 (men: 1.8% in BGS vs. 1.5% in NVS II vs. 1.6% in LUPS). However, our female study participants reported three fold higher intakes than the female individuals of the BGS and the NVS II (women: 0.5% in BGS vs. 0.4% in NVS II vs. 1.7% in LUPS). On average, the reported alcohol intakes were lower than the recommended upper limits for daily intakes in male and female individuals. Underreporting of alcohol intake cannot be excluded in our cohort, however for such low quantities of alcohol intake no increased risk for cardiovascular disease has been reported in recent literature [12].

The assessed salt intake of 3.3 and 2.6 g/d for male and female individuals of the cohort was below the recommended level of the DGE. The observed results were also lower than the results from the last national nutrition survey in Germany (8.0 g/d for men; 6.0 g/d for women). Salt intake in most western countries is estimated to reach 10 g/d and more [82]. Because of possible detrimental effects of high salt intake on blood pressure, left ventricular mass, arterial stiffness and renal function a worldwide reduction of salt to 5 g/d is proposed to reduce blood pressure in patients with and without hypertension and concomitant risk for cardiovascular disease and stroke [82-84,119].

5.1.3. Intake of foods and food groups

The consumption of carbohydrate rich foods in our study participants was lower than shown by the NVS II and the BGS (men: 420 g/d in BGS vs. 357 g/d in NVS II vs. 260 g/d in LUPS; women: 315 g/d in BGS vs. 279 g/d in NVS II vs. 211 g/d in LUPS). Regarding the FFQ items contributing to the group of carbohydrate rich foods (except for bread and rolls) the consumption was 10 – 30% lower than the recommendations of the German Society of Nutrition, but similar to intakes assessed within the NVS II (men: 177 g/d in NVS II vs. 180 g/d in LUPS; women: 144 g/d in NVS II vs. 139 g/d in LUPS). In

contrast, the consumption of bread and rolls was 2.5 – 2.7times lower than in the NVS II (men: 180 g/d in NVS II vs. 70 g/d in LUPS; women: 134 g/d in NVS II vs. 49 g/d in LUPS). The consumption of pastries and fast food, classified as sweet and solid baked goods within the NVS II were comparable or slightly higher in our cohort (men: 46 g/d in NVS II vs. 49 g/d in LUPS; women: 33 g/d in NVS II vs. 36 g/d in LUPS). The lowest consumption of fast food was reported in the oldest group of men and women, which was also demonstrated by the results of the NVS II [65] and may reflect that older people did not adapt to the dietary habit of consuming fast food. The reduced consumption of bread may be influenced by recent studies demonstrating a potential benefit of diets low in carbohydrates [16,120]. However, most of the studies investigated only effects of the amount of carbohydrates rather than the quality of the carbohydrates. Results from previous studies reported significant improvements of weight loss, lipid profile and systolic blood pressure favouring low-carbohydrate diets, but recent German carbohydrate guidelines summarized no long-term benefits for low or very low carbohydrate intake [16,75,76,115,116,120]. More detailed results, investigating the source of carbohydrates diets rich in wholegrain products, fruits and vegetables and low in refined grains, pastries, added sugar and sugar sweetened beverages were shown to reduce the risk for elevated serum lipids, obesity (BMI and waist), hypertension, the MetS, CHD and T2D [14,17,19,70,82,87,121]. Similar to the results of men and women of the NVS II and the BGS our study participants also did not reach the recommendations of the German Society of Nutrition to consume 400g vegetables a day (men: 241 g/d in BGS vs. 222 g/d in NVS II vs. 164 g/d in LUPS; women: 246 g/d in BGS vs. 243 g/d in NVS II vs. 205 g/d in LUPS). While, women have reached about 50%, men reached only 40% of the recommended intake. Higher vegetable intake observed in male and female individuals with increasing age, was also reported in the results of the NVS II and the British Diet and Nutrition Survey [65,122]. It is remaining unclear whether this fact can be attributed to an increasing health consciousness in older study participants. Our results are not confirming the trend of increased fruit intake seen in the NVS 2006 compared to the BGS (men 180g/d in BGS vs. 230 g/d in NVS II vs. 109 g/d in LUPS; women: 206 g/d in BGS vs. 278 g/d in NVS II vs. 151 g/d in LUPS). However, a higher consumption of fruits in men and women at higher age reported in the NVS II could also be seen in our results. The overall higher consumption of fruits and vegetables in women shown in our study described typical dietary patterns for men and women which were also observed in previous nutrition surveys in Germany and Great Britain [65,66,122]. In other European countries the intake of fruits and vegetables varies among men and women [123]. Several studies have documented beneficial effects of an adequate fruit and vegetable consumption on obesity, hypertension, the MetS, cardiovascular and coronary heart disease, diabetes and cancer [77,124-128]. Despite these benefits, people (also in other countries) [129,130], evidently have difficulties to follow the recommendations. Many factors like age, sex, socioeconomic status, health behaviour and health

awareness contribute to the fruit and vegetables intake [123,131]. Our present study shows that women at higher age consumed more fruits and vegetables than younger men and women. Therefore women of higher age are supposed to have higher intakes of fibres, vitamins, minerals and micronutrients like plant sterols, which are thought to be beneficial for their health condition.

To compare our results based on fat intake to the results of the NVS II we classified butter and margarine as spreadable fats. The daily intake reported by our cohort was below the recommended limits and the consumption within the NVS II (men: 29 g/d in NVS II vs. 8 g/d in LUPS; women 20 g/d in NVS II vs. 5.7 g/d in LUPS). Thereby, in both genders the intake of margarine was slightly higher than the intake of butter. Regarding to the fact that fats are used for the preparation of meals (roasting, for sauces, vegetable tossed in butter etc.) this was not explicitly assessed within the present study, spreadable fat was only evaluated for the use on bread and rolls. The relatively low reported intake of spreadable fat is in accordance with the low bread consumption in the cohort. Assuming that one teaspoon of spreadable fat (=5g) is commonly estimated for one slice of bread, women consumed 1 slice of bread and men 1 ½ slice of bread which reflects the reported consumption for bread and rolls of our study participants. The low reported amount of spreadable fats may be attributable to difficulties in estimating the realistic portion size or having forgotten to report the consumption of these fats. The use of oils for preparing dishes in our cohort could not be compared to the NVS II since this was not evaluated in the national nutrition survey of 2006. To receive more information about oils which were used for cooking or preparing dishes we asked the study participants to report the kind of oil used on a regular basis. The highly preferred oils, in particular olive oil, rapeseed oil and sunflower oil do have a fatty acid pattern which might positively influence serum lipids and lipoproteins providing beneficial unsaturated fatty acids, particularly MUFAs [69,70]. The higher intakes of oils observed in women may be due to the circumstance that women usually are more frequently preparing dishes and possibly have a higher awareness of the favourably oils.

In comparison with the national nutrition surveys the consumption of milk, dairy products and cheese in our cohort was lower (men: 223 g/d in BGS vs. 265 g/d in NVS II vs. 164 g/d in LUPS; women: 225 g/d in BGS vs. 244 g/d in NVS II vs. 173 g/d in LUPS). Male and female study participants of our cohort only reached an intake of 60 – 70% of that assessed in the NVS II. Dairy products provide several nutrients and as whole-fat variations possibly undesirable quantities of SFA and trans FA. Despite the fact that recent publications found no negative associations of dairy products with cardiovascular disease [131] most studies reported detrimental effects of their saturated fatty acid content with atherosclerosis and therefore it is recommended to prefer more low-fat dairy products [133,134]. Our results did show that women preferably consume more low-fat dairy products than men. Accordingly the consumption of whole-fat cheese did not differ between men and women.

Both genders of the LUPS cohort reported a higher consumption of meat, meat products and sausages than recommended by the German Society of Nutrition. This was shown in the BGS and the NVS II and also confirmed by the data presented here (men: 201 g/d in BGS vs. 160 g/d in NVS II vs.168 g/d in LUPS; women: 126 g/d in BGS vs. 84 g/d in NVS II vs. 106 g/d in LUPS). The consumption of meat was remarkable decreased between the BGS in 1998 and the NVS II 2006 [65,66]. Researcher presumed this decrease resulting from recent food scandals within 2005 to 2006 and as a result of increasing prices for meat and meat products [135]. Compared to the data of the NVS II our results showed on average a raise by 20g per day in women whereas in men the intake remained mostly constant. However, overall male study participants consumed meat and meat products twice as much as recommended. The amount of low-fat white meat as percentage of total meat consumption was 67% in men and 59% in women. Because of high portions of total fat, especially SFA and cholesterol contained in meat and meat products diets rich in these products may be associated with weight gain, an increasing LDL cholesterol, insulin resistance and detrimental glucose tolerance [132,136,137], and therefore with an increased risk for cardiovascular disease, coronary heart disease and stroke. Regarding to the intake of SFA and trans FA it has to be considered that not only red and processed meat but also whole-fat dairy products, eggs, spreadable fats, fast food and sweets deliver these kinds of fats.

The reported consumption of eggs in our cohort was within the recommendation of 1 – 2 eggs a week. The consumption of eggs was lower in our study participants than assessed in the NVS 2006 (men: 21 g/d in NVS II vs. 16.3 g/d in LUPS; women: 16 g/d in NVS II vs. 13.6 g/d in LUPS). While the consumption of milk and dairy products, spreadable fats and eggs were within the recommendations, the food groups of meat and meat products, sweets and particularly fast foods may belong to the food group which particularly leads to undesirable high total fat, SFA and trans-FA intake.

The positive change to a higher consumption of fish observed within the NVS II compared with the BGS was also seen in our study. Both, men and women met the recommendation of 1 - 2 portions or 150 – 200g fish a week and were in a similar intake range to the consumption assessed within the NVS 2006 (men: 21 g/d in BGS vs. 29 g/d in NVS II vs. 27 g/d in LUPS; women: 17 g/d in BGS vs. 23 g/d in NVS II vs. 25 g/d in LUPS). Similar to the data of the national nutrition survey, the higher intake of fish at higher age was confirmed by the results of our study participants. Because of the supposed beneficial effects of oily fish on lipid patterns we asked the study participants to specify the kind of fish preferably consumed [15,86]. The majority of males consumed low-fat fish like pollack and tuna and only 10 – 30% consumed oily fish like herring or mackerel. Female study participants consumed primarily low-fat fish and only 9 -18% reported the consumption of oily fish. However, at higher age male and female study participants were more likely to consume oily fish. Eventually, older

individuals tried to increase their intake of biological high-grade and easily digestible protein as well as their intake of n-3 FA and preferred fish in exchange for meat. The observed higher intake of fish in participants from Hamburg of the NVS II compared to the entire NVS II cohort (men: 34 g/d in NVS II for Hamburg vs. 29 g/d in NVS II vs. 27 g/d in LUPS; women: 31 g/d in NVS II for Hamburg vs. 23 g/d in NVS II vs. 25 g/d in LUPS) could not be confirmed within our data.

Soups and stews are typical traditional and popular foods in Germany. In contrast to the results of the national nutrition survey the intake of soups and stews was considerably lower in both, male and female study participants. For soups we did not observe a larger consumption with higher age, but the consumption of stews was larger at higher age, in both genders.

The reported intake of sweets in our cohort was similar to intakes at the BGS and the NVS II (men: 50 g/d in BGS vs. 55 g/d in NVS II vs. 46 g/d in LUPS; women: 41 g/d in BGS vs. 48 g/d in NVS II vs. 48 g/d in LUPS). The intakes of men and women corresponded to the intake of half a chocolate bar, one piece of cake or one scoop of ice cream and therefore conformed to the recommendation not to exceed 1 portion energy-dense food like sweets a day. In general, the intake of sweets was lower with increasing age comparable to the data of the NVS II. However, the intake of sweet spreads was higher and the intake of chocolate lower at higher age, which was also seen in the NVS II [65]. This could be due to a more traditional breakfast in older individuals with the use of jam and honey on bread or rolls.

Salty snacks were classified to the group of energy-dense foods, because of their high fat and salt content. This food group included potato chips, peanut puffs, salted nuts, popcorn and other salty snacks. The assessed amount of salty snacks within the cohort was nearly 6 - 10times higher than in the national nutrition survey 2006 (men: 8g/d in NVS II vs. 48 g/d in LUPS; women: 5 g/d in NVS II vs. 48 g/d in LUPS). The majority (> 90%) of the salty snacks were reported via the individual filled out questions of the FFQ85. Summarizing the food groups of salty snacks and sweets to a group of energy-dense foods the consumption was twice as much as recommended. The large amount of energy, fat and sugar provided by this food group can be hazardous. Regarding to positive associations like the risk of obesity, raised triglycerides, increased BMI, MetS, CVD and all-cause mortality the consumption of this food group should be reduced [13,18,20-23,85,89].

An intake of more than 1.5 L of energy-free beverages for male and female study participants per day is recommended. Intakes of at minimum 1.5 L energy-free beverages were reported within all age groups. Similar to the results from the NVS II water, coffee and tea provided the greatest quantities of the total beverage consumption. Intakes of fruit and vegetable juices were similar to the quantities assessed within the NVS II, however our female study participants reported a higher fruit juice consumption than in the NVS II (232 ml/d in NVS II vs. 275 ml/d in LUPS). According to the German Society of Nutrition one cup (about 200 ml) of fruit juice a day is acceptable. The intake of soft drinks

reported by female study participants was lower than in male study participants. Regarding to total amount of consumed soft drinks in the actual cohort, females preferably consumed light soft drinks compared to males (67% vs. 43%). A higher intake of energy-free beverages and a lower intake of high-energy beverages and fruit juice go in line with the recommendations of several nutrition societies. High-energy beverages (only consumed by 3 – 7% of the study participants), especially so called sugar-sweetened beverages may promote a high intake of non-saturating calories thereby increasing the risk of obesity and the MetS, in particular children and adolescents [19,87-89].

Compared to data of the BGS 1998 and NVS 2006 the LUPS cohort reported less intake of alcoholic drinks (men: 346 ml/d in BGS vs. 308 ml/d in NVS II vs. 134 ml/d in LUPS; women: 76 ml/d in BGS vs. 81 ml/d in NVS II vs. 52 ml/d in LUPS). However we can confirm typical gender specific drinking patterns like a four-time higher consumption of beer in male study participants. Beer was the most common alcoholic beverage in men (81%), whereas women reported an almost half and half alcohol intake of beer (48%) and wine (50%). The reported quantities of spirits were low in both genders. One reason for this remarkable difference of the overall reported alcohol intake in particular male study participants of the BGS and NVS II compared to male individuals of our study might be found in different methods of reporting. Participants may have had difficulties to assign their individual consumption quantities to the mentioned portion size and therefore may have underestimated their intake. Due to the fact that the examination took place on site the study participants might have been extremely cautious to report their real alcohol intake, in face of medical confidentiality.

In summary, reported dietary patterns among individuals of the NVS II and of our study are quite similar to many aspects. Comparing the patterns assessed via LUPS and NVS II for male individuals, differences can be seen at most in the consumption of meat and meat products. The five mostly consumed food groups in men of the NVS II were carbohydrate rich foods, milk and milk products, fruits, vegetables and meat and meat products, whereas the ranking in our study was carbohydrate rich foods, meat and meat products, milk, vegetables and fruits. The lower intake of meat and meat products within the NVS II was supposed by the investigators to some food scandals within the assessment interval of the NVS II between years 2005 – 2006 [65].

The five mostly consumed food groups for females within the NVS II were carbohydrate rich foods, fruits, milk, vegetables and meat and meat products, whereas female study participants of the LUPS cohort showed the following ranking of food consumption carbohydrate rich foods, vegetables, milk, fruits, meat and meat products. The results reported in our study show a typical different dietary pattern for men and women. The higher consumption of meat and meat products reported in the LUPS cohort compared to the NVS cohort could be attributed to food scandals but also to some characteristics of the study population like educational and socioeconomic status. The different intake of fruits and vegetables may also be due to seasonal differences within the dietary assessment

intervals between the LUPS and the NVS II cohort. Intake patterns may also represent individual health consciousness and the intention to limit calorie intake, especially in female study participants. Over-reporting of healthy food like fruits and vegetables is going in line with a higher social desirability and is profound to avoid [105].

5.1.4. Intake of supplements, sweeteners and dietetic food

Vitamin and mineral supplements are commonly used in Germany. The NVS survey has shown that 31% of men and 24% of women regularly use vitamin or mineral supplements [65]. In the LUPS cohort 25% of men and 33% of women reported to take mineral supplements, 13% of men and 16% of women reported the use of vitamin supplements and 10% of men and 13% of women the use of poly supplements. Compared to NVS II data we found that women were more likely to use supplements, going almost in line with other studies [138-145]. Cross-sectional studies have suggested that increased age is associated with supplement use [138-144]. Our study suggests that females aged 51-60 years were more likely to use mineral and vitamin supplements compared to the other age groups. In contrast, for male individuals no association with higher age was observed. One reason for less supplement use in male study participants might be a less educational level of the majority of the mainly manual workers in the study and therefore less likely to use supplements compared to results of other studies [138-144,147]. Some studies demonstrated an inverse association between supplement use and BMI and alcohol intake and a positive association between physical activity and supplement use [138,140,146,147]. In our cohort we measured a higher BMI (27 kg/m² vs. 25 kg/m²) and higher alcohol intakes (7 g/d vs. 4 g/d) in men compared to women and therefore we could assume that men were more likely to use less supplements. In addition, our female participants reported to be more physical active than males, assuming a higher health consciousness accompanied by a higher use of supplements. In terms of smoking, the literature shows inconsistent associations to supplement use [138,140,146-149]. Several studies suggest that the consumption of supplements is more frequently in former and never smokers. For males and females of our study no clear associations for smoking and supplement use could be seen. Li et al. reported that regular supplement users consumed more fruits, fish, vegetables and dairy products and less total meat [139,147,150,151] than non-users. This could be confirmed by results of females of our cohort who reported higher intakes of fruits, vegetables, dairy products and less meat, suggesting that supplement users, in particular female individuals, seem to have healthier dietary patterns than non-supplement users like men.

Artificial sweeteners (non-nutritive sweeteners) were regularly consumed by a certain percentage of our cohort. Whereas 15% of the US population uses artificial sweeteners, 16% of male and 21% of female study participants of the LUPS cohort reported to use sweeteners [152]. Commonly used artificial sweeteners were cyclamate, aspartame, acesulfame-K, neotame, saccharin, sucralose and

stevia. The taste of sweetness is 30 up to 8000 times higher in artificial sweeteners than is in sugar. Women sometimes are more likely to consume energy-balanced diets and thereby use artificial sweeteners. Further research has to be done in particular randomized clinical trials to better understand currently discussed potential side effects of artificial sweeteners like influencing the body weight, appetite and energy balance [152-154].

An energy-balanced diet, especially the use of low-fat dairy products and low-fat meat and sausages is recommended by all nutrition guidelines as part of a healthy lifestyle and to positively influence the incidence and course of diseases like hypertension, the MetS, diabetes and arteriosclerotic complications [12,14,62-64]. According to the higher consumption of low caloric food in female participants we do suppose women are compared to men more likely to be health conscious.

The interpretation of the above mentioned research results needs to implicate some limitations of our study. At present we report only age-adjusted values of male and female study participants for the nutritional intake, but did not control yet for presumed confounders like body mass index, education status or other lifestyle features [106,107,155,156]. We are not supposed to generalize our findings to the total German population, since our cohort included solely individuals, predominantly male, who are employed by the Lufthansa Technik in Hamburg, Germany. However, we have recruited participants from all departments, e.g. technicians, pilots and financial managers of the company, representing a broad range of dietary habits from working individuals.

6. Concluding Remarks

This study investigated self-administered dietary patterns of a healthy worker cohort, employed at a German company, aged between 25-60 years. The analyses based on nutritional and clinical data assessed in the Lipid and Glucose under Prospective Surveillance Study (LUPS), in which 1.962 healthy employees of the Lufthansa Technik GmbH Hamburg were enrolled to determine risk parameters of the metabolic syndrome and their components. Moreover, the relation of this prevalence for the predisposition to develop early changes in lipid and glucose metabolism should be investigated.

The results obtained in this study are raw data from the baseline examination, adjusted for age and stratified for gender. Adjustment of nutritional intake to several potential confounders influencing diet-disease relations will be done [81,107,138], however this first descriptive examination primarily shows nutritional intake and dietary patterns without examining associations to potential confounders like smoking or physical activity.

The present study showed a significantly higher carbohydrate and dietary fibre intake in women than in men and a significantly higher dietary fibre intake with increasing age. The intake of protein was in line with the recommended range of 10 – 20% of total energy intake and showed a higher intake in women and a lower intake in men at higher age. Except for monounsaturated fatty acids, the intakes of fatty acids did not meet the recommendations of the German Society of Nutrition. Compared to the youngest age group in men and women the intake of total fat and monounsaturated fatty acids were lower in men and higher in women at the higher age group. The intakes of dietary cholesterol, alcohol and salt on average were in the recommended ranges.

In men and women the daily consumption of carbohydrate rich foods, vegetables, milk and dairy products, fats and fruits were below the recommendations. Daily intakes of non-alcoholic and alcoholic beverages, fish and eggs met the recommendations for men and women, whereas the consumption of meat and meat products and energy-dense foods (sweets and salty snacks) exceeded the recommended amounts, particularly in men. It has been reported in the literature that some foods and nutrients were associated with the prevalence of the metabolic syndrome or its components [17-19,67,76,87,120,121]. Overall, a “healthy” dietary pattern which includes whole grains, fibre, fruits, vegetables, legumes, fish, poultry, nuts, seeds, and oil compared to a “Western” dietary pattern which is characterized by meat, meat products, whole-fat dairy products, sweets, baked goods, fast food, French fries and soft drinks was associated with a lower incidence and prevalence of the metabolic syndrome, its components and secondary diseases [13,15,20-23,87,98]. In our study female participants, primarily women of higher age preferred greater amounts and more

frequently foods contributing to a “healthy” dietary pattern compared to men. Although men do not reach the degree of a healthy dietary pattern assessed for women the consumption of less desirable foods like meat, meat products, fast food, French fries and soft drinks was decreased and the intake of fruits and vegetables was increased with higher age. Evidently there was a raising awareness for a more desirable dietary pattern, particularly among women of higher age. The following recommendations, which are similar to the actual Guidelines of the Nutrition Associations [11,12,62-64] based on the reported food and food group intakes of our cohort could be taken:

1. Increase vegetable and fruit intake
2. Increase whole grain intake by replacing refined grains with wholemeal variations
3. Reduce intake of animal products as meat and meat products
4. Replace whole-fat products by low-fat variations, especially in meat and dairy products
5. Reduce intake of sugar sweetened beverages
6. Use oils to replace solid fats, if possible
7. Reduce intake of fast food

As the increasing prevalence of nutrition-depending diseases like obesity, hypertension, dyslipidaemia, the MetS, T2D and CVD increases burden to the affected population and raises the costs for the health system, more focus should be given to the awareness for a healthy diet starting at young age with special advice to male individuals. Individuals with metabolic disorders should receive professional nutritional advice and learn to shift their usual dietary pattern to healthier alternatives.

Prospectively, associations between the reported nutritional intakes and risk factors of the metabolic syndrome should be examined. Thereby, effects of possible confounders, which are also assumed to influence the incidence and prevalence of the MetS, should be calculated. Furthermore, prospective examinations of the nutritional intake of our cohort should be assessed to investigate longitudinal changes of the dietary habits.

7. Summary

Background: The rising prevalence of the metabolic syndrome implicates a high risk of developing diabetes mellitus type 2, cardiovascular disease and all-cause mortality. In healthy individuals and people at risk, modifications of lifestyle mainly based on nutritional recommendations are the most effective interventions in preventing or treating metabolic disturbances and its secondary diseases. Therefore, actual information on dietary habits, particularly of individuals at increased risk for developing the MetS is needed to plan prevention programs or providing individual nutritional advice.

Objectives: Aim of this study was to describe the habitual nutritional intake and dietary patterns of 1.887 employees of a German company enrolled in the Lipid and Glucose under Prospective Surveillance (LUPS) study. Reported energy, nutrient and food intake in female and male individuals and different age groups were assessed in a baseline cross-sectional analysis using a standardized semi-quantitative food frequency questionnaire. Furthermore reported nutritional intakes are compared to current nutritional recommendations for the general population to prevent metabolic disorders.

Methods: The LUPS project was established to assess putative risk factors of the MetS in healthy individuals and to examine relations between these risk factors and early disturbances in the lipid and glucose metabolism. Of the 1.962 individuals aged 25 – 60 years recruited between November 2008 and June 2010 and 75 individuals were excluded from the analysis because of either having already the diagnosis of diabetes or due to missing data. Overall, 1.274 male and 613 female study participants were included in the nutritional analysis. The mean age of the female and male study participants was 42 $\pm$ 9 years. Prior to the baseline examination visit all study participants had to fill in a comprehensive dietary questionnaire, NARI (nutritional intake in risk groups) [90]. Nutritional intake was assessed from a standardized 85-item self-administered semi-quantitative food frequency questionnaire (FFQ85) and 17 additional questions asking for the use of supplements and dietetic foods as well as for details on foods which may specifically influence the lipid and glucose metabolism. All questionnaires were checked for completeness and plausibility by trained nutritionists. Energy and nutrient intakes (g/d and % of total energy intake) were calculated, based on the reported frequency of food intakes multiplied with the recorded portion sizes small, medium, large using predefined food codes based on the Bundeslebensmittelschlüssel (BLS) [91] and the computer software program PRODI® [92].

Age adjusted mean daily energy and nutrient intakes with 95% CI were calculated stratified by gender. In men and women the consumption was compared between 3 age groups to examine potential differences between age groups. The patterns of food and food group intakes in men and women (daily amounts and the frequency of intake) were also assessed in 3 groups (Age: 5^{th} Percentile, Median, 95^{th} Percentile). To describe the habitual use of supplements, artificial sweeteners, sugar substitutes, dietetic foods and low-calorie foods the proportion of male and female users was calculated. No adjustment was made for potential confounders such as BMI, smoking habits, socioeconomic status or physical activity.

Results: Compared to females male study participants reported significantly higher intakes of unfavourable food like refined grains, baked goods, fast food, meat and meat products and lower intakes of more desirable food like fruits, vegetables, oils, low-fat dairy products and energy-free beverages. They reported higher intakes of total fat, saturated fatty acids and dietary cholesterol and lower intakes of dietary fibre and carbohydrates. In the highest age group the consumption of meat, eggs, chocolate, whole-fat milk products, salty snacks, fast food, sugar, French fries, refined grain products, hot chocolate, fruit juice and sugar sweetened beverages was at the lowest and the consumption of fish, fruits, cooked and raw vegetables, nuts and seeds, wholemeal bread and rolls and tea was at highest levels compared to the youngest age group. Typical traditional foods in Germany like potatoes, stews, jam and honey and coffee were more often consumed by individuals in the oldest age group. Women at higher age were more likely to consume oils compared to younger women. Particularly in men, reported intakes of total fat, saturated fat, monounsaturated fat and dietary cholesterol were lower and the intake of dietary fibre and carbohydrates were higher at older age. For women, except for monounsaturated fatty acids which were consumed to larger amounts in the elderly, only small differences were observed between the age groups. Overall reported use of dietary supplements (mineral and poly), artificial sweeteners, sugar substitutes, dietetic foods and low-calorie foods was higher in women than in men. Thereby, dietary supplements were more likely consumed at higher age, especially in female study participants.

Conclusions: The study shows the first examination of nutritional intake and dietary patterns in a healthy worker cohort assessed by a food frequency questionnaire. Significant differences of energy, nutrient and food intakes between men and women were assessed with a more favourable pattern for women. Further, a higher consumption of more desirable food in the elderly was reported. In future studies, early nutrient-related changes of lipid and glucose metabolism and associations between nutritional intake and/ or dietary patterns and the risk to develop the MetS should be investigated.

7. Zusammenfassung

Hintergrund: Die stetig steigende Prävalenz des Metabolischen Syndroms geht mit einem erhöhten Risiko für Diabetes mellitus Typ 2 und kardiovaskulären Krankheiten einher, was die Gesamtmortalität erhöhen kann. Sowohl für gesunde Menschen, als auch für Personen mit einem erhöhten Risiko, ist eine Veränderung des Lebensstils v.a. eine Umstellung der Ernährungsgewohnheiten basierend auf den Ernährungsempfehlungen der Fachgesellschaften, die effektivste Methode, Stoffwechselstörungen und deren Begleiterkrankungen vorzubeugen und therapeutisch zu unterstützen. Um zielgruppenorientierte Präventionsmaßnahmen zu planen oder um Patienten eine individuelle Ernährungsberatung zu ermöglichen, müssen jedoch zunächst genaue Informationen über die Ernährungsgewohnheiten der Bevölkerung bekannt sein.

Ziele: Ziel dieser Studie war es, die reguläre Nahrungsaufnahme und die Ernährungsmuster von 1.887 Mitarbeitern einer deutschen Firma, die in die *Lipid and Glucose under Prospective Surveillance (LUPS)* Studie eingeschlossen wurden, zu beschreiben. Dies erfolgte mit Hilfe eines standardisierten semiquantitativen Verzehrshäufigkeitenfragebogens. Die Energie- und Nährstoffaufnahme sowie die Lebensmittelverzehrsmengen wurden mit Hilfe der ermittelten Basisdaten getrennt für Männer und Frauen sowie für verschiedene Altersgruppen erfasst und analysiert. Außerdem wurde die erhobene Nahrungsaufnahme der männlichen und weiblichen Studienteilnehmer mit den Ernährungsempfehlungen der Allgemeinbevölkerung zur Prävention ernährungsmitbedingter Krankheiten verglichen.

Methodik: Die LUPS Studie wurde durchgeführt, um potentielle Risikofaktoren des Metabolischen Syndroms in der Bevölkerung zu identifizieren und um Zusammenhänge zwischen diesen Risikofaktoren und frühen Veränderungen im Fett- und Glukosestoffwechsel ausfindig zu machen. Zwischen November 2008 und Juni 2010, wurden 1.962 Studienteilnehmer im Alter zwischen 25 und 60 Jahren rekrutiert. Von diesen wurden 1.274 männliche und 613 weibliche Teilnehmer in die Auswertungen der Nahrungsaufnahme eingeschlossen. Die verbleibenden 75 Teilnehmer wurden auf Grund eines bereits bekannten Diabetes mellitus Typ 2 oder fehlender Werte im Verzehrshäufigkeitenfragebogen von der Berechnung ausgeschlossen. Das mittlere Alter der Studienteilnehmer lag bei 42 $\pm$ 9 Jahre. Vor Ihrer Basisuntersuchung mussten alle Probanden einen umfangreichen Verzehrshäufigkeitenfragebogen, NARI (*Nutritional intake in risk groups)* ausfüllen [90]. Der Fragebogen umfasst 85 Fragen (FFQ85) zur Häufigkeit des Verzehrs und Portionsgrößen von Lebensmitteln und Lebensmittelgruppen, die jeder Proband selbstständig ausfüllen muss. Weitere 17 Fragen wurden dazu verwendet, die Einnahme von Nahrungsergänzungsmitteln, diätetischen

Lebensmitteln, Süßstoffen und weiteren speziellen Lebensmitteln, die möglicherweise Einfluss auf den Fett- und Glukosestoffwechsel haben, zu erfassen. Nach Abgabe wurde jeder Fragebogen von geschulten Ernährungswissenschaftlern auf Vollständigkeit und Plausibilität überprüft. Basierend auf der angegebenen Portionsgröße und Verzehrshäufigkeit wurden mit Hilfe vordefinierter Lebensmittelcodes, welche aus dem Bundeslebensmittelschlüssel (BLS) [91] abgeleitet wurden und der Ernährungssoftware PRODI® [92], die aufgenommenen Energie und Nährstoffwerte berechnet.
Die Auswertung der vorliegenden Daten erfolgte adjustiert für das mittlere Alter der männlichen und weiblichen Studienteilnehmer. Die täglichen Energie- und Nährstoffaufnahmen (g/d und als % der Gesamtenergiezufuhr) wurden als arithmetisches Mittel mit den 95% Konfidenzintervallen getrennt für Männer und Frauen berechnet. Um Unterschiede der Nahrungsaufnahme in den verschiedenen Altersgruppen zu erkennen, wurde diese jeweils für Männer und Frauen getrennt für 3 Altersgruppen berechnet. Die Beschreibung des Verzehrs der einzelnen Lebensmittel sowie der Lebensmittelgruppen erfolgte durch Berechnung der täglichen Verzehrsmengen sowie der Verzehrshäufigkeit. Diese Verzehrsmengen wurden ebenfalls getrennt für Männer und Frauen und für 3 Altersgruppen beschrieben (Altersgruppen: 5th Perzentile, Median, 95th Perzentile). Die tägliche Einnahme bzw. das Nutzen von Nahrungsergänzungsmitteln, Süßstoffen, Zuckeraustauschstoffen, diätetischen Lebensmitteln, „light“ Produkten und Lebensmittel, die möglicherweise den Fett- und Glukosestoffwechsel beeinflussen, wurde als Anteil (n%) der Nutzer zu den Nichtnutzern getrennt für Männer und Frauen beschrieben.

Ergebnisse: Insgesamt verzehrten Männer im Vergleich zu Frauen signifikant größere Mengen „ungesunder“ Lebensmittel wie z.B. Weißmehlprodukte, Backwaren, „Fast Food“, Fleisch und Wurstwaren und geringere Mengen an protektiven Lebensmittel wie Obst, Gemüse, pflanzlichen Ölen, fettarmen Milchprodukten und energiefreien Getränken. Dementsprechend hatten Männern, auch nach Adjustierung für die Gesamtenergieaufnahme, eine höhere Aufnahme von Gesamtfett, gesättigten Fettsäuren und Cholesterin und eine geringere Aufnahme von Kohlenhydraten und Ballaststoffen. Männer und Frauen in den höheren Altersklassen verzehrten geringe Mengen an Fleisch, Eiern, Schokolade, fettreichen Milchprodukten, salzigen Knabbereien, „Fast Food“, Zucker, Pommes, Weißmehlprodukten, heißer Schokolade, Saft und zuckergesüßten Getränken, während die verzehrte Menge protektiver Lebensmittel wie Fisch, Obst, Gemüse, Nüsse, Samen, Vollkornprodukte und Tee bei den älteren Teilnehmern erhöht war. Außerdem war der Verzehr traditioneller deutscher Lebensmittel wie von Kartoffeln, Eintöpfen, Marmeladen und Honig sowie von Kaffee in den höheren Altersklassen höher. Für Frauen in den höheren Altersklassen wurde außerdem ein höherer Ölverzehr berichtet als für jene in den jüngeren Altersklassen. Diese Unterschiede der Nahrungsaufnahme spiegelten sich auch in einem unterschiedlichen Nährstoffprofil wider. So war bei

den Männern in den höheren Altersklassen die Gesamtfettaufnahme, die Aufnahme gesättigter Fettsäuren, einfachungesättigter Fettsäuren und Cholesterin geringer, während die Aufnahme von Kohlenhydraten und Ballaststoffen im Vergleich zu den jüngeren Teilnehmern höher war. Ausgenommen für einfachungesättigte Fettsäuren, die in den höheren Altersklassen erhöht waren, unterschied sich die Nährstoffaufnahme der Frauen kaum zwischen den drei Altersgruppen. Für die Einnahme von Nahrungsergänzungsmitteln, Süßstoffen, Zuckeraustauschstoffen, diätetischen Lebensmitteln und „light“ Produkten zeigte sich eine häufigere Nutzung bei den Frauen als bei den Männern. Dabei war die Einnahme von vor allem Mineralstoffsupplementen und Mischpräparaten bei älteren Studienteilnehmerinnen häufiger als bei den Jüngeren.

Schlussfolgerungen: Diese erste Untersuchung bildet die Nährstoffaufnahme und den Lebensmittelverzehr, erfasst mit einem Verzehrshäufigkeitenfragebogen, einer gesunden Kohorte ab. Für die Energie- und Nährstoffaufnahme sowie den Lebensmittelverzehr wurden signifikante Unterschiede zwischen Männern und Frauen sowie zwischen den Altersgruppen festgestellt. Dabei wiesen Frauen ein günstigeres Ernährungsmuster auf als Männer und ältere Studienteilnehmer verzehrten einen höheren Anteil protektiver Lebensmittel als jüngere. Weitere Untersuchungen, die im zeitlichen Verlauf mögliche Beziehungen zwischen der Lebensmittel- und Nährstoffaufnahme und frühen Veränderungen im Fett- und Glukosestoffwechsel sowie der Entwicklung des Metabolischen Syndroms zeigen, sollten folgen.

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9. List of tables

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11. Curriculum Vitae

Name	Frisch, Annett
Date of birth	February 12th 1982
Place of birth	Halle/ Saale
Citizenship	German

Education

1988 – 1992	Primary School, Halle/ Saale
1992 – 2000	Grammar School, Halle/ Saale
June 2000	Graduate of Grammar School
2000 – 2003	Training to chemical laboratory assistant, Halle/Saale
June 2003	Graduation as Chemical laboratory assistant
2003 – 2008	Study of Nutrition sciences, University of Halle-Wittenberg
December 2008	Graduation as Nutritionist (Diploma)

Research

Since 2009	PhD thesis, Institute of diabetic and health services research, Asklepios proresearch in Hamburg Analysis of nutritional patterns in individuals at risk for the development of the metabolic syndrome assessed by a food frequency questionnaire

Halle/Saale,

12. Eidesstattliche Erklärung

Hiermit versichere ich an Eides Statt, dass ich die vorliegende Arbeit „Analysis of nutritional patterns in individuals at risk for the development of the metabolic syndrome assessed by a food frequency questionnaire“ selbstständig und ohne fremde Hilfe verfasst habe. Es wurden keine anderen als die in der Arbeit angegebenen Quellen und Hilfsmittel benutzt. Die den benutzten Werken wörtlich oder inhaltlich entnommenen Stellen sind als solche kenntlich gemacht. Weiterhin erkläre ich, dass ich noch keine vergeblichen Promotionsversuche unternommen habe und die vorliegende Dissertation nicht in der gegenwärtigen bzw. in einer anderen Fassung bereits einer anderen Fakultät / anderen wissenschaftlichen Einrichtungen vorgelegt habe.

Des Weiteren erkläre ich, dass ich keine bestehenden Vorstrafen habe und gegen mich keine anhängigen Ermittlungsverfahren laufen.

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