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Relationship between diet, lifestyle and cardiovascular disease risk
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Contents

ACKNOWLEDGEMENTS.....	II
CONTENTS.....	III
LIST OF FIGURES.....	VI
LIST OF TABLES.....	VII
LIST OF ABBREVIATIONS.....	VIII
1 INTRODUCTION	1
2 LITERATURE REVIEW	3
2.1 Diet related databases in European countries	3
2.1.1 Food supply data of the Food and Agriculture Organization of the United Nations (FAO)	4
2.1.1.1 Trends in dietary habits	5
2.1.2 Food availability of the DAta Food NEtworking (DAFNE)-Initiative	6
2.1.2.1 Dietary patterns among European countries	8
2.1.2.2 Trends in food habits	8
2.1.3 Individual dietary surveys	9
2.2 Cardiovascular diseases (CVD)	11
2.2.1 General information	11
2.2.2 Pathogenesis of atherosclerosis	12
2.2.3 Coronary heart diseases.....	14
2.2.3.1 Angina pectoris.....	15
2.2.3.2 Myocardial infarction.....	15
2.2.3.3 Cardiac insufficiency.....	16
2.2.3.4 Cardiac arrhythmia	16
2.2.4 Cerebrovascular diseases	16
2.2.4.1 Stroke	17
2.2.5 Cardiovascular mortality in Europe	17
2.2.5.1 Trends in cardiovascular mortality	19

2.2.6 Cardiovascular morbidity	21
2.2.7 Costs of cardiovascular diseases	22
2.3 Relationship of CVD with dietary patterns.....	23
2.3.1 Cardiovascular risk factors	23
2.3.2 Food related cardiovascular risk factors	26
2.3.2.1 Lipids.....	27
2.3.2.2 Fruit and vegetables.....	40
2.4 Relationship of CVD with socioeconomic status	41
2.4.1 Human Development Index (HDI).....	42
2.5 Relationship of CVD with lifestyle factors	42
2.5.1 Smoking	42
2.5.2 Physical activity	45
2.5.3 Overweight and obesity	46
3 METHODS AND MATERIAL	49
3.1 Dietary pattern information	49
3.2 Mortality information	51
3.3 Statistical analysis	52
4 RESULTS.....	54
4.1 Analysis of European dietary patterns.....	54
4.1.1 Comparison of dietary patterns in European countries.....	54
4.1.2 Trends of dietary patterns in European countries	59
4.2 Lifestyle patterns	62
4.2.1 Smoking	62
4.2.2 Physical activity	64
4.2.3 Overweight and obesity	65

4.3	Analysis of European Cardiovascular Mortality	67
4.3.1	Cardiovascular Diseases Mortality statistics	67
4.3.2	Gender differences in CVD	69
4.3.3	Trends in cardiovascular mortality	69
4.4	Relationship between dietary patterns and CVD in Europe	72
4.5	Relationship between socioeconomic status and CVD in Europe...	75
5	DISCUSSION	77
6	CONCLUSION.....	85
7	SUMMARY	88
8	ZUSAMMENFASSUNG.....	89
9	REFERENCES	91
10	CURRICULUM VITAE	113

List of figures

Figure 1: Death by cause in Europe, men, latest available year	18
Figure 2: Death by cause in Europe, women, latest available year	18
Figure 3: DAFNE food classification system of added lipids	50
Figure 4: Share of calories from lipids in dietary energy supply in 2003	55
Figure 5: Mean availability of added lipids in European country, latest available year.....	56
Figure 6: Mean availability of fruits in European countries, latest available year	57
Figure 7: Mean availability of vegetables in European countries, latest available year.....	58
Figure 8: Trends in animal fat supply in selected European countries 1961-2003	60
Figure 9: Trends in fruits supply in selected European countries 1961-2003....	61
Figure 10: Trends in vegetable supply, selected European countries 1961-2003	62
Figure 11: Percentage of regular daily smokers in Europe aged 15+, latest available year	63
Figure 12: Average number of days of moderate physical activity by country during the last week.....	65
Figure 13: Percentage of overweight and obese people in relation to the total population by country, all ages	66
Figure 14: Age-standardized death rates of cardiovascular diseases per 100 000 by country, 2004	68
Figure 15: Evolution of cardiovascular mortality of selected European countries between 1970 and latest available year.....	72
Figure 16: Association between added lipids from animal origin and age- standardized cardiovascular mortality rates per 100 000, latest available year.....	74
Figure 17: Relationship between age-standardized cardiovascular mortality and Human Development Index in 2005.....	76

List of tables

Table 1: Sources of nutritional data	3
Table 2: ICD-10 classification of cardiovascular diseases	12
Table 3: Risk factors for coronary heart diseases	24
Table 4: Theories for an earlier development of cardiovascular diseases in men	25
Table 5: Strength of evidence on lifestyle factors and risk of developing cardiovascular diseases.....	27
Table 6: Dietary strategies for cardiovascular disease prevention	29
Table 7: Nutrient guidelines for the prevention of cardiovascular diseases	29
Table 8: Evidence of a link between fat consumption and the primary prevention of CHD and stroke	30
Table 9: Most important potent activities of ω -3 fatty acids on cardiovascular health and its underlying mechanisms.....	37
Table 10: DAFNE food classification system	50
Table 11: Development of animal fat supply (kg/capita/year) in selected European countries 1961-2003.....	59
Table 12: Time trends in age-adjusted cardiovascular mortality rates from 1970s to latest available years in 2000.....	71
Table 13: Association between standardized death rates from cardiovascular-, ischemic- and cerebrovascular diseases and dietary patterns (simple correlation coefficients and p values).....	73

List of Abbreviations

\$	Dollar
%	Percent
BMI	Body mass index
CA	Cardiac arrhythmia
CHD	Coronary heart disease
CI	Cardiac insufficiency
CVD	Cardiovascular disease
DAFNE	Data Food Networking
DALY	Disability Adjusted Life Years
DGE	Deutsche Gesellschaft für Ernährung (German Society of Nutrition)
DHA	Docosahexaenoic acid
e.g.	For example
EPA	Eicosapentaenoic acid
EPIC	European Prospective Investigation into Cancer and Nutrition
EU	European Union
EUROCISS	European Cardiovascular Indicators Surveillance Set
FAO	Food and Agricultural Organization
FBS	Food Balance Sheets
G	Gramm
HBS	Household Budget Survey
HDI	Human development index
HDL	High-density lipoprotein
HFA-DB	Health for all database
ICD	International Statistical Classification of Diseases and Related Health Problems
Kg	Kilogramm
LDL	Low density lipoprotein

m²	Square meter
MI	Myocardial infarction
MONICA	Monitoring Trends and Determinants in Cardiovascular Disease
MUFA	Monounsaturated fatty acid
PPP	Purchasing power parities
PUFA	Polyunsaturated fatty acid
SES	Socioeconomic status
SFA	Saturated fatty acid
TFA	Trans fatty acid
WHO	World Health Organization
α	Alpha
ω	Omega

1 Introduction

Cardiovascular diseases (CVD) are the leading causes of death in Europe, accounting for over 4.3 million deaths annually. In general, about half of the total European mortality are linked to this group of chronic diseases, where the majority is formed by coronary heart diseases, followed by strokes. [ALLENDER, 2008]

According to the World Health Organization (WHO), profound changes in diet and lifestyles have contributed to an epidemic of non-communicable diseases, including cardiovascular disease as a major contributor. [WHO, 2003] An inflammatory disease, namely atherosclerosis is the major underlying pathology of cardiovascular diseases in general.

Increased age, male sex and a positive family history count to the non-modifiable cardiovascular risk factors. [KEIL et al., 2001] In contrast, smoking, overweight and obesity, diabetes mellitus, hypertension, physical inactivity, hypercholesterolemia as well as hypertriglyceridemia belong to the lifestyle-associated risk factors. [KOLENDA and MÜLLER, 2005] It is well established, that nutrition as a modifiable risk variable has an important multifactor influence on the prevention of cardiovascular disease. That is why it is of high priority to modify dietary habits positively for a maximal risk reduction. In that context, dietary fat quantity and quality have been strongly investigated to reduce cardiovascular death in European countries. Although there is a large number of different designed studies that found a positive or negative relationship between individual fat consumption and cardiovascular diseases, scientific evidence is partially controversial.

There remains the question how and to which extent dietary behaviour can reduce cardiovascular mortality. Yet the influence of diet, which may explain remarkable inter-country specific differences in the number of age-standardized cardiovascular mortality rates within Europe, is not entirely clear.

The aim of this study was to identify differences of several lifestyle factors like smoking, overweight, obesity and physical activity as well as dietary patterns

among 33 European countries, with a focus on the supply and availability of fruits, vegetables and fat quality and quantity. Trend analysis on the average supply of selected food groups was another topic of this study. Finally, a relationship between dietary patterns and cardiovascular diseases in Europe was tested.

2 Literature Review

An individual's food intake is influenced by various factors, namely historical, religious, agricultural, physiological, socioeconomic and psychological ones. These numerous criteria act together in a complex manner that fundamentally shape a person's dietary choices. [GEDRICH, 2003]

Due to large differences of dietary habits between countries, no valid overall, European diet can be defined. [SPIEKERMANN, 2005] As a result, there exists a large heterogeneity of dietary patterns in European citizens, living in different geographical regions as well as in the same region. [SLIMANI et al., 2002]

2.1 Diet related databases in European countries

The availability of reliable and comparable information on dietary habits is essential to evaluate and monitor nutritional patterns in European countries. This data on food and nutrient patterns should be the key information to design effective dietary guidelines on a population basis and initiate policies to promote a healthy diet. [ELMADFA et al., 2005]

At present, there exist three sources at different levels of information on dietary ingestion in Europe.

Table 1: Sources of nutritional data [TRICHOPOULOU and LAGIOU, 1998, p.14]

Level	Source
1. National	Food Balance Sheets
2. Household	Household Budget Surveys
3. Individual	Dietary Surveys

The Food and Agricultural Organisation of the United Nations (FAO) estimates national food supply data in form of Food Balance Sheets (FBS) on an annual basis. Secondly, the Data Food Networking (DAFNE) databank provides comparable dietary food availability data based on household budget surveys (HBS). Despite this agricultural nutritional information, most countries sporadically undertake specially designed dietary surveys to describe the individual's food consumption. [SERRA-MAJEM L, 2001]

For interpretation of nutritional data, one must consider the variation in methods, as well as the different stages of data collection in the food chain. [RODRIGUES et al, 2007]

2.1.1 Food supply data of the Food and Agriculture Organization of the United Nations (FAO)

The FAO annually produces FBS in numerous countries. These agricultural statistics provide internationally comparable food supply and utilization data during a specified period. Food supply is determined by food quantities of production adding total imports, and including stock changes, whereas on the food utilization side total food quantities exported, feed to animals, used for seed or waste, processing for food, other uses, and food available for human consumption are integrated in the calculation process. [FAO, 2008] For obtaining the average per caput supply the total amount of food items are divided by the resident population consuming it during the reference period. The mean food supply is then presented in both kg/year and g/day. [FAO, 2001]

However, food supply data derived from FBS does not indicate possible existing variations in the diet of different age groups, gender, geographical areas and subgroups, determined by their socio-demographic determinants. Therefore, the nutritional information can only be seen as estimations of a population's average food supply. [ELMADFA et al., 2005] [FAO, 2008]

2.1.1.1 Trends in dietary habits

According to food supply data of FBS, generated by the FAO, European dietary structures have dramatically changed over time. Total energy availability and energy availability derived from fat, particularly of animal origin have steadily increased in European countries since the 1960s. These increasing trends in specific food groups have occurred at the expense of carbohydrate's supply. [BALANZA et al., 2006]

The greatest quantitative changes in dietary behaviour have been reported in the European Mediterranean area. While the Mediterranean diet in the 1960s was characterized by favoured low total energy availability from fat, particularly from animal sources, compared to northern counterparts, the nutritional choices of Mediterranean countries indicate a gradually significant shift away from its traditional dietary patterns. [BALANZA et al., 2006] Between 1961 and 2001, an increasing trend in the availability of meat, milk and dairy products could be identified in Italy, Greece and Spain, contributing largely to that raise in the proportion of energy available from animal sources. [GARCIA-CLOSAS et al., 2006] With respect to those trends in the availability of fat from animal sources, the largest increase by far was identified in the Mediterranean area, in comparison with northern and eastern European regions. More precisely an average raise of 50% of fat from animal sources in the Mediterranean area occurred from 1960s to 2000. In contrast, there was a characteristic fall in Northern Europe of 17% and a slight increase of 4.1% in the eastern region during this period. [BALANZA et al., 2006]

In summary, European Mediterranean nations show an unfavourable trend towards a Western diet, regarding the supply of several food groups. [GARCIA-CLOSAS et al., 2006] Additionally, that impressive ongoing progress of convergence can be seen in estimations on dietary fatty acid composition in diet in the European Union. The Mediterranean area reported the highest increase in saturated fatty acid's availability of 7% in the 1960s to nearly 11% in 2001/2003. In contrast, countries like Finland, Sweden and the UK could reduce their high share of energy attributed to saturated fatty acids within this period. Regarding cholesterol, the availability of 210 mg/person/day in the 60s almost

doubled in Mediterranean countries, showing values of about 410 mg/person per day four decades later. The high values for saturated fatty acids and cholesterol supply reflect a diet high in meat, dairy products and animal fats. [SCHMIDHUBER, 2003]

In comparison with the WHO recommended maximum levels of 10% of saturated fatty acids of total energy share, the majority of European countries excessively exceed optimal values on the one hand. On the other hand differences in dietary patterns remain, Mediterranean countries occupying a position at the lowest range of saturated fatty acid's supply in the European Union. Apart from the raise in lipid availability, fruit and vegetable supply has increased since the 60s in all countries of the European Union, suggesting a level above the dietary recommendations. [SCHMIDHUBER and TRAILL, 2006]

In the 1960s, geographic neighbourhood could explain similarities in diet between different countries. During the last 4 decades, the importance of distance on diet decreased due to declines in trade barriers, costs of transportation and economic integration. As a result, overall dietary patterns have become more homogenous across the European Union. [SCHMIDHUBER and TRAILL, 2006]

Various interacting factors, including rapid urbanisation, growing incomes, globalisation as well as social, economic and technical changes influence these trends in dietary behaviour. [ALEXANDRATOS, 2006]

In ecological projections for 2015 and 2030 respectively, FAO estimates an ongoing increasing trend in the per capita energy availability, partly caused by a raise of available livestock products, namely meat and milk. [HARRISON, 2002]

2.1.2 Food availability of the DAta Food NETworking (DAFNE)-Initiative

In 1993, the DAFNE I project of the DAFNE initiative, including 5 European countries namely Belgium, Germany, Greece, Hungary and Poland was initiated and mainly supported by the European Commission. The project's aim was to develop a cost effective pan-European food databank based on household budget surveys, which offers internationally comparable food availability data for

monitoring dietary habits within and between European countries. Additionally this source for nutritional information can shape the basis for formulating dietary recommendations. [TRICHOPOULOU and LAGIOU, 1998] Besides estimated food availability data the databank includes demographic and socio-economic indicators, which allow the identification of dietary disparities among population-subgroups. Households can be categorized by locality (rural, semi urban and urban), education of the household head (elementary, secondary and higher education) occupation of the household head (manual, non-manual, retired, unemployed and other) and types of household composition (number and age of members). [TRICHOPOULOU et al., 2005]

National Statistical Offices of most European countries regularly conduct nationally representative and standardized HBS. They are then processed and harmonized by the DAFNE coordinating centre in Greece. Information of all foods and beverages, available at the household level is collected during a reference period, usually 1 year to eliminate seasonal variation and bulk purchases. It includes information on purchased goods, contributions from own household productions as well as received gifts. Average food availability per person per day is calculated by dividing the household availability by the number of household members, assuming an equal distribution of food within the household. [TRICHOPOULOU et al., 2005]

Household budget surveys provide useful estimations of food availability as well as daily energy and nutrient availability for monitoring dietary habits in Europe. [TRICHOPOULOU, 2003] [NASKA et al., 2007] Furthermore, nutritional data derived from HBS, can help to identify and quantify dietary variations among European adults. [TRICHOPOULOU et al., 2002] Additionally it allows establishing a relationship of cardiovascular mortality rates with dietary patterns. [LAGIOU et al., 1999]

Within the years, the DAFNE project has been expanded, and updated. Currently the nationally representative data of mean daily food availability of 24 participating European countries at a household level is freely available online.

2.1.2.1 Dietary patterns among European countries

The DAFNE-initiative reported several variations in dietary choices among European countries based on national household budget surveys. In general, the availability of fresh fruits, vegetables and added vegetable oils, particularly olive oil, remains higher in southern populations, compared to the rest of Europe. [TRICHOPOULOU et al., 2002] Whereas Greece, Italy and Spain still follow a characteristic Mediterranean lipid intake, the French citizens prefer butter and vegetable oils rather than olive oil. However, in contrast central and northern European countries seem to favour added vegetable fats and animal lipids. [NASKA et al., 2006]

When analysing meat availability, Mediterranean regions show high levels of red meat, while central and northern European countries record high daily amounts of meat products. [NASKA et al., 2006]

North to south differences in Europe are also evident in the estimations of daily energy and nutrient availability based on HBS data in the late 1990s. Regarding contribution of total lipids in daily energy availability, Germany reported 7% lower values compared to Greece with levels of about 43%. With 14%, the availability of saturated fatty acids was higher in Germany than in Greek households. On the other hand, monounsaturated fatty acids were identified as important components in Greece, accounting for 21% of the daily energy availability. In both countries, added lipids were the predominant contributors of available daily fat, followed by meat, meat products and cheese. [NASKA et al., 2007]

2.1.2.2 Trends in food habits

Focusing on comparisons across countries, in the 1960s a clear north/south gradient in fruit and vegetable availability between Mediterranean and northern European countries was identified. Within the last 4 decades, this gap of characteristic food choices between Mediterranean and northern regions has narrowed. [NASKA et al., 2006] The time trend analysis of dietary patterns between the late 80s and late 90s indicate that in southern Europe the

availability of fresh fruit and vegetables decreased, while in northern and central regions a slight increase could be noted. [TRICHOPOULOU et al., 2002] As a result, the current diet of several central and northern European countries is characterized by a vegetable and fruit availability, which is close to the Mediterranean pattern. Taking a closer look at meat availability, one can observe the leaving from the traditional dietary habits, resulting in an increase of red meat availability in Mediterranean countries. [NASKA et al., 2006] Nevertheless, in most European countries the mean availability of animal lipids and vegetable fats tended to decrease with time. [TRICHOPOULOU et al., 2002]

2.1.3 Individual dietary surveys

In Europe the number of individually conducted dietary nutrition surveys, which allow inter-country comparison is limited, caused by differences in assessment methods, categorisation of age groups and a lacking periodical conduction. [TRICHOPOULOU and NASKA, 2003] On the one hand, an individual-based approach describes the most appropriate source for nutrition monitoring and surveillance. [SJÖSTRÖM et al., 2005] On the other hand, these types of surveys are rarely conducted at a national level due to their immense costs and time-spent. [RODRIGUES et al, 2007]

The *European Nutrition and Health Report 2004* provides information on individually conducted food consumption of 13 countries of the European Union and Norway. Although the data used, cannot be compared directly, due to differences in assessment methods, year of arrangements as well as the categorisation of age groups, the report gives a good overview of the nutritional situation of selected European nations.

In general, the average fat intake in participating European adult men and women was relative high. Greek men reported the highest proportion of fat in total energy, ranging between 44-46%, mainly caused by high olive oil consumption in the daily diet. With respect to women, nearly the same picture was present with an identified level of 46-48% of total energy in the Greek,

followed by Belgium (42%), French and Spain (39%) women. In contrast, the lowest proportion of fat in total energy intake was observed in Norwegian and Portuguese adults. The average high intake of saturated fatty acids (SFAs) in the European Union indicated a high proportion of consumed animal products in the daily diet. Regarding the share of SFAs in total energy, in Austria and Belgium the highest values were identified. Contrary to these demanding levels, the mean saturated fatty acid intake was relatively low in Italian as well as in Portuguese adults. In Hungary the polyunsaturated fatty acids (PUFAs) intake was below the recommended minimum level of 6% of total energy, compared to Belgian and Greek adults, where a value of 7 to 9% were found. The mean high fat intake resulted in high measured cholesterol levels, recording the highest values in France and Hungary with about 500mg/day and 400mg/day respectively. In comparison, a cholesterol intake within the WHO recommendation of 300mg/day was identified in men and women living in Finland and the UK, as well as Norwegian and German young women. [ELMADFA et al., 2005]

In addition, dietary intake in 27 participating centres across 10 different European countries can be analysed by results of the *European Prospective Investigation into Cancer and Nutrition (EPIC)*, where a standardized 24-hour dietary recall was used as an assessment tool. Nutrition data of about 36 000 subjects demonstrate a high variation in the amount of consumed added fats and oils. In general, Greek and Spanish EPIC centres reported a high consumption of total added fats and oils, while in Germany, France and all other centres the intake was quantified to be moderate. Marked differences in added fat's and oil's quality were also identified. In the participating Mediterranean countries, namely Italy, Spain and Greece the daily diet was characterized by a high intake of vegetable oils, particularly olive oil and a low consumption of animal fat. In contrast, German EPIC centres showed the highest consumption of added fats and oils of animal origin, mainly butter, followed by the French and Nordic countries. Participants of Northern Europe, as Sweden, Denmark and Norway reported a high consumption of margarine as well as dairy cream, both

contributing to animal fat intake, whereas in Norway added fats and oils contributed to 8% of total energy intake, the level in Greece was 22%. [LINSEISEN et al., 2002]

In conclusion, the mean daily diet of Mediterranean EPIC participants was characterized by a higher consumption of plant foods like fruits and vegetables and a lower intake of animal and processed foods than their Northern counterparts. [SLIMANI et al., 2002]

The EPIC–Heart study, the cardiovascular component of the EPIC project, aims to investigate the relationship between dietary patterns and cardiovascular outcomes. The first working group of the project will concentrate on the association of cardiovascular mortality and diet as well as several biological risk factors. [DANESH et al., 2007]

2.2 Cardiovascular diseases (CVD)

2.2.1 General information

The item cardiovascular diseases (CVD) cover the class of diseases, which affect the heart and vascular system. They cover a wide range of different outcomes. In the 10th edition of the International Statistical Classification of Diseases and Related Health Problems (ICD) they occupy the specific codes between I00 and I99 (Table 2).

Table 2: ICD-10 classification of cardiovascular diseases [WHO, 2008a]

ICD-Code	Disease
I00-I02	Acute rheumatic fever
I05-09	Chronic rheumatic heart diseases
I10-15	Hypertensive diseases
I20-25	Ischaemic heart diseases
I26-28	Pulmonary heart disease and diseases of pulmonary circulation
I30-52	Other forms of heart disease
I60-69	Cerebrovascular diseases
I70-79	Diseases of arteries, arterioles and capillaries
I80-89	Diseases of veins, lymphatic vessels and lymph nodes, not elsewhere classified
I95-99	Other and unspecified disorders of the circulatory system

There, similar cardiovascular diseases are summarized in one category and given a unique code. This internationally comparable classification of diseases, published by the World Health Organization, is revised periodically. Furthermore, it is an appropriate worldwide-used tool for studies on mortality and morbidity statistics.

2.2.2 Pathogenesis of atherosclerosis

Atherosclerosis is the most frequent underlying pathology of numerous cardiovascular diseases. The complications of atherosclerosis are the most common cause of death in the industrialized western world. [KEIL et al., 2001]

The development of atherosclerosis describes a complex chronic inflammatory process, which can take up to several decades until the occurrence of any clinical events. [WIELAND, 2006]

The term atherosclerosis summarises any vascular wall's hardening and thickening of large-sized arteries. [KEIL et al., 2001]

The pathogenesis of atherosclerosis can be explained by various diverse hypotheses. However, the most commonly accepted theory is the *Response-to-Injury-Hypotheses*, where the development of atherosclerosis starts with the vessel's endothelial damage and ultimately leads to complex lesions or atherosclerotic plaques. [ELMADFA and LEITZMANN, 2004] This initialisation can be caused by diabetes mellitus, obesity, hypertension, smoking, hypercholesterolemia, shear stress, a sedentary lifestyle and aging, leading to endothelial activation and/or dysfunction. [GEBBERS, 2007] The endothelial damage results in adhesion of monocytes and the release of migration signals, such as macrophage chemo-attractant-protein-1, chemokine receptor 2 and minimal oxidised low-density lipoprotein. Furthermore, lymphocytes, leucocytes, and monocytes accumulate into the sub endothelial area of vessels where they differentiate to macrophages. [ADAM, 2003] Additionally, this monocytic activation within the sub-endothelial space leads to cytokine release and oxidation of LDL(low-density lipoprotein)-cholesterol. [CROWTHER MA, 2005]

The subsequent uptake of LDL-derived cholesterol into macrophages is a major cellular event, contributing to the progress of atherosclerosis. Via the so-called "*Scavenger pathway*" macrophages assimilate oxidized LDL in an unregulated way. Besides, this modified form showed strong pro-inflammatory and thrombogen effects in several studies. [WIELAND, 2006] Due to this intracellular lipid accumulation, macrophages convert into foam cells. Their accumulation results in the formation of "fatty streaks", which represent the first stage of atherosclerosis named "*early lesion*". [WAHRBURG and ASSMANN, 2004]

If the progress of the vascular lesion advances, the result "*fibrous lesion*" is mainly characterized by first calcifications, proliferation of extra cellular matrix and smooth muscle cells of the vascular media. Furthermore, an aggregation of thrombocytes into the impaired endothelium additionally results in progressive atherosclerosis. [WIELAND, 2006]

Ultimately, ulcerations, bleedings, the formation of microthrombes and calcifications ("complex lesion") become apparent, leading to the lumen narrowing, may ending in total vascular occlusion. [WAHRBURG and ASSMANN, 2004] These various complex lesions, plaque rupture and thrombosis finally cause acute clinical cardiovascular manifestations. [GLASS and WITZTUM, 2001]

The extent of atherosclerotic changes in the arterial's wall and the time of the clinical event depend on the number and value of risk factors. [WAHRBURG and ASSMANN, 2004]

Coronary heart diseases (CHD), heart attack, stroke, peripheral circulatory disorder and aneurysms belong to the most important clinical complications of atherosclerosis. [WAHRBURG and ASSMANN, 2004]

2.2.3 Coronary heart diseases

Coronary heart diseases describe a collective term of diseases that are mainly caused by a morbid constriction of coronary arteries during the process of atherosclerosis. [POLTE, 2001] The vascular lumen's narrowing results in the heart's undersupply of blood, which is also called ischemia (ischemic heart diseases). Therefore, the myocardium's blood supply of oxygen and energy-delivered substrates is impaired and clinically appears in different outcomes. [ELMADFA and LEITZMANN, 2004]

Clinical manifestations of CHD are:

- angina pectoris
- myocardial infarction
- cardiac insufficiency
- cardiac arrhythmia [POLTE, 2001]

2.2.3.1 Angina pectoris

Acute cases of angina pectoris are characterized by heavy chest pain with dissemination into the left arm, frequently occurring after physical or emotional stress. These attacks can appear up to several times a day and usually happen abruptly. [ELMADFA and LEITZMANN, 2004] Furthermore, typical symptoms can include a feeling of trepidation, shortness of breath, sickness and disorders in the upper area of the stomach as well as cauterisation behind the sternum and back pain. In this connection, coronary vessels tighten, thus leading to a lack of oxygen. In general, angina pectoris sends an alarm signal of an impending heart attack and has to be medically treated quickly. [POLTE, 2001]

2.2.3.2 Myocardial infarction

A myocardial infarction (MI) leads to palpable symptoms like intense chest pain, pain in shoulders and arms, cauterisation behind the sternum and spreading pain till the lower jaw. Besides, an attack can be characterized by anxiety, shortness of breath, cold sweat, nausea and paleness. Compared to angina pectoris these symptoms can occur as well in sedateness of the body. More than half of the MI patients ignore the symptoms and die because of it. [POLTE, 2001]

The underlying pathology is a constriction or blockage of coronary blood vessels. Those parts of the myocardial tissue that can't be supplied with blood and consequently with adequate oxygen and nutrients anymore, underlie cell death, which is named necrosis. The resulting effects on the heart's function caused by this tissue damage depend on the area and extent of impairment. For instance, if the myocardium is not supplied with blood for 45 minutes, approximately one third underlies necrosis. In worst case, the myocardial damage leads to cardiac death. [POLTE, 2001] Patients, who survive a MI, have an increased risk for a new heart attack, caused by the development of scars in the myocardium over the years. [ELMADFA and LEITZMANN, 2004]

2.2.3.3 Cardiac insufficiency

Cardiac insufficiency (CI) can generally result from several functional and structural cardiac disorders, thus impairing the heart's ability to provide an adequate blood supply for the human's body. Shortness of breath and palpitations are typical symptoms of CI. Usually they occur during marginal stress and in an advanced phase as well in sedateness of the body. The development of CI is characterized by the appearance of oedemas initially in legs and later in human organs. These oedemas result from the infiltration of blood into the tissue, due to a backpressure of blood into the right half of the heart. [POLTE, 2001]

2.2.3.4 Cardiac arrhythmia

Cardiac arrhythmia (CA) classifies various disorders, which are characterized by abnormal electrical activity in the heart (arrhythmia). In that context, CA can be differentiated into bradycardia and tachycardia. The first form is characterized by frequency of heartbeats that are less than 60 beats per minute, whereas tachycardia is labelled as a heart rate faster than 100 beats per minute. Additionally, in both outcomes the heartbeat can be irregularly. Symptoms of CA include vertigo, cardiac syncope, a possibly decrease of blood pressure and cardiac shock as well as characteristics of circulation still stand in case of the most life-threatening CA, namely ventricular fibrillation. [SCHEELE and BOSS, 1999]

CA stems from several causes like constriction of coronary blood vessels, tissue damage of a previous MI, prevalent stress, and disorders in electrical excitation, due to dietary undersupply of several minerals. [POLTE, 2001]

2.2.4 Cerebrovascular diseases

The item cerebrovascular diseases cover any disorders that affect the disease in the blood vessels supplying the brain. [ROCHE-LEXIKON MEDIZIN, 1999]

2.2.4.1 Stroke

The event of stroke is characterized by an abrupt disturbed blood flow in the brain. This may lead to handicaps like palsies, speech disorders or other dysfunctions. Vascular obliteration like cerebral thrombosis or embolism accounts for approximately 80 % of total strokes rates. In case of ischemic stroke, the underlying pathology is an arterial narrowing or occlusion, caused by atherosclerosis of cerebral blood vessels. As a result, the brain will not receive enough blood, thus resulting in an undersupply of oxygen and nutrients. Within 6 hours without treatment, the neurocytes in the brain die off. [POLTE, 2001]

Another form of cerebrovascular disease, namely hemorrhagic stroke, occurs when a blood vessel in the brain ruptures, leading to a cerebral bleeding. [POLTE, 2001]

2.2.5 Cardiovascular mortality in Europe

Cardiovascular diseases are the leading cause of deaths in Europe accounting for over 4.3 million deaths annually. About 48% of all deaths are due to cardiovascular outcomes, mainly formed by coronary heart disease and strokes. Compared with 54% of all deaths in women, cardiovascular mortality is lower in men, representing 43% of the total mortality rate (Figure 1 and 2). In general, CHD is the single most common cause of death in European countries, followed by strokes. Over one in 5 women, exactly 22%, as well as one in five men, (21%) dies from CD. [ALLENDER et al., 2008]

Figure 1: Death by cause in Europe, men, latest available year [ALLENDER et al., 2008]

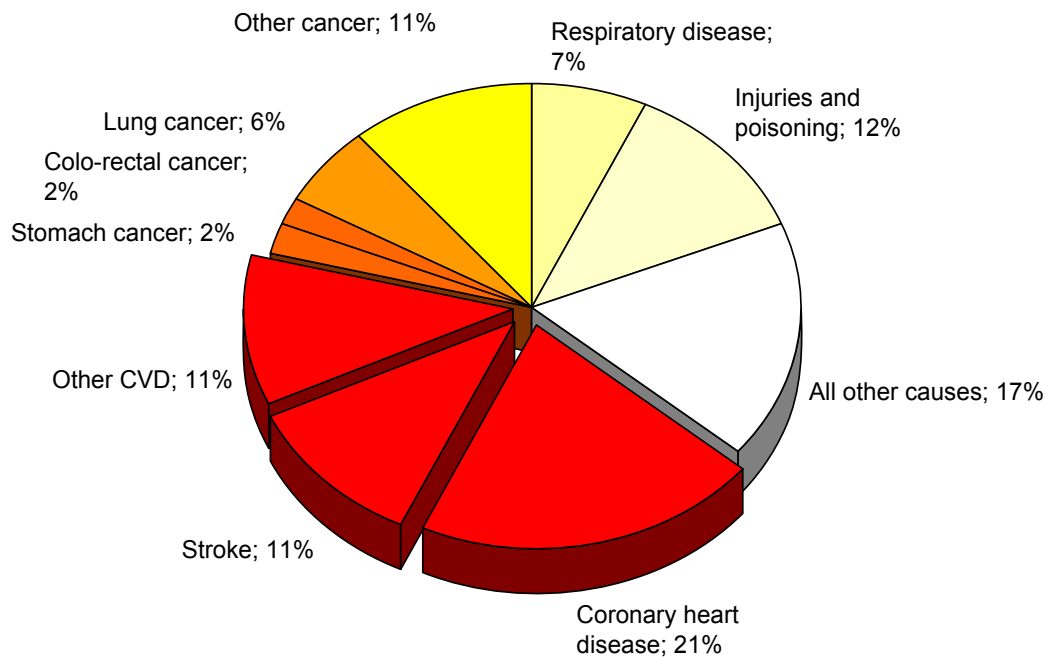
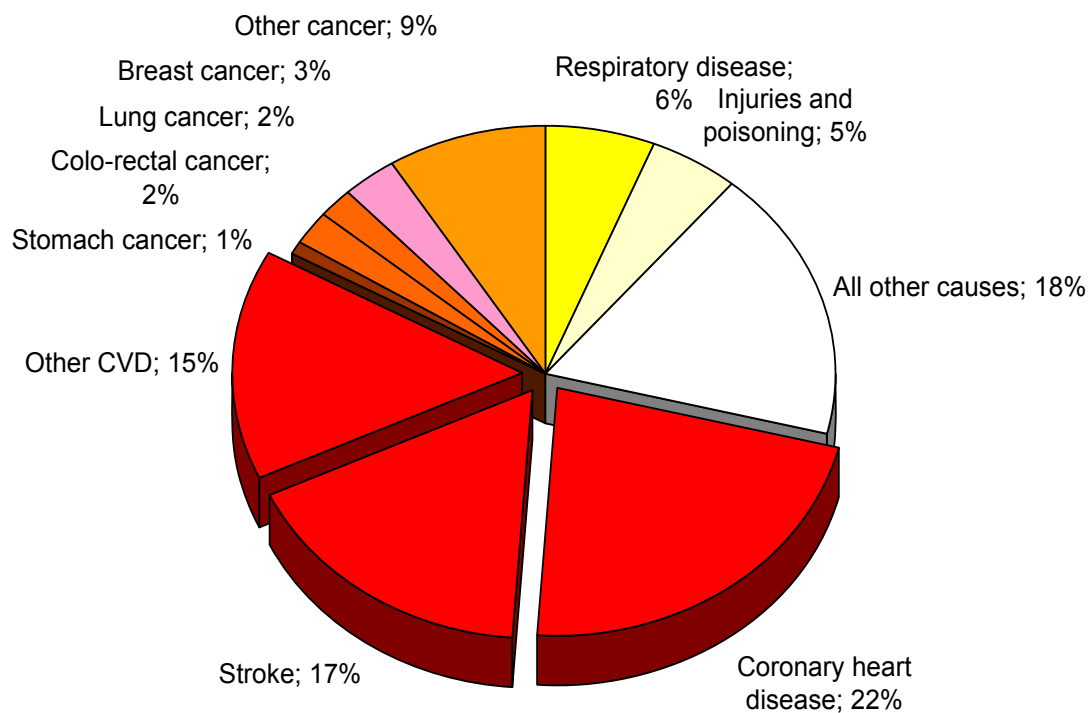


Figure 2: Death by cause in Europe, women, latest available year [ALLENDER et al., 2008]



Despite rapid changes in cardiovascular mortality, there still exists a considerable variation between different European countries. In view of ischemic heart diseases, a clear north-east to south-west gradient was apparent in 2000. Compared with other European nations in Central and Eastern countries, mortality rates were clearly higher. For ischemic heart diseases, the lowest values were found in France, Portugal, Italy, Spain, Switzerland and the Netherlands. For instance, a person aged 45-74 living in Latvia was approximately 7 times more likely to die from ischemic heart disease, than a French inhabitant. [MÜLLER-NORDHORN et al., 2008]

Regarding cerebrovascular diseases, the lowest mortality patterns were apparent in the centre of Western Europe, represented by countries like Switzerland, France, Norway, Spain, the Netherlands and Italy. Several Central and Eastern European countries as well as some regions near the Mediterranean Sea like Greece, Portugal and certain parts of southern Italy and Spain surrounded that cycle of low cerebrovascular mortality. Estonia, Bulgaria, Macedonia and Latvia showed the highest rates. [MÜLLER-NORDHORN et al., 2008]

2.2.5.1 Trends in cardiovascular mortality

Between 1970 and 2000 age-standardized mortality rates for ischemic heart disease, stroke and total cardiovascular diseases decreased continuously in Western Europe in people aged between 45-74 years. Total cardiovascular mortality rates in men and women fell respectively by approximately 50% and 60%, representing an annual decline of 1.8% and 2%. Finland and Spain clearly exceeded this average decline. In contrast, in Eastern Europe cardiovascular mortality increased until the early 90s, where the maximum level was reached. A decline of 3% per year in Poland and Hungary occurred thereafter in both sexes. The Baltic States reported the most impressive average annual changes of minus 5% from 1994 to 2000. [KESTELOOT et al., 2006]

Regarding the specific age group of 75 to 85 years, trends in cardiovascular death rates presented a quite similar picture between 1970 and 1996. During that period, age standardized mortality rates declined in most European nations,

except several Eastern European countries and Greece. [KESTELOOT et al., 2002]

Compared to the continuous declines in age-standardized CVD mortality rates in most northern, southern, and western European countries the crude rates show a relative stable picture in western countries and increase in most eastern European nations. The steady ageing of the population causes an increasing trend in non age-specific mortality. In most countries of the European Region, an increase of the proportion of people aged 65 and over was observed since 1980. On average, the percentage of the population above 65 years increased from 12.1% to 13.7%. [SCHOLTE op REIMER et al., 2006]

In trend analyses of the *WHO MONICA(Monitoring trends and determinants in cardiovascular disease)-project* from the mid 80s to the 90s, the coronary event rate was falling in most participating MONICA Northern and Western European centres. In contrast, the decline occurred slower in Southern, Central and Eastern Europe and even an increase was noticed in several populations. For instance the greatest reduction in coronary incidence rate for men could be identified in a Finnish population namely North Karelia, reporting annual relative percentage declines of 6.5%. In comparison one male population in Lithuania, two in Poland, two in Russia, one in Belgium, one in Spain and one in former Yugoslavia was characterized by increasing coronary event rates, ranging from 0.3 to 2.8 % per year. For women the most remarkable decrease occurred in Moscow-Conrol (Russia) with 6.7% annually, while in Novi Sad (former Yugoslavia) an increase of 2.8% was present. [TUNSTALL-PEDOE et al., 1999]

Unlike trends in coronary event rates the development of case fatality during the studied period, results show decreasing trends in most of the Southern, Northern and Western MONICA populations. A contrast trend situation was analysed in Central and Eastern populations, where the fall in case fatality was less rapid or even an increase occurred. [TUNSTALL-PEDOE et al., 1999]

According to the contribution of changes in falling coronary mortality rates in Western populations, two thirds could be attributed to a decline in coronary incidence and one third to a decline in coronary heart disease case fatality. [TUNSTALL-PEDOE et al., 1999]

In summary, the project concludes that the main decline of coronary heart disease mortality can be linked to the prevention and a smaller part to an improvement in intensive care. [KEIL, 2005] Besides mortality data, surviving a cardiovascular event becomes more prevalent among European citizens due to an improvement of clinical treatment. In conclusion, the total burden of cardiovascular disease, including mortality as well as morbidity, remains large in European countries. [SCHOLTE op REIMER et al., 2006]

2.2.6 Cardiovascular morbidity

For estimations of the total burden of cardiovascular disease besides mortality rates, morbidity patterns also have to be analysed. In that context, the number of prevalent cardiovascular cases presents the best indicator in a population. However, standardized comparable morbidity data is much more difficult to obtain. [KROMHOUT, 2001]

According to the *EUROCISS-project* (European Cardiovascular Indicators Surveillance Set) registers for cardiovascular morbidity are lacking in most European countries, except Belgium, Denmark, Finland, France, Germany, Italy, Norway, Spain and Sweden. [EUROCISS working group, 2003]

Disability Adjusted Life Years (DALYs) describe a morbidity indicator, which measures the years of life lost due to premature death and years of healthy life lost due to disability. In estimations of the WHO *World Health Report 2004* cardiovascular diseases accounted for over 34 million DALYs in Europe in 2002, which is 23% of the total value. Coronary heart diseases and strokes made up approximately 10% and 7% of cardiovascular DALYs respectively. Whereas in less developed European countries the highest proportion of DALYs was due to cardiovascular diseases, in developed European nations they represented the second single cause after neuropsychiatric disorders. As a result, cardiovascular diseases are also important contributors to disability and ill health. [WHO, 2004d]

In the *WHO MONICA-project*, standardized comparable morbidity data was obtained in 37 different populations in 21 countries with a main emphasis on

Europe. Altogether coronary incidence, which included non-fatal, as well as fatal events, of 29 populations in 16 different European nations, was examined for ten years, starting in the early 1980s.

The annual average 10-year age-standardized incidence rates per 100 000 in Southern and Western Europe were definitely lower than in Eastern, Northern and Central MONICA populations. Men aged 35 to 64 living in North Karelia, in Finland were 4 times more likely to suffer from a coronary event compared to male citizens living in Catalonia, Spain. Regarding women, the highest rates were found in Glasgow (265), the United Kingdom, and the lowest again in Catalonia (35), Spain again. Without exceptions, the average coronary incidence rate in European men was clearly higher compared to women. [TUNSTALL-PEDOE et al., 1999]

In addition to coronary event rates, the *WHO MONICA project* also investigated coronary case fatality, which was defined as dying within 28 days after a coronary event. By MONICA criteria, the Europe-wide picture of this morbidity indicator is similar to that of the coronary event rate, where case fatality is higher in Central and Eastern European populations than in the rest of Europe. In both, men and women a Polish region namely Tarnobrzeg Voivodship reported the highest case fatality regarding all European centres. For instance, men living there are 2.5 times more likely to die of coronary heart disease within 28 days than a male citizen in Ticino (Switzerland). For women the lowest case fatality rates occurred in a Northern Swedish population with an average value of 34.4%. On average, case fatality in women was definitely higher compared to male sex. [TUNSTALL-PEDOE et al., 1999]

Although data from the MONICA project is not necessarily representative for the study populations and is more than 10 years old, it represents the most recent comparable European morbidity patterns of coronary heart disease. [ALLENDER et al., 2008]

2.2.7 Costs of cardiovascular diseases

Despite human losses, cardiovascular morbidity as well as mortality in European countries provides an enormous economic burden for the health

system. [WHO, 2007] The economical consequences not only include direct health care costs, but also provide informal care by the patients' families. Furthermore, a loss of economic productivity, caused by inability to work or premature death is due to CVD. [TENDERA, 2006] These so-called indirect costs can even exceed direct costs. [WHO, 2004a]

Cardiovascular diseases are estimated to cost the European Union (EU) 169 billion Euros annually, where 62% of total costs are formed by health care expenditure, 21% by productivity losses and 17% by informal care. In detail, coronary heart diseases and cerebrovascular diseases represent approximately one-quarter and one-fifth of overall CVD costs, respectively. [LEAL et al. 2006]

A steadily increasing life expectancy since 1990 [WHO, 2005a] contributes to the possible increasing trend in economic costs of cardiovascular diseases in future. The older the people get, the higher the chance to suffer from one or more non-fatal cardiovascular events. [TENDERA, 2006]

2.3 Relationship of CVD with dietary patterns

2.3.1 Cardiovascular risk factors

Cardiovascular risk factors are parameters, which describe an increased statistical probability for the occurrence of cardiovascular events. [WIELAND, 2006] Table 3 demonstrates that beside non-modifiable risk factors, numerous well-established lifestyle-associated risk factors and psychosocial influences contribute to the formation of CVD. [KOLENDA and MÜLLER, 2005]

Table 3: Risk factors for coronary heart diseases [KOLENDA and MÜLLER, 2005, p.232]

1. Non modifiable risk factors	• Age • Sex • Genetics
2. Lifestyle associated RF	• Smoking • Nutrition related RF - Cholesterol - Triglycerides - Homocysteine - Overweight and Obesity • Risk with consequential diseases - Diabetes mellitus type 2 (proportionate) - Hypertension (proportionate) • Physical inactivity
3. Psychosocial RF	• Chronic stress • Social isolation • Hostile behaviour • Depression • Socioeconomic discrimination

Increased age, male sex and a positive family history count to the non-modifiable cardiovascular risk factors. [KOLENDA and MÜLLER, 2005] The prevalence of cardiovascular death significantly increases with age, accounting for up to 50% in the elderly population. [SCHOLTE op REIMER et al., 2006] Major causes for the cardiovascular burden in the elderly are especially coronary heart disease, heart failure, arterial fibrillation, hypertension and aortic stenosis. [SCHOLTE op REIMER et al., 2006] Among persons aged over 70 coronary heart diseases were responsible for over one in 6 deaths in the European Union in 2003. [NIEDERLAENDER, 2006]

In general, men develop heart disease 10 years earlier than women, independent from conventional risk factors such as high blood pressure, smoking, obesity, diabetes and hyperlipoproteinemia. In conclusion, men develop cardiovascular disease 2.5 to 4.5 times more likely than women do during most of their living years, caused by the high incidence of premature atherosclerosis. These sex-related varieties in risk diminish with increasing age, starting at the women's menopause and vanish approximately at the age of 75. Furthermore, their extent differs according to single cardiovascular outcomes. For instance, this gender difference in risk is definitely higher for coronary heart disease, than for stroke. [STRÖDTER, 2007]

There are three variable theories under discussion why male sex belongs to the classic non-modifiable cardiovascular risk factors: [STRÖDTER, 2007]

Table 4: Theories for an earlier development of cardiovascular diseases in men [STRÖDTER, 2007]

1. Men's unhealthier lifestyle
2. Men's more aggressive hormonal initial situation: levels of the sex hormone testosterone decrease with age
3. Men's general lower hormonal vascular protection

In general, the development of atherosclerosis and its clinical manifestations are determined by complex interactions between lifestyle, dietary habits and lipoprotein metabolism. [KROMHOUT et al., 2002] Early atherosclerosis and thus cardiovascular diseases as outcomes are due to a large extent clearly preventable by improving nutritional habits as well as lifestyle factors. [WOLFRAM, 2003]

A large international standardised case-control study, including 15 152 subjects with previous acute myocardial infarction and 14820 controls in 52 different countries worldwide found out that 90% of all myocardial infarctions in both sexes can be predicted by 9 risk factors. Thereby smoking, apolipoprotein B/ apolipoprotein A1, hypertension, diabetes, abdominal obesity, psychosocial factors, daily consumption of fruit and vegetables, alcohol intake and physical inactivity play a basic role. In addition, the *Interheart study* shows that a

combination of improving lifestyle factors can lower the risk for myocardial infarction by about 80%. [YUSUF et al., 2004]

2.3.2 Food related cardiovascular risk factors

The focus of dietary exposure has been on single nutrients, minerals, food groups as well as dietary patterns to establish a relationship with cardiovascular risk. In that context the influence of diet on the occurrence of cardiovascular diseases has been extensively studied and linked to other cardiovascular risk factors like diabetes, high blood pressure and obesity. [REDDY and KATAN, 2004] Among the lifestyle associated risk factors for coronary heart disease nutrition as a modifiable risk factor plays an important role in the prevention of cardiovascular diseases. Hypercholesterolemia, hypertriglyceridaemia, an increased plasma-homocysteine level, overweight and obesity belong to the nutrition related cardiovascular risk factors. Additionally, there is a close causal relationship between hypertension and obesity, which are both influenced by nutrition. [KOLENDA and MÜLLER, 2005]

In the past 20 years, further research on the molecular mechanism of atherosclerosis and the metabolic effects of various nutrients and dietary patterns helped to understand other multiple biological mechanisms than its action on plasma lipoproteins. Diet can potentially influence coronary heart disease risk directly through several intermediary biological pathways. Besides its effects on lipid levels, nutrition can influence blood pressure, thrombotic tendency, cardiac rhythm, endothelial function, systemic inflammation, insulin sensitivity, oxidative stress and homocysteine levels. [HU and WILLETT, 2002]

In the Diet, Nutrition and Prevention of Chronic Diseases Report 2003 the WHO/FAO summarized the strength of evidence regarding cardiovascular diseases and several lifestyle factors, including dietary determinants (Table 5).

Table 5: Strength of evidence on lifestyle factors and risk of developing cardiovascular diseases [WHO, 2003]

Evidence	Decreased risk	No relationship	Increased risk
convincing	• regular physical activity • linoleic acid • fish and fish oils (EPA and DHA) • vegetables and fruits (incl. berries) • potassium • low to moderate alcohol intake (for CHD)	• vitamin E supplements	• myristic and palmitic acid • trans fatty acids • high sodium intake • overweight • high alcohol intake (for stroke)
probable	• α-linolenic acid • oleic acid • non-starch polysaccharides • wholegrain cereals • nuts(unsalted) • plant sterols/stanols • folate	• stearic acid	• dietary cholesterol • unfiltered boiled coffee
possible	• flavonoids • soy products		• fats rich in lauric acid • impaired fetal nutrition • beta-carotene supplements
insufficient	• calcium • magnesium • vitamin C		• carbohydrates • iron

2.3.2.1 Lipids

Early observational studies already came to the assumption that there is a strong relationship between dietary fat and cardiovascular diseases. Results of the large epidemiological *Seven Countries Study* by KEYS et al. in the 60s showed the importance of dietary exposure, particularly fat consumption and the incidence of myocardial infarction in various European countries. [KEYS and PARLIN. 1966]

Recent evidence on the relationship between dietary fats derives from a huge number of animal studies, observational studies, clinical trials and metabolic studies. [REDDY and KATAN, 2004] Regarding nutrition related influences, dietary fats and cholesterol play a potential role in cardiovascular development, mostly by modulating plasma lipoprotein concentrations. [SCHAEFER, 2002] It is well established, that dyslipoproteinaemia is a major risk determinant for premature atherosclerosis and therefore cardiovascular outcomes.

In particular, increased LDL-cholesterol levels are epidemiological and causal linked to the progress of atherosclerosis. For the development of its atherogene potential, LDL has to be modified in the vessel's subendothelial area. Several modifications, especially oxidative and enzymatic forms cause LDL accumulation into the vessel's wall and the evolvement of its pro-inflammatory effects. [WIELAND, 2006] Compared to native LDL, oxidized LDL is preferentially taken up by phagocytes, namely macrophages in the vessel's wall. This immense accumulation results in their conversion into foam cells, which release specific growing factors and stimulate the formation of connective tissue as well as the deposit of fibrous plaques in the arterial wall. Furthermore, they promote the formation of clots, which additionally clog vessels and lead to clinical manifest cardiovascular outcomes like heart attack, stroke and angina pectoris. [WEISS, 2005]

Generally, elevated LDL-cholesterol and decreased high-density lipoprotein (HDL)-cholesterol levels in plasma describe secured hazard factors for coronary heart diseases. [WOLFRAM and BOEING, 2006] In that context, increased LDL-cholesterol levels determine a target value concerning therapeutic intervention. For patients suffering from a manifest coronary heart disease and for primary prevention in high-risk persons LDL-cholesterol concentrations <100 mg/dL are recommended. [WIELAND, 2006]

Additionally, the LDL/HDL ratio describes a crucial factor for the development of atherosclerosis. While a ratio of approximately 2:1 seems to be worthwhile, a proportion of 4:1 indicates a rise in the hazard for atherosclerosis. [WEISS, 2005] As a result, the most effective measurement of primary and secondary prevention of atherosclerosis is a consequent reduction of the LDL-cholesterol

level. In general, a fat reduced as well as modified diet and a normalisation in body weight can achieve this target. [WIELAND, 2006] A beneficial modification of the fatty acids composition of the diet has the public health potential to reduce the burden of cardiovascular disease. [WOODSIDE and KROMHOUT, 2005] There exist three prominent dietary strategies for an effective prevention of CVD based on modification of fat intake.

Table 6: Dietary strategies for cardiovascular disease prevention [HU and WILLETT, 2002]

1. Substitution of unsaturated fats, especially polyunsaturated fat for saturated and trans-fats
2. Increase of ω -3 fatty acid's consumption from fish oil or plant sources
3. Diet high in fruits, vegetables, nuts and whole grains and low in refined grains

Moreover, several professional cardiovascular societies have developed recommendations for nutrient's intake to benefit from a cardio-protective diet (Table 7). [WAHRBURG and ASSMANN, 2006a]

Table 7: Nutrient guidelines for the prevention of cardiovascular diseases [WAHRBURG and ASSMANN, 2006a, p.981]

Nutrient	Recommended intake
Total fat	25-30 E% ¹
SFAs plus TFAs	<10% E% (<7% E% if LDL-cholesterol is increased)
MUFAs	15-20 E%
PUFAs, thereby ω -6/ ω -3 ratio 5:1	7-10 E%
carbohydrates (particularly high in fibre and low in glycemic index)	$\geq$ 50 E%
low refined carbohydrates	<10 E%
Cholesterol	<300 mg/d <200mg/d (increased LDL-cholesterol)
table salt	$\leq$ 6g/d

¹ E%=percent of total energy

In 2006, the German Society of Nutrition (DGE) published an evidence-based guideline on fat consumption and selected nutrition related diseases. Based on systematic analysis and assessment of existing literature the relationship between fat quality as well as quantity and the occurrence of coronary heart disease and stroke was established. Table 8 presents that regarding coronary heart diseases, scientific evidence is convincing that long chain ω -3 polyunsaturated fatty acids are associated with a decreased risk and in contrast, trans fatty acids with an increased risk. A decreased risk for ischemic stroke is probably associated with an increased consumption of long chain ω -3 PUFAs. For stroke, the existing literature tends to show no correlation with dietary fatty acid intake. [DGE, 2006b]

Table 8: Evidence of a link between fat consumption and the primary prevention of CHD and stroke [DGE, 2006b]

Increased intake of	CHD	Stroke
Total fat intake	Oo	o
SFAs	↑	o
MUFAs	o	oo
PUFAs (ω-6 FAs)	↓	oo
Long chain ω-3 PUFAs	↓↓↓	↓↓ ¹ oo ²
Trans Fas	↑↑↑	o

¹ ischemic stroke

² haemorrhagic stroke

Evidence	Increased risk	Reduced risk	No correlation
Convincing	↑↑↑	↓↓↓	ooo
Probable	↑↑	↓↓	oo
Possible	↑	↓	o

▪ Dietary cholesterol

Compared to saturated fatty acids, dietary cholesterol has just a marginal increasing effect on serum cholesterol levels. An increase of the daily cholesterol consumption by 100 mg results in a mean raise of LDL-cholesterol levels by 2 mg/d. [WAHRBURG and ASSMANN, 2006b]. A decrease in

cholesterol supply causes an increasing endogenous synthesis particularly in the liver, which is regulated by a feedback mechanism through dietary cholesterol. Hence, a drastic reduction in the consumption of dietary cholesterol by reducing the intake of cholesterol rich foods has small effects on serum cholesterol levels, except in cholesterol-sensitive persons. [WEISS, 2005] Concerning exogene cholesterol supply a differentiation between hyporesponders and hyperresponders has to be made. Whereas in two thirds of individuals dietary cholesterol has small effects on total cholesterol levels (hyporesponders), in hyperresponders a distinctive increase can be noticed. [WÄCHTERSHÄUSER and STEIN, 2004] Therefore, fat- metabolism in these people should not be affected negatively by additional cholesterol consumed in the daily diet. [WEISS, 2005]

▪ **Saturated fatty acids**

A wide body of evidence indicates that a diet rich in saturated fats clearly contributes to an increased risk for developing atherosclerosis and thereby cardiovascular events. [KULLER, 2006] Primarily sources for saturated fats are foods of animal origin, particularly dairy food, meat and meat products. These adverse effects on cardiovascular health are due to the potential of saturated fatty acids (SFAs) to elevate total and LDL-cholesterol levels. The metabolic effects vary between different fatty acids. For instance, a significant LDL-cholesterol increasing effect can be clearly linked to the long chain SFAs lauric-, myristic-and palmitic acid. [WAHRBURG and ASSMANN, 2006b] In contrast, stearic acid has a small influence on plasma cholesterol concentrations, which is likely caused by its rapid conversion into oleic acid. [SCHAEFER, 2002] Saturated fatty acids of specific chain length inhibit the LDL-receptor's activity, leading to a slower LDL-absorption into the cell and increasing LDL cholesterol concentrations in the serum. [DIETSCHY, 1998] Results of predictive equations for lipoprotein levels show that an increase of 1% in energy from saturated fatty acids brings about a raise in LDL-cholesterol concentrations of about 0.033 to 0.045 mmol/L. [GRIEL et al., 2006]

Despite the LDL-cholesterol increasing effect, saturated fatty acids simultaneously affect HDL-cholesterol levels. A saturated fatty acid's increase for every 1%, is linked to an favoured increase of HDL-cholesterol by approximately 0,011 to 0,013 mmol/L. [GRIEL et al., 2006] Nevertheless, compared to the LDL-cholesterol raising effect, it is only marginal, thus resulting altogether in an increasing LDL to HDL ratio altogether. Although diet can influence HDL-cholesterol levels, the focus for preventing cardiovascular disease should be on the nutrition-related influences on LDL-cholesterol concentrations. [WAHRBURG and ASSMANN, 2006b] The intake of saturated fatty acids and cholesterol can be reduced effectively by consuming food of animal origin, fatty dairy products rich in fats, eggs, meat and meat products in moderation. [DGE, 2006a]

Findings from MENSINK et al. support the hypothesis that replacing saturated fatty acids with unsaturated fats is more beneficial for cardiovascular health compared to an exchange with carbohydrates. Carbohydrates frequently cause a LDL- and HDL-cholesterol lowering effect at the same dimension, thus resulting in an unchanged LDL/HDL ratio. [SACKS and KATAN, 2002]

Early epidemiologic studies like the *Seven Countries Study* by Keys et al., reported a strong positive correlation between the consumption of saturated fatty acids and CHD mortality. This close relationship was also obvious in data examination of the 25-year follow-up. [KROMHOUT et al., 1995] With regard to selected food groups the mean consumption of foods from animal origin, with the exception of fish intake was positively associated with mortality from CHDs in that follow up of the *Seven Countries Study*. Unlike the negative impact of a diet rich in saturated fats and cholesterol on cardiovascular health, vegetable food groups showed a negative relationship to coronary heart disease mortality. [MENOTTI et al., 1999]

The *Nurses' Health Study*, a large prospective cohort study, also investigated the influence of dietary fatty acids on cardiovascular disease of approximately 80 000 women over a period of 14 years. In multivariate risk analyses an increased intake of long-chain saturated fatty acids was linked to a slightly

higher relative risk for coronary heart disease (RR=1.14; 95% CI, 0.93-1.39; P=0.03). When the role of saturated fatty acids in relation to the risk of coronary heart diseases was examined separately, only stearic-acid showed a significant higher risk. [HU et al., 1999] Further multivariate analysis from a 20-year follow up of the *Nurses' Health Study* also showed no statistically significant correlations between the saturated fatty acid consumption and the hazard for coronary heart disease occurrence. [OH et al., 2005]

In view of the effects of SFAs on plasma lipoproteins and cardiovascular risk, scientific evidence is not that consistent.

For instance, a study conducted by MOZAFFARIAN et al. found a relationship between higher SFA intakes with less progression of coronary atherosclerosis in postmenopausal women. These data derived from the *Estragon Replacement and Atherosclerosis trial*. In those women, who reported a relatively low total fat intake of about 25% of energy, a greater intake of saturated fatty acids (10,6%-16% of energy) was associated with less progression of coronary atherosclerosis compared to women with a lower consumption of saturated fatty acids (3,5-7% of energy). [MOZAFFARIAN et al., 2004]

However, according to the WHO/FAO in 2003 convincing associations for reduced risk of CVD include the saturated fatty acids palmitic and myristic acids. For stearic acid no relationship on the risk for developing cardiovascular diseases is probable. [WHO, 2003]

▪ **Trans fatty acids**

Trans unsaturated fatty acids naturally occur in fat, meat and dairy products originated of ruminants, produced by the action of bacteria in the animal's stomach. Additionally they can be produced through strong heating of oils and fats. Furthermore, partially hydrogenated vegetable oils, which are processed in food industry, are a major source for individual trans fat intake. [DGE, 2007] That's the reason why trans fatty acids (TFAs) are mainly consumed through deep fried fats foods, bakery products, packaged snack foods, margarines and crackers. Dietary trans fats have markedly adverse effects on serum lipid

concentrations. Besides an increasing effect on LDL-cholesterol, serum triglycerides and Lp(a), trans fatty acids simultaneously decrease HDL-cholesterol concentrations. [MOZAFFARIAN et al., 2006] According to the *European Food Safety Authority* (EFSA) this unfavourable influence on the HDL-cholesterol level is responsible that trans fatty acids are slightly more atherogenic effective compared to saturated fats. [WEISS, 2005] Furthermore, trans fatty acids increase the total cholesterol to HDL-cholesterol ratio and reduce LDL's particle size, further contributing to cardiovascular disease. In addition to these negative effects on serum lipid levels, several studies suggest that trans fatty acids may promote systemic inflammation through raising tumor necrosis factor, interleukin 6 and C-reactive protein. In addition, they may cause endothelial dysfunction. [MOZAFFARIAN et al., 2006]

Large prospective cohort studies like the *Seven Countries Study*, the *Nurses' Health Study* or the *Zutphen Elderly Study* have shown a positive association between the intake of trans fat and coronary heart disease mortality. [KROMHOUT et al., 1995], [OH et al., 2005], [OOMEN et al., 2001] A meta-analysis of prospective cohort studies including approximately 140 000 subjects found out that a 2% increase in energy from trans fatty acid is linked to a 23% raise in cardiovascular incidence. When the results of 3 retrospective case-control studies were added the extent of adverse effects of trans fatty acids increased to a percentage of 29% in pooled relative risk analysis. [MOZAFFARIAN et al., 2006]

In the majority of case control-studies, which used trans-fatty acids in adipose tissue as biomarkers for coronary heart disease risk, an increased concentration was associated with higher incidence. [LINSEISEN and WOLFRAM, 2006] Some studies indicate existing differences in the effects of TFAs derived from ruminants, compared to those consumed by processed plant oils on cardiovascular outcomes. A study conducted by JACOBSEN et al. suggests that ruminant-trans fatty acids don't contribute to the development of coronary heart disease. [JACOBSEN et al., 2008]

The German Society of Nutrition (DGE) underpins the assumption that there is convincing evidence regarding a positive relationship between increased trans fatty acid consumption and the risk for coronary heart disease. [DGE, 2006b] The Diet, Nutrition and Prevention of Chronic Diseases Report 2003 the WHO/FAO confirmed these results. [WHO, 2003]

- **Monounsaturated fatty acids**

Oleic acid (C18:1) represents the only nutritionally important monounsaturated fatty acid (MUFA), which is mainly abundant in rapeseed oil and olive oil. [WEISS, 2005] The traditional Mediterranean diet, which is characterized by a moderate to high intake of olive oil and thus monounsaturated fatty acid, was associated with lower cardiovascular risk in these countries. Further investigation on the mechanisms of beneficial effects of various components of a typical Mediterranean diet is needed and recently can't be linked to monounsaturated fatty acids alone. Multiple studies show that a substitution of SFA for MUFAs in the diet improves cholesterol levels. [LÓPEZ et al., 2006] For instance, replacing long-chain SFAs with MUFAs (8% of energy) resulted in a mean fall in LDL-cholesterol levels by about 19 %. [KRIS-ETHERTON and YU, 1997] Thereby the LDL-cholesterol decreasing effect of ω 6-PUFAs is more pronounced compared to MUFAs. Additionally, unlike saturated fatty acids they have been associated with a beneficial increase in HDL-levels and a lowering effect on triglycerides in plasma. [WOLFRAM and BOEING, 2006] Several studies suggest that MUFA's anti-atherogenic mechanisms have great potential for preventing cardiovascular disease other than improvements of cholesterol levels. Substantial evidence indicates that MUFAs improve LDL-cholesterol's resistance for oxidative modification, and have a beneficial impact on the endothelial's function as well as on platelet adhesion, coagulation, and fibrinolysis that may reduce PAI-1 levels. [LÓPEZ et al., 2006]

In conclusion, evidence on the association of MUFAs and primary prevention of coronary heart disease is inconsistent. In the majority of studies, no significant reduction of coronary heart diseases observed could be linked to the consumption of MUFAs. Furthermore, there exists a high number of studies

where MUFAs intake is accompanied with a significant increase in coronary heart disease incidence. [WOLFRAM and BOEING, 2006] For instance, findings of the *Nurses' Health Study* show that an increased intake of MUFAs was statistically significant associated with a raise in relative risk for coronary heart disease by 30%. After the adjustment for other factors, this relationship did not exist anymore. [HU et al., 1997] In a 20-year follow up MUFAs consumption wasn't significantly linked to CHD after adjusting for dietary and non-dietary factors. [OH et al., 2005]

- **Polyunsaturated fatty acids**

When dietary saturated fat is substituted by ω -6 polyunsaturated fatty acids, the total and LDL-cholesterol concentrations decrease. [WAHRBURG and ASSMANN, 2006b] Predictive equations demonstrate that an increase of PUFAs of 1% can decrease total cholesterol by approximately 0.024 mmol/L. Compared to saturated fatty acids, this predicted cholesterol-lowering response of PUFAs is about half the total and LDL-cholesterol raising effect of saturated fat. Polyunsaturated fatty acids of the ω -6 and ω -3 series both clearly have shown its cardio protective actions, independent of total and LDL-cholesterol lowering effects. [KRIS-ETHERTON et al., 2004]

Numerous epidemiologic studies have shown a beneficial association between PUFAs' intake and cardiovascular disease morbidity and mortality. For example results of the *Nurses' Health Study* demonstrate that for each 5% increase in energy from PUFAs the relative risk for cardiovascular disease was 0,62 (95% confidence interval, $P = 0.003$). [HU et al., 1997] In a follow up of 20-years, the percentage of energy from PUFAs was statistically significant associated with a lower coronary heart disease risk. [OH et al., 2005]

Positive effects of PUFAs on cardiovascular health lead to the assumption that dietary saturated fatty acids should be replaced by PUFAs on an appreciable extent for an effective prevention of coronary heart disease. [HU and WILLETT, 2002]

However, epidemiologic evidence is not consistent regarding the association between PUFA consumption and cardiovascular disease.

Several prospective cohort studies found no significant negative relationship and some show adverse effects of PUFAs on the cardiovascular system, leading to the assessment of the DGE that evidence for primary prevention of cardiovascular diseases is possible through an increase of PUFA intake in diet. [LINSEISEN and WOLFRAM, 2006]

ω -3 Fatty acids

α -linolenic acid, docosahexaenoic (DHA) and eicosapentaenoic (EPA) acid are the most important ω -3 fatty acids in nutrition. Whereas linseed oil, rapeseed oil, soybean oil and walnut oil specify the major sources of α -linolenic acid, docosahexaenoic and eicosapentaenoic acid mainly occur in fatty saltwater fish, such as herring, mackerel, salmon and tuna. [WÄCHTERSCHÄUSER and STEIN, 2004] Their cardiovascular protective effects are mediated by numerous biological mechanisms independent of a decreasing effect on blood cholesterol. [HOLUB and HOLUB, 2004]

Table 9: Most important potent activities of ω -3 fatty acids on cardiovascular health and its underlying mechanisms [WAHRBURG and ASSMANN, 2006a, p.979]

Effect	Cause
antiarrhythmic	Changes in membrane phospholipid's composition with increased membrane fluidity and changed activity of ionic channels in the heart muscle's tissue
antithrombotic	<u>Changes in the eicosanoid profile:</u> thromboxane A2 ↓ thromboxane A3 ↑
anti-inflammatory	<u>Changes in the eicosanoid profile:</u> leukotriene B4 ↓ leukotriene B5 ↑
improved endothelial function	NO-production ↑ Cytokines and mitogens ↓
improved lipid profile	Synthesis of triglycerides and VLDL ↓ Secretion of LDL ↓
anti-hypertensive	prostacyclin ↑ (among other things)

In fat metabolism long-chain marine ω -3 fatty acids, namely DHA and EPA acid have a pronounced serum-triglyceride lowering effect, caused by an inhibition of the hepatic VLDL and triglyceride synthesis. A daily intake of 2-4 g of EPA and DHA in summary has a serum triglycerides decreasing effect on average by 20-40 %. [WAHRBURG and ASSMANN, 2006b]

Besides their improving effects on lipid profiles, long-chain marine ω -3 fatty acids are expected to act independently by several mechanisms. [HOLUB and HOLUB, 2004]

For instance, they inhibit inflammatory processes that influence the blood coagulation through a decrease in platelet adhesion and–aggregation. In that context the synthesis of beneficial eicosanoids out of ω -3 fatty acids play a potential role in the development of its antithrombotic and anti-inflammatory effects. [WAHRBURG and ASSMANN, 2006a]

Long chain ω -3 fatty acids influence the process of inflammation, which is relevant in the development of atherosclerosis. In that context they decrease the production of the inflammatory arachidonic acid-derived eicosanoids like prostaglandins, thromboxanes, leukotrienes and other oxidized derivates, cytokines, reactive oxygen species and the expression of adhesion molecules. [CALDER, 2006]

Additionally long chain ω -3 fatty acids have a small blood pressure lowering effect in normotensive as well as hypertensive subjects. [CALDER, 2004]

Furthermore the presence of long chain ω -3 fatty acids in cardiomyocyte membrane phospholipids have been shown to prevent arrhythmias, due maybe to electrical stability of the cell caused by a decrease in electrical excitability and modulation of the activity of ion' channels. Secondly, ω -3 fatty acids may have an anti-arrhythmic effect via the autonomic nervous system through increasing heart rate variability. [CALDER, 2004]

Epidemiological evidence regarding the relationship between dietary ω -3 fatty acids and cardiovascular disease largely derives from studies on fish intake. [REDDY and KATAN, 2004]

An inverse correlation between the consumption of fatty fish, hence dietary intake of DHA and EPA has been observed in the majority, but not in all epidemiologic studies.

A meta-analysis of observational studies, including 14 cohort and 5 case control studies came to the result that fish consumption versus little to no intake reduces the risk for fatal coronary heart disease by about 17% as well as total coronary heart disease significantly by 14%. [WHELTON et al., 2004]

Another systematic literature research by WANG et al. confirmed that ω -3 fatty acids, derived from fish or fish-oil supplements, but not α -linolenic acid, could reduce cardiac and sudden death and maybe stroke. Their positive influence on cardiovascular health occurred to be more effective in secondary than in primary prevention. [WANG et al., 2006]

Unlike these heart protective effects the latest *Cochrane* meta-analysis, where 48 randomised controlled trials and 41 cohort studies were examined, came to the conclusion that long chain and shorter chain ω -3 fatty acids neither reduce nor increase cardiovascular events. [HOOPER et al., 2006]

However, this null conclusion should not question the favoured heart protective effects of omega-3 fatty acids, which have been shown in a high variation of well-designed studies. Therefore, the recommendations of cardiac societies, which promote the intake of 1g/day of the two omega-3 fatty acids DHA and EPA, should not be discarded. A possible explanation for the inconsistent results could be that in some investigations the fish or the fish oil was contaminated with methyl-mercury, which diminishes the positive effects of DHA and EPA in epidemiologic studies. Furthermore, the exclusion of only one methodologically questionable study, namely the *DART-2 trial*, leads to the results, that additive ω -3 FA intake significantly reduces the risk for lethal coronary heart disease. [VON SCHACKY C and HARRIS, 2007]

However, large well-designed randomized controlled trials will have to be conducted in future to establish a clear relationship between the intake of ω -3 fatty acids and cardiovascular outcomes. [WANG et al., 2006]

2.3.2.2 Fruit and vegetables

An adequate fruit and vegetable intake is linked to several health benefits, due to an assumed complex interaction of containing biological active compounds. In general, fruits and vegetables are characterized by a favoured low energy density, a lack of cholesterol, a low fat content with beneficial fatty acid profile as well as a high content of vitamins, minerals, secondary plant compounds and fibres. A higher consumption of fruits and vegetables can be associated with reduced consumption of foods from animal origin and therefore for instance saturated fatty acids. [BECHTHOLD, 2007] Replacing this can be an explanation why in the *National Heart, Lung, and Blood Institute's Family Heart Study* men and women, who consumed over 4 servings of fruit and vegetables per day showed significant lower LDL cholesterol levels than those who consumed less. [DJOUSSE et al., 2004]

Additionally in many previous cohort studies, the relationship between fruit and vegetable consumption and risk for cardiovascular disease has been investigated.

In the *Nurses' Health Study* and the *Health Professionals Follow-up Study*, health and dietary habits of almost 110 000 participating men and women were analysed within a period of 14 years. A high fruit and vegetable intake was inversely associated with cardiovascular risk. Participants, who reported to consume less than 1,5 fruit and vegetable servings had a higher risk of heart disease and stroke by about 30% than those who ate 8 or more servings a day. [HUNG et al., 2004]

In a Meta-analysis, including results of 9 cohort studies, the risk of coronary heart disease decreased by 4% for each daily additional fruit and vegetable portion and by 7% of fruit consumption. The inverse association for vegetable intake was clearer for cardiovascular mortality than for a fatal-or non-fatal MI. [DAUCHET et al., 2006] Findings of a large case control study, namely the *Interheart-Study*, underpin the positive effects of fruit and vegetables on cardiovascular health. Participants, who reported daily fruit and vegetable consumption, showed a reduced risk of myocardial infarction by about 30% compared to the group of lower intake. [YUSUF et al., 2004]

In the *World Health Report 2002* the WHO, estimated that 35% of ischemic heart diseases and 11% of stroke were associated globally with low consumption of fruit and vegetables. [WHO, 2002b]

In 2003, the WHO identified convincing associations for reduced risk of cardiovascular disease and consumption of fruit and vegetables. [WHO, 2003]

The German Society of Nutrition (DGE) also assumed that there is convincing evidence for the prevention of coronary heart diseases and strokes through high fruit and vegetable intake. [SCHULZE, 2007]

2.4 Relationship of CVD with socioeconomic status

Usually the socioeconomic status (SES) is measured by education, income and occupational status or all three levels combined. [NOCON et al., 2007] In the assessment of socioeconomic disparities within a population, education has been shown to have the most important impact caused by the fact that educational attainment might also affect occupation and income and can influence a person's access and understanding of nutritional information. [TRICHOPOULOU et al., 2002] In general, a higher socioeconomic level has been associated with a healthier dietary behaviour.

Thus in a meta-analyses a higher socioeconomic level was associated with higher intakes of fruit and vegetables. [IRALA-ESTÉVEZ et al., 2000] Moreover, individuals of lower SES reported to consume more total fat, saturated fat, meat and meat products compared to their higher social class counterparts. [HULSHOF et al., 2003] [LOPEZ-AZPIAZU et al., 2003] In the *EPIC-Study*, participating European citizens who where higher educated had lower intake values of added fats and oils. [LINSEISEN et al., 2002]

Furthermore, lower SES examined across educational level and annual income has been attributed to increased prevalence of cardiovascular risk factors such as hypertension, obesity, diabetes mellitus and hypercholesterolemia. [PANAGIOTAKOS et al., 2008] Additionally, an inverse relationship between SES and smoking and physical inactivity has been observed. In summary, SES

is linked to a variety of health determinants, thus influencing the development of cardiovascular events. [NOCON et al., 2007]

2.4.1 Human Development Index (HDI)

Since 1990 the United Nations Development Programme has annually produced its Human Development Reports, including calculations of the human development index (HDI) for a large number of countries.

This composite index offers a powerful alternative instead of using the gross domestic product to characterise a country's development. The human development index provides three dimensions of human development, namely living a long and healthy life, access to knowledge and education and the standard of living. Life expectancy is measured as an indicator for health, adult literacy and combined gross enrolment in primary, secondary and tertiary level education for the educational component and the gross domestic product expressed in purchasing power parity US dollars for the standard of living. Each index of the three dimensions are calculated separately for each country, they are then combined to an overall human development by calculating the average. The HDI is expressed as a value between 0 and 1. The closer a nation reaches a HDI value of 1 the higher the estimated human development. The index is classified into three major groups: A level of 0.8 or above represents a high human development, between 0.5 and 0.799 a medium achievement and below 0.5 a low human development. [Human Development Report 2007/2008, 2007]

Recently, the Human Development Report is available for 2007/2008 including a calculated HDI from 2005.

2.5 Relationship of CVD with lifestyle factors

2.5.1 Smoking

In the year 2000 an absolute number of about 450 000 cardiovascular death was attributed to smoking in Europe. For men 20% of all cardiovascular death

was due to smoking, whereas in women the percentage was 3%. When concentrating on the age group of 35-69 the highest proportions of cardiovascular death were linked to smoking, accounting for 32% in men and 6% in women. Regarding the EU 25, values of 16% for men and 5% for women were observed. [PETO et al., 2003]

Smoking promotes cardiovascular diseases through multifactorial mechanisms. For instance, it affects the circulation system by producing a shift in the hemostatic balance of the endothelium. Moreover, it provides endothelial injury and cell dysfunctions, which lead to atherosclerosis and its thrombotic complications. [US Department of Health and Human Services, 2004] Cigarette smoking modifies a person's lipid profile, through raising LDL cholesterol levels and lowering HDL levels at the same time. [WHO, 2004c]

In addition, single components of cigarette smoke link adverse effects to cardiovascular health. Smoking can decrease oxygen supply and increase the physiologic demands of the myocardium. [US Department of Health and Human Services, 2004]

In general, smokers have an increased requirement of antioxidative substances like vitamin E and C due to the raising effect of nicotine on free radical's formation. [WÄCHTERSHÄUSER and STEIN, 2004]

Evidence from many epidemiologic studies show that cigarette smoking significantly contributes to cardiovascular mortality as well as morbidity in individuals. A literature review of *Surgeon General, U.S. Department of Health and Human Services* summarized that there is sufficient evidence for a causal relationship between smoking and coronary heart disease, stroke, abdominal aortic aneurysm and sub clinical atherosclerosis. [US Department of Health and Human Services, 2004]

The *Interheart-Study*, a large international standardised case-control study, investigated smoking as a risk factor for acute myocardial infarction. In participating European countries a large proportion of myocardial infarctions were estimated being due to smoking, in detail 29% in Western Europe and 30% in Eastern Europe. Furthermore, current and former smoking persons living in these regions had twice the risk of a heart attack in relation to non-

smokers. Including all 52 countries, the results represent that persons, who daily smoked more than 40 cigarettes are 9 times more likely to develop myocardial infarction compared to non-smokers. As a result, a possible linear dose-response is indicated for the number of consumed cigarettes. In addition to raised lipids and psychological factors, smoking was quantified to be one of the three major risk factors for myocardial infarction. [YUSUF et al., 2004]

The long term hazards of smoking in relation to cause-specific mortality has been monitored in a prospective study on almost 35 000 male British doctors over a period of 50 years. Smoking on average shortened life by about 10 years on average. Age standardized mortality rates for ischemic heart diseases, cerebrovascular and other vascular diseases were definitely higher among current smokers, compared to lifelong non-smokers. Cardiovascular mortality rates also rose with the number of smoked cigarettes per day. For those, who daily smoked 25 or more cigarettes the mortality rates almost doubled in comparison to non-smokers. In summary, approximately one quarter of mortality among smokers was formed by ischemic heart disease. Furthermore, the study presents the health beneficial effects of quitting smoking during life. For men born around 1920 smoking cessation at age 50 halved hazard and cessation at age 30 avoided almost all of it. [DOLL et al., 2004]

Furthermore, the burden of cardiovascular diseases caused by smoking habits of the original *Framingham Heart Study* population was observed during 20 years. Smoking decreased the duration of life free of cardiovascular disease by 6.22 years for men and 4.93 years for females throughout life. Additionally, regular smokers had a significantly higher risk of dying once they experience a cardiovascular event in comparison with non-smokers, who spend more life years with cardiovascular disease. Male and female non-smokers live on average 2.43 and 2.66 years respectively longer with cardiovascular disease. [AL MAMUN et al., 2004]

The *MONICA project* demonstrates that when relating changes in risk factors to changes in coronary event rates in men over 10 years in all *MONICA* populations it turned out that a decline in smoking participants had provided the greatest contribution to the decrease in coronary heart diseases. Over the

studied period of 10 years on average European men consistently reported decreasing trends in smoking. In contrast, in about 50 % of participating European regions, an increasing trend could be observed for women. [KUULASMAA et al., 2000]

In summary, clinical and experimental studies indicate that the underlying pathology of cigarette smoking is an increase of inflammation, thrombosis and oxidation of low-density lipoprotein cholesterol. [AMBROSE et al., 2004]

Besides active smoking, passive smoking has also been linked with adverse effects on the cardiovascular system and causes coronary heart disease. Exposure of adults to second-hand smoke has an increased risk by 25-30% to develop any heart disease. [U.S. Department of Health and Human Services, 2006]

2.5.2 Physical activity

The *World Health Report 2002* estimates that 22% of ischemic heart diseases are attributable to physical inactivity worldwide. [WHO, 2002b] Therefore, the WHO global strategy for the prevention and control of the global epidemic of non-communicable diseases, such as cardiovascular diseases, focuses on the encouragement of physical activity. [WHO, 2002a]

Since the 1950's, a large number of epidemiological studies have respectively investigated the influence of physical activity on cardiovascular risk and premature death. The majority of these reported a reduction of cardiovascular risk due to physical activity between 10 to 50%. [WEISSER, 2005]

There is convincing evidence that physical activity is linked to reducing the risk of developing cardiovascular diseases, particularly coronary heart diseases. Low cardio-respiratory fitness, which belongs to the group of modifiable lifestyle factors, contributes to the occurrence of cardiovascular outcomes. [WHO, 2003] The underlying positive effects of physical activity may be due to an improvement of glucose metabolism, body fat reduction and lowering blood

pressure. [WHO, 2002b] Moreover, regularly practiced fitness improves endothelial function, insulin sensitivity as well as lipid profile. [WHO, 2007b] In that context physical activity, in particular endurance training, leads to an increase in triglycerides' and free fatty acids' conversion as well as to a significant raise of HDL-cholesterol levels. Especially men and persons, who have an extremely low HDL-cholesterol value, profit the most from regularly physical exercise like biking, jogging, swimming and walking. [WÄCHTERSHÄUSER and STEIN, 2004] Besides these effects, regular physical activity also helps to maintain a healthy body weight. [HILL et al., 2007] Presumably, bodily inactivity can be viewed as a cardiovascular risk factor more severely than hypercholesterolemia and high blood pressure. [SCHULER, 2005]

For the promotion and reduction of cardiovascular diseases in adults, the WHO recommends at least 30 minutes of moderate-intense physical activity 5 days per week. [WHO, 2004b] A dose-response relation seems to exist, regarding the volume as well as the intensity of physical activity. The higher the levels of bodily exercise the more beneficial effects for health and the lower the risk for cardiovascular related deaths and diseases. [WARBURTON et al., 2006]

2.5.3 Overweight and obesity

Overweight and obesity attributed to more than 1 million deaths and 12 million life years of ill health annually. Regarding cardiovascular diseases, they are responsible for 35% of ischemic heart diseases and 55% of hypertensive diseases among European adults. [WHO, 2007c] In fact, obesity is identified as an independent risk factor for CVD such as CHD, heart failure and sudden death. A weight gain of 10 kg is associated with an estimated increase of CHD and stroke by 12% and 24%, respectively. [POIRIER et al., 2006]

The emerging global epidemic of overweight and obesity has become a major public health problem of high priority for the WHO in the 21st century. Estimations for the year 2010 expect that 150 million adults, living in the European Region suffer from abnormal or excessive body weight. An imbalance in dietary energy and energy expenditure largely explains the rapidly raising

prevalence of overweight and obesity. A lack of physical activity as well as the consumption of energy-dense foods, that are high in fat and/or sugar, contributes to gain weight. [WHO, 2007c]

Overweight and obesity may affect the heart through its impact on health determinants, which are linked to unfavourable metabolic changes like increased blood pressure, undesirable cholesterol levels as well as increased insulin resistance. As a result, in overweight and obese people the risk of coronary heart disease (CHD), stroke, diabetes mellitus and several forms of cancer raises. [WHO, 2002, 100] For instance, about 80% of cases of type 2 diabetes are linked to a body mass index (BMI) above 21kg/ m². [WHO, 2007c]

In that process, fat distribution of overweight and obese persons plays an important role in the development of cardiovascular events. Compared to the 'gynoid body form' where fat is mainly localized in hip and thigh, the 'android' body shape which is characterized by abdominal fat storage, tends to be associated with hypertriglyceridemia, hypercholesterolemia, hyperinsulinemia and lower HDL levels more often. A reduction of body weight by 7-10 kg can cause a definite improvement of plasma lipid's status. [WÄCHTERSHÄUSER and STEIN, 2004]

The *Interheart-Study* clearly showed that the risk for myocardial infarction doubled, in people with abdominal obesity compared to those with a normal waist to hip ratio. Furthermore, 63% and 28% of all heart attack cases could be attributed to abdominal fat in Western Europe and Central plus Eastern Europe respectively. [YUSUF et al., 2004]

Additionally, the *Renfrew-Paisley Study* investigated long-term cardiovascular consequences of obesity in a 20-year follow up of more than 15 000 individuals aged 45-64. Persons with a BMI≥30 were linked to a higher adjusted hazard for fatal or non-fatal coronary heart disease (1.60, 95%CI 1.45-1.78), heart failure (2.09, 95%CI 1.68-2.59), stroke (1.41, 95%CI 1.21-1.65), venous thrombo-embolism (2.29, 95%CI 1.60-3.30) and atrial fibrillation (1.75, 95%CI 1.17-2.65) compared with normal body weight. Overall, obesity was related to 9 additional cardiovascular deaths and 36 additional cardiovascular hospital admissions per

100 men and 7 additional deaths and 28 hospital admissions in 100 women.
[MURPHY et al., 2006]

Several studies on the optimum BMI to reduce mortality and morbidity indicate a mean adult value of about 20-22 kg/m². Exceeding this favoured BMI levels results in a progressive increase of risk in all populations. [WHO, 2002b]

3 Methods and Material

3.1 Dietary pattern information

For time trend analyses of selected food commodities data of the food balance sheets, provided by the Food and Agriculture Organization of the United Nations was used. Data was downloaded from an archive CD-Rom of the FAO Statistical Databases (FAOSTAT), last updated in March 2006. The focus was on the supply of fruit, vegetables and fat, derived from animal or vegetable origin.

Evolution of diet over the last 40 years, actually from 1961-2003 could be evaluated in European countries, shown in numerous graphs. Furthermore, variations in trends of food commodities across European countries were examined.

Currently available FBS-data on fat supply of 2003 was taken to analyse possible existing inter-country differences. Therefore, the total fat supply was shown in fat to energy ratio, which is defined as the percentage of energy derived from fat in the total supply of energy (in kcal).

If dietary data is energy adjusted instead of presented in absolute terms, overestimation errors of several food items could be reduced. [NASKA et al., 2007]

The DAFNE-database was utilised to compare dietary habits in 24 European nations, with an emphasis on the mean availability of fruits, vegetables and added lipids. DAFNE data is freely available through the web-based DAFNEsoft application tool.

Figure 3: DAFNE food classification system of added lipids [The DAFNE databank, 2008]

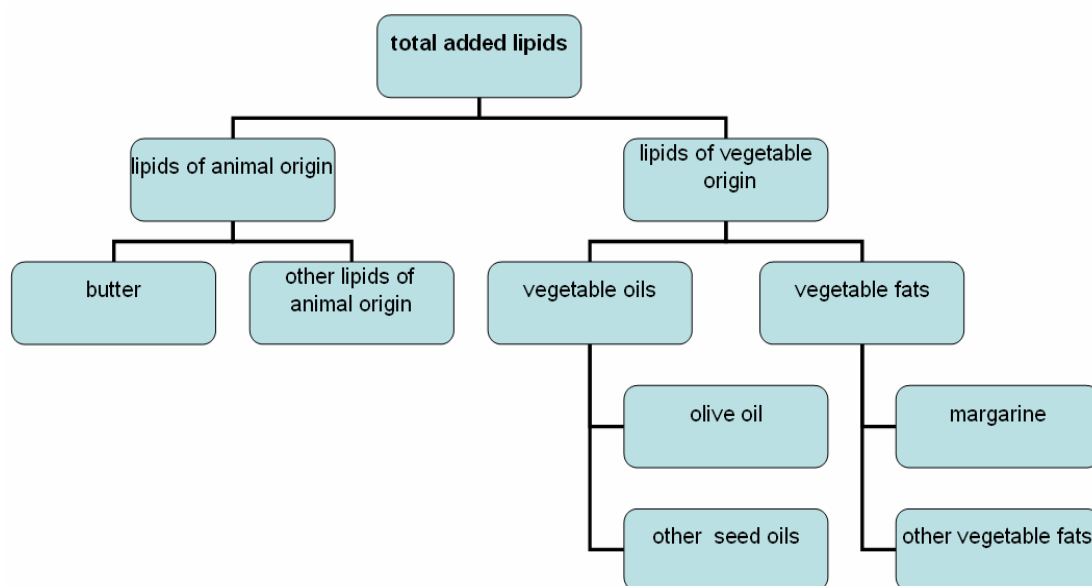


Table 10: DAFNE food classification system [The DAFNE databank, 2008]

Fish and seafood	Meat and meat products
• Fish • Seafood • Fish dishes	• Red meat (fresh and frozen) - Pork meat - Beef, veal and calf meat - Red meat other than pork or veal - Poultry (fresh and frozen) - Offals (fresh and frozen) • Canned meat and meat products • Meat dishes
Fruits (fruit juices excluded)	Vegetables (vegetable juices excluded)
• Fresh fruits - Apples - Citrus - Bananas - Grapes - Plums - Berries - Apricots and peaches - Cherries and sour cherries - Pears - Other fresh fruits • Processed fruits	• Fresh vegetables - Green leafy vegetables - Cabbage - Tomatoes - Carrots - Onions and garlic - Other fresh vegetables • Processed vegetables

Moreover, the DAFNE database provided the most appropriate data on specific dietary patterns for statistical correlations with mortality from all causes, total cardiovascular diseases, ischemic heart diseases and cerebrovascular diseases.

3.2 Mortality information

Data on cardiovascular mortality rates were provided by the WHO and retrieved from its European health for all database (HFA-DB), which contains approximately 600 indicators for the 53 European WHO member states. These indicators include information of basic demographics, health status, health determinants and health care, containing time series of several countries started in the 1970s.

Data used in this study covered age-standardised mortality rates of all ages, which were expressed as rate per 100 000 per year. In view of the large heterogeneity in age across European countries, standardisation was needed for comparison of mortality rates between countries. Age standardisation was performed by the direct method, representing what the crude death rate would have been if the population had the same age distribution as the standard European population. Diseases of the circulatory system (cardiovascular diseases) were defined as ICD-10 codes I00-I99, cerebrovascular diseases as ICD-10 codes I60-I69 and ischemic heart diseases as ICD-10 codes I20-I25. [WHO, 2008c]

The country grouping Eur-A categorizes 27 countries in the WHO European Region with very low child and adult mortality, namely Andorra, Austria, Belgium, Croatia, Cyprus, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Israel, Italy, Luxembourg, Malta, Monaco, the Netherlands, Norway, Portugal, San Marino, Slovenia, Spain, Sweden, Switzerland and the United Kingdom. In contrast, the Eur-B+C category includes 26 countries in the WHO European Region with higher levels of mortality, notably Albania, Armenia, Azerbaijan, Belarus, Bosnia and Herzegovina, Bulgaria, Estonia, Georgia, Hungary, Kazakhstan, Kyrgyzstan,

Latvia, Lithuania, Montenegro, Poland, Republic of Moldova, Romania, Russian Federation, Serbia, Slovakia, Tajikistan, TFYR Macedonia, Turkey, Turkmenistan and the Ukraine. The European Union (EU)-group includes all 27 member states of the European Union, such as Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Germany, Estonia, Finland, France, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Sweden, Slovakia, Slovenia, Spain and the United Kingdom,

For comparison among 30 different European countries, cardiovascular mortality data of the year 2004 was used, due to the fact that this year showed the most complete dataset.

Cardiovascular evolution was evaluated for each country from the 1970s to 2000. To reduce random variation in annual mortality rates in trend calculations, rates were averaged for 3 years. Therefore the 3 earliest sequent years, usually from the 1970s and the 3 latest sequent available years from the 21st century were used. However, for several countries time series were not available for the selected time series. Secondly trends in percentage of the initial mortality rate were calculated by the software programme Microsoft Excel 2002. Furthermore this programme was used to visualise trends in cardiovascular mortality rates for the last 4 decades.

Moreover, the HFA-DB provided the most appropriate mortality data for statistical correlations with DAFNE food availability information. In the case of Spain and Norway, where DAFNE facts were not available for a single year, the average mortality rate of the specified time range was calculated.

3.3 Statistical analysis

Statistical analysis of DAFNE data, including 24 European countries was carried out using the statistical software package SPSS version 15.0.

Simple Spearman's correlation coefficients were utilised to identify a relation between each of the exposure variables (per capita availability per day) and each of the outcome variables (death per 100000 persons per year). Additionally, correlations between SES determinants like HDI and gross

domestic product in purchasing power parities (PPP) in US \$ per capita, derived from the WHO HFA-DB, were examined by those bivariate correlations. Statistical significance was set at the 0.05 level (two-tailed).

According to the identification of significant differences in mortality rates among men and women the Mann-Whitney-U-Test displayed the ideal method for evaluation. Moreover, non-parametric tests were used to find out, if there were statistically significant geographical distinctions in the number of cardiovascular death. When European countries were classified by standardized cardiovascular mortality (high rates >325 per 100 000; low <325 per 100 000), the Mann-Whitney-U-Test represents a meaningful approach to evaluate potentially existing variations in the amounts of food available in the disposed category.

4 Results

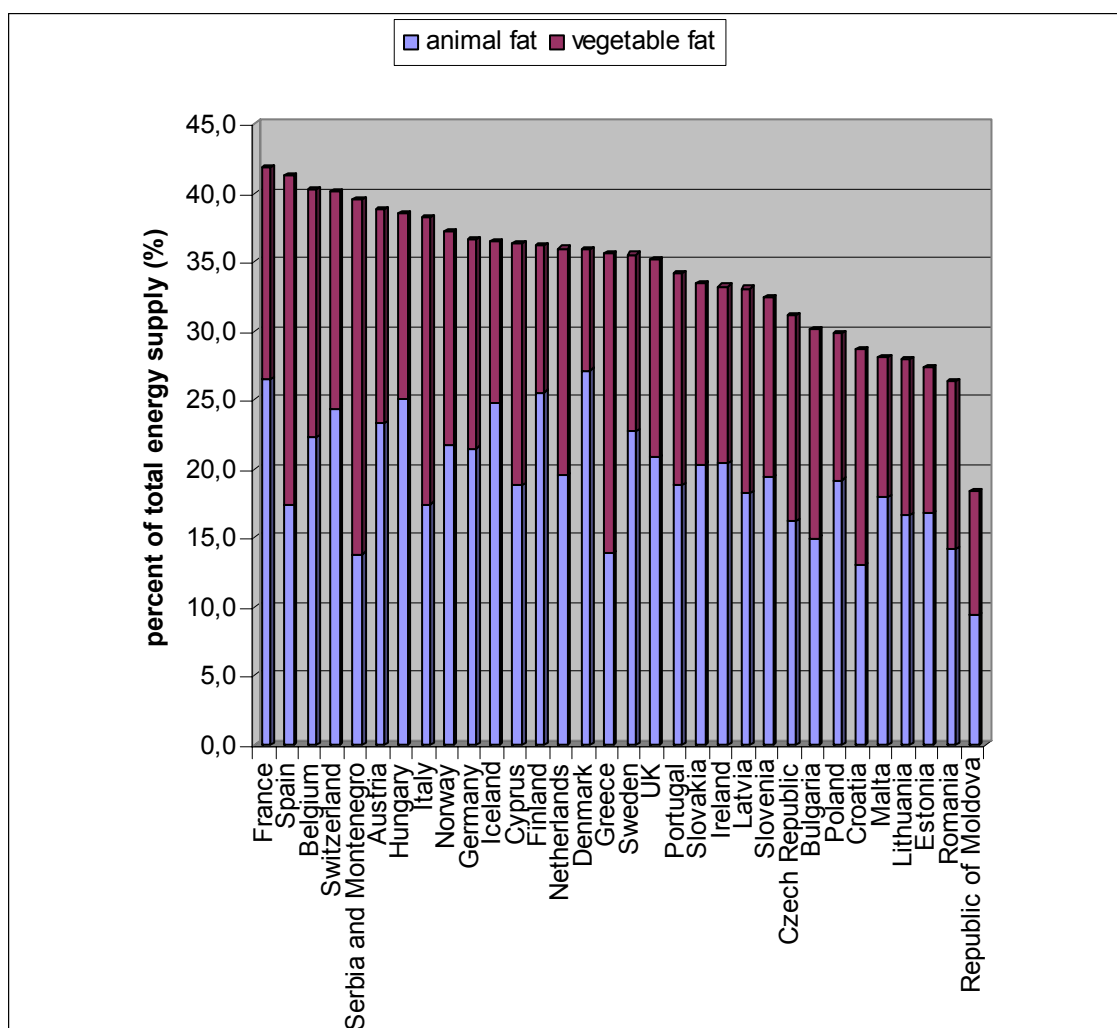
4.1 Analysis of European dietary patterns

4.1.1 Comparison of dietary patterns in European countries

Looking at the share of calories from lipids in dietary energy supply there was a heterogeneous picture among European countries (Figure 4). In addition to the total amount of fat presented in energy-adjusted terms, types of dietary fat also showed numerous differences within Europe. Figure 4 demonstrates that the fat to energy ratio varied between 41.8% in France to 18.4% in the Republic of Moldova. Except Hungary, the share of calories from lipids in the dietary energy supply was generally low in Eastern Europe. In comparison to other European countries, several Western European nations like France, Belgium and Switzerland reported high ratios of mean fat to energy supply.

Whereas in Northern and Western European citizens a higher animal fat supply was prevalent, the majority of countries geographically localized in the South was characterized by higher amounts of fat derived from vegetable origin. For example considering the share of animal fat to total energy supply, the Danish had a three times higher ratio (27.1%) than people living in the Republic of Moldova (9.4%).

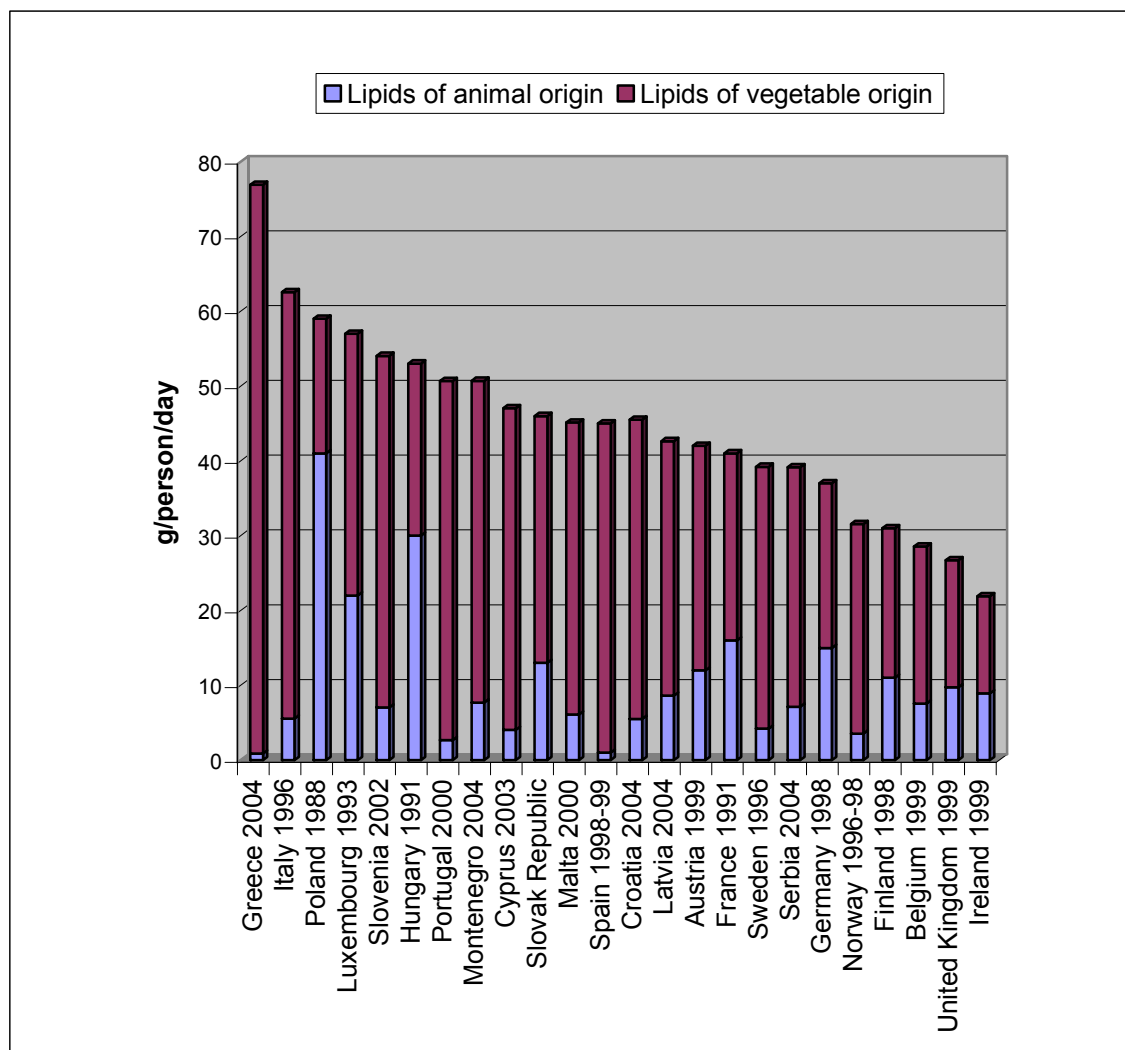
Figure 4: Share of calories from lipids in dietary energy supply in 2003 [FAO, 2006]



According to latest disposable DAFNE food availability data, added fat quantity and quality clearly differed between the observed 24 European nations. Figure 5 shows that added lipids of vegetable origin determined the main part of added lipids available for consumption in European nations like Greece, Italy, Portugal, Slovenia, Montenegro, Cyprus, and Croatia. Unlike that situation in Southern European countries, a high mean availability of added lipids of animal origin characterized the diet of European nations localized in the east. For example, the Greeks added on average 0,88g lipids derived from animal sources per person to their daily diet, compared to Polish inhabitants, who reported values of 41 g per person/day.

Considering the mean availability of total added lipids, Greece reported the highest values in 2004 (77g/capita/day), followed by Italy (63g/capita/day).

Figure 5: Mean availability of added lipids in European country, latest available year [The DAFNE databank, 2008]



According to dietary information provided by the DAFNE databank the available amounts of fruit presented in g/capita/day were in general higher in Southern European countries, except in Serbia and Croatia. A comparison of fruit availability of several European countries presented in figure 6 clearly indicates that Greece, Malta and Cyprus reached mean values above 250g/person/day, compared to Poland or Ireland, which reported to have approximately 2.5 times less fruit/person/day available for consumption. It has to be noted that generally

in Northern European countries, daily fruit availability was lower than in the rest of Europe.

Figure 6: Mean availability of fruits in European countries, latest available year [The DAFNE databank, 2008]

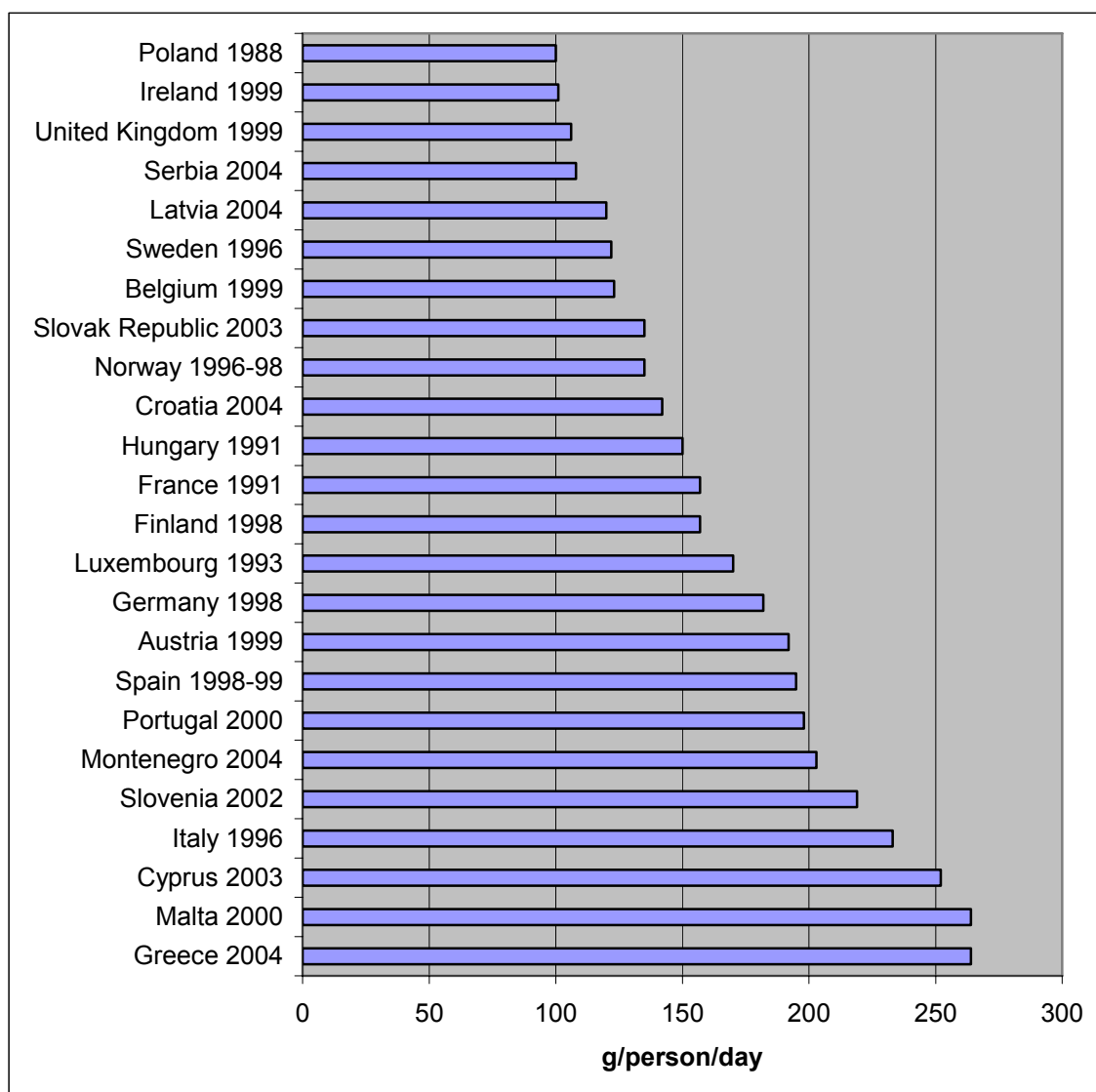
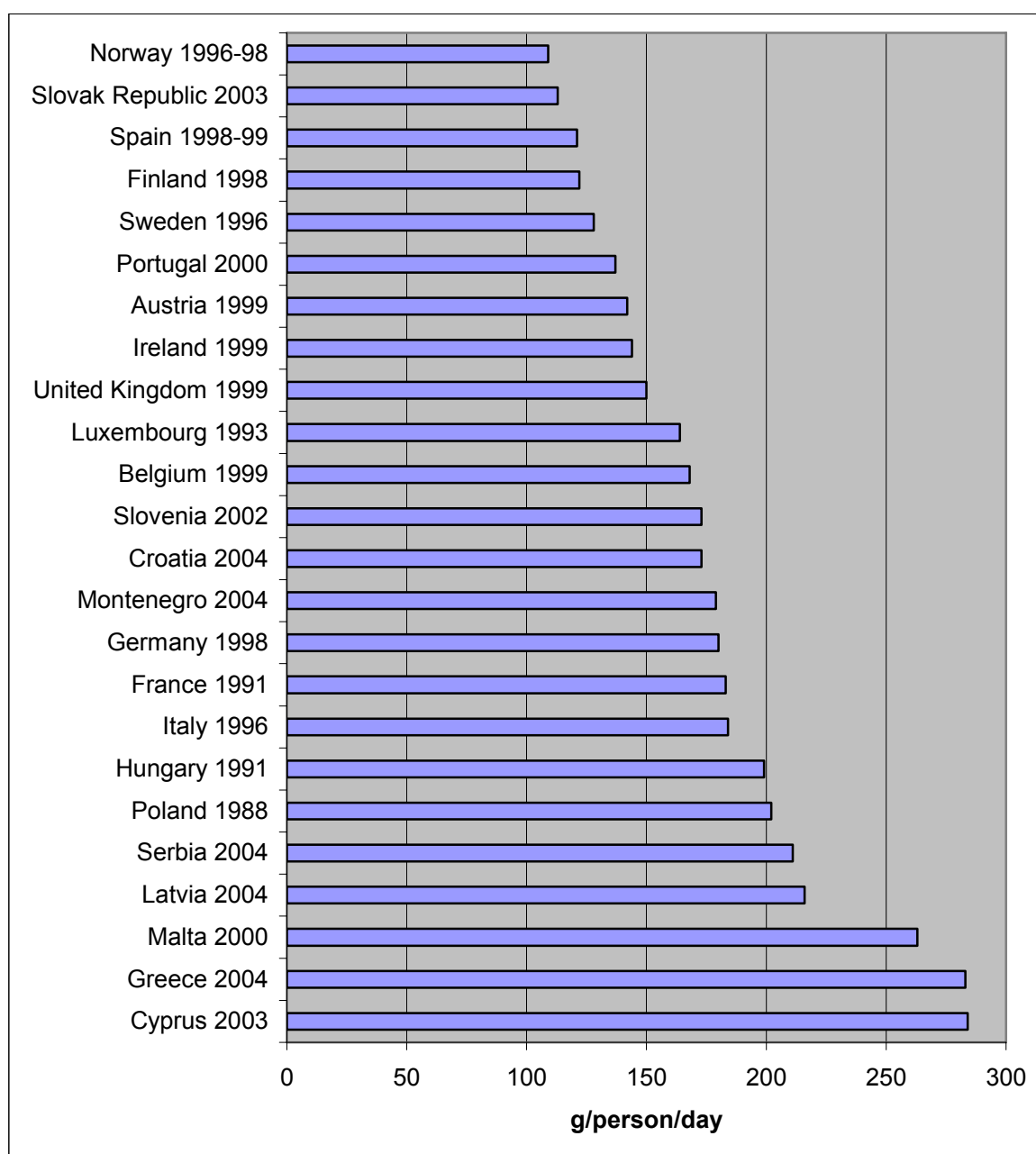


Figure 7 again presents a large range in daily vegetable availability. Again, the Mediterranean countries Cyprus (284g/person/day), Greece (283 g/person/day) and Malta (263g/person/day) occupied the leading position. In contrast, in Norway the amount of vegetables available for consumption was only 109 g/capita/day in the observed period 1996-1998, followed by the Slovak Republic (113g/capita/day) and Spain(121g/capita/day). In general, lower vegetable

availability was characteristic for Northern Europe. More differences in DAFNE vegetable availability data due to geographical variation were not really identified among those 24 European countries.

Figure 7: Mean availability of vegetables in European countries, latest available year [The DAFNE databank, 2008]



4.1.2 Trends of dietary patterns in European countries

Table 11 shows the evolution of animal fat supply presented in kg/capita/year over the last 4 decades in selected European nations. In trend analysis, country specific variations definitely existed. The highest increases of animal fat supply were observed in Spain (+246.7 % in 2003 compared to 1961), followed by Italy (+220.6%) and Greece (+100%). A raise in Hungary, Germany, Switzerland, Romania and Sweden was also considerable. In contrast, the average per capita supply of fat derived from animal sources showed a relatively large decreasing tendency in the United Kingdom (-63.6% in 2003 compared to 1961), Norway (-48.8) and Finland (-47.5).

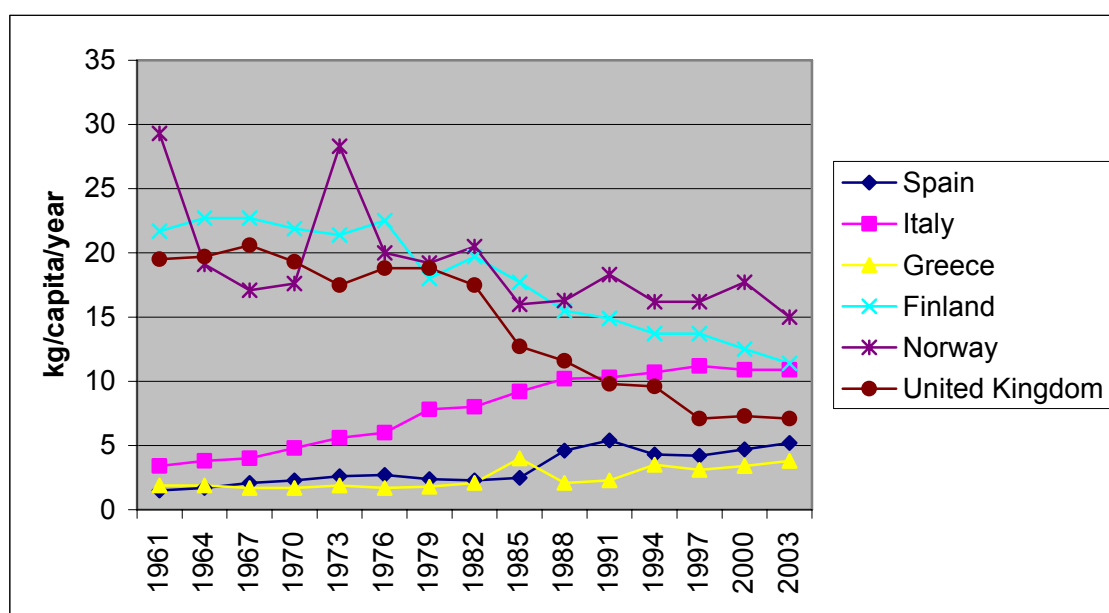
Table 11: Development of animal fat supply (kg/capita/year) in selected European countries 1961-2003 [FAO, 2006]

Country	1961	2003	Trend (%)
Spain	1,5	5,2	246,7
Italy	3,4	10,9	220,6
Greece	1,9	3,8	100,0
Hungary	22,6	28	23,9
Germany	19	21,8	14,7
Switzerland	10,2	11,3	10,8
Romania	3,8	4,2	10,5
Sweden	18,9	19,1	1,1
Bulgaria	4,3	3,8	-11,6
Austria	22,3	17,8	-20,2
Poland	21,1	14,7	-30,3
Ireland	17,9	10,5	-41,3
Finland	21,7	11,4	-47,5
Norway	29,3	15	-48,8
United Kingdom	19,5	7,1	-63,6

It has to be mentioned, that the highest decreases in daily animal fat supply per kg/capita over the last 4 decades appeared in some Northern European countries, whereas the opposite trend was observed in several participating

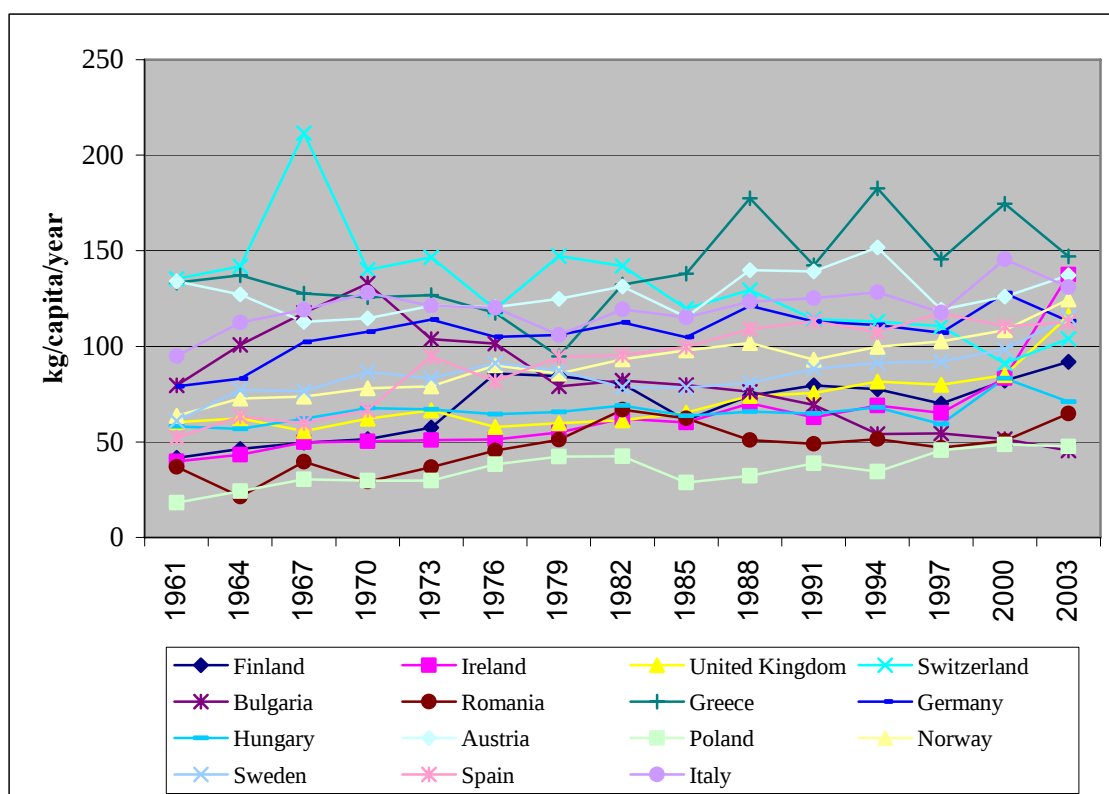
Mediterranean countries (Figure 8). However, in several Southern European countries, Romania and Bulgaria the average animal fat supply was low in 2003 in comparison with European countries localized in the north.

Figure 8: Trends in animal fat supply in selected European countries 1961-2003 [FAO, 2006]



In all observed European countries except Bulgaria and Switzerland the average per capita fruit supply increased within the studied period of 42 years (Figure 9). Expressed in percentage of changes compared to the initial year 1961, Ireland reported the highest increases in average fruit supply (+246.6%), followed by Poland (+161.5%) and Finland (120.9%). On the other hand, Greece recorded only marginal favoured trends in fruit supply (+10.2%). Thereby it is necessary to mention that Ireland, Poland and Finland had characteristic low values of average fruit supply in 1961, compared to other nations in Europe. Regarding the year 2003, in eastern European countries low fruit supply was in general observed whereas the Greeks reported the highest average values, followed by Europeans living in Ireland and Austria.

Figure 9: Trends in fruits supply in selected European countries 1961-2003 [FAO, 2006]

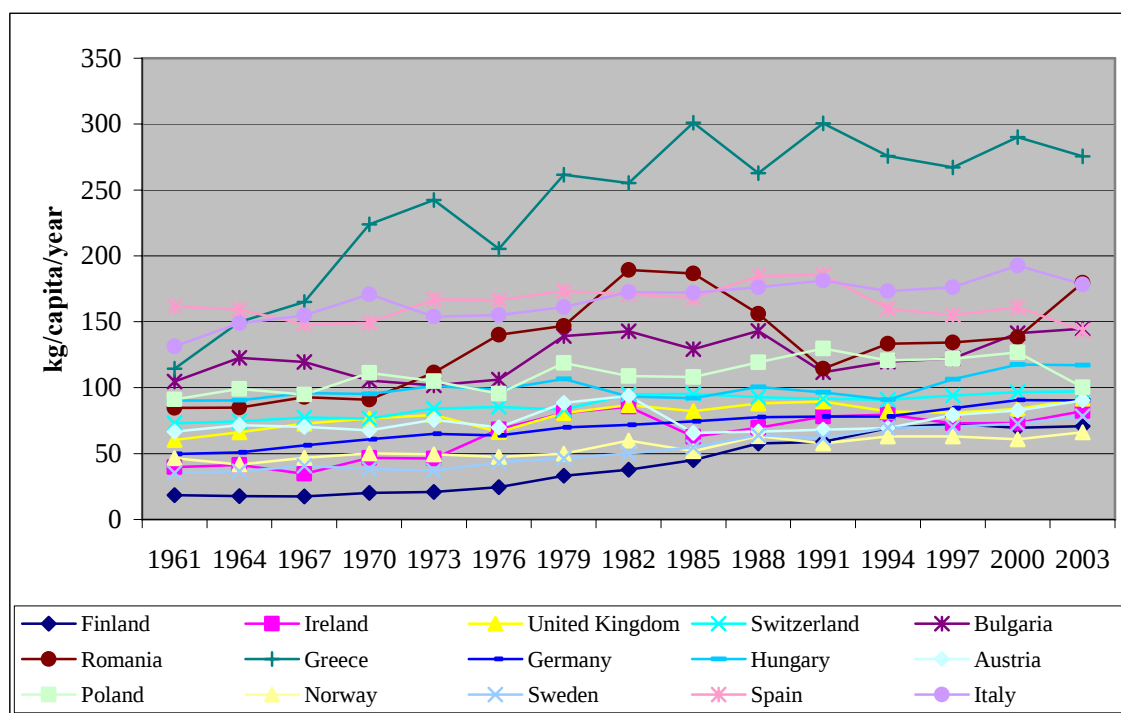


Trend analyses in the amounts of vegetables available in European countries differ notably from each other (Figure 10). The majority of observed nations reported an increasing tendency over the last 4 decades. Spain was the only country where the average vegetable supply was lower in 2003 than in 1961 (161.7 compared to 143.4 kg/capita/year). The most remarkable increases were identified in the Scandinavian countries Finland (+282.2%) and Sweden (+122.1%), as well as in Greece (+140.8%). Compared to the other observed European countries most eastern nations like Poland, Hungary and Bulgaria tended to show only slightly increases in vegetable supply (+10-40%).

Considering the average vegetable supply in Europe in 2003 a clear south-north gradient was found. For instance, the Greek population had approximately 4 times more vegetables available for consumption than the people from Norway or Finland (275.7 kg/capita/year compared to 66.2 and 70.7 respectively). Moreover, it is necessary to mention that several eastern European countries,

namely Romania and Bulgaria reported vegetables supply above 140 kg/capita/year in 2003.

Figure 10: Trends in vegetable supply, selected European countries 1961-2003 [FAO, 2006]

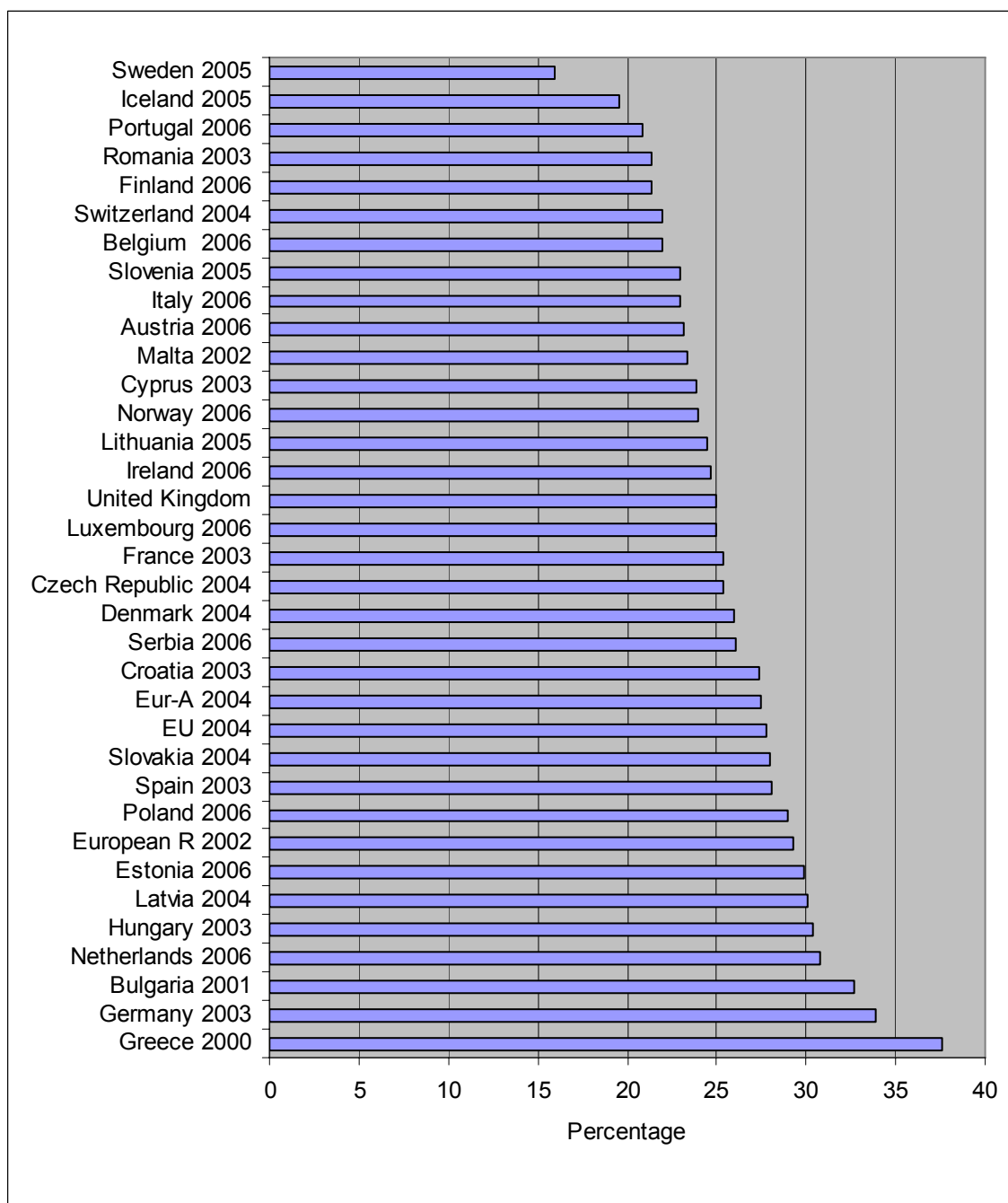


4.2 Lifestyle patterns

4.2.1 Smoking

The prevalence of smoking in Europeans aged older than 15 ranged from about 16% in Sweden in 2005 to 38% in Greece in 2000, indicating a high variation within Europe (Figure 11). In the European Region, including altogether 53 European countries altogether nearly one in three persons used to smoke regularly. Whereas Sweden and Iceland reported percentage rates of regular daily smokers below 20%, Latvia, Hungary, the Netherlands, Bulgaria, Germany and Greece clearly exceeded 30%. According to geographical similarities, there was no marked association.

Figure 11: Percentage of regular daily smokers in Europe aged 15+, latest available year [WHO HFA-DB, 2008b]



European Region: 53 European countries included

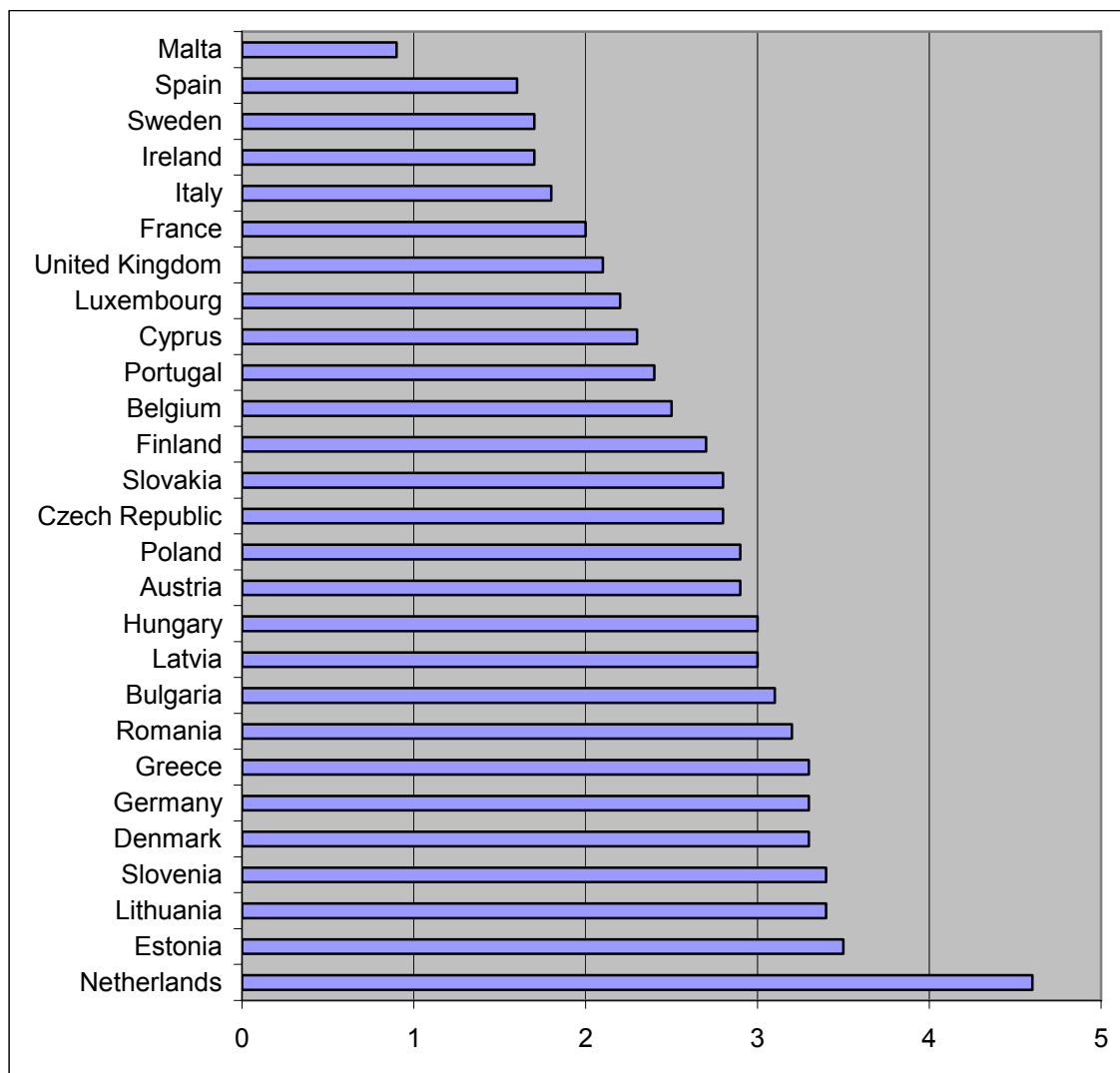
EU: the 27 member states of the European Union

Eur-A: 27 countries in the WHO European Region with very low child and adult mortality

4.2.2 Physical activity

An analysis of the average performance of physical activity reveals contrasting situations in European nations. Whereas Malta reported to do moderate physical activity on 0.9 days during the last 7 days, the levels in Netherlands were 5 times higher (4.6 days on average). Southern European countries, except Greece and Slovenia tended to be less physical active than the rest of Europe. In general, nations localized in the east of Europe occupied a position in the middle range. Furthermore, the Baltic States were characterized by higher levels of moderate physical activity compared to other European countries. [EUROPEAN COMMISSION, 2006]

Figure 12: Average number of days of moderate physical activity* by country during the last week [EUROPEAN COMMISSION, 2006]



*moderate physical activity: e.g. carrying light loads, cycling at a normal pace, playing doubles tennis

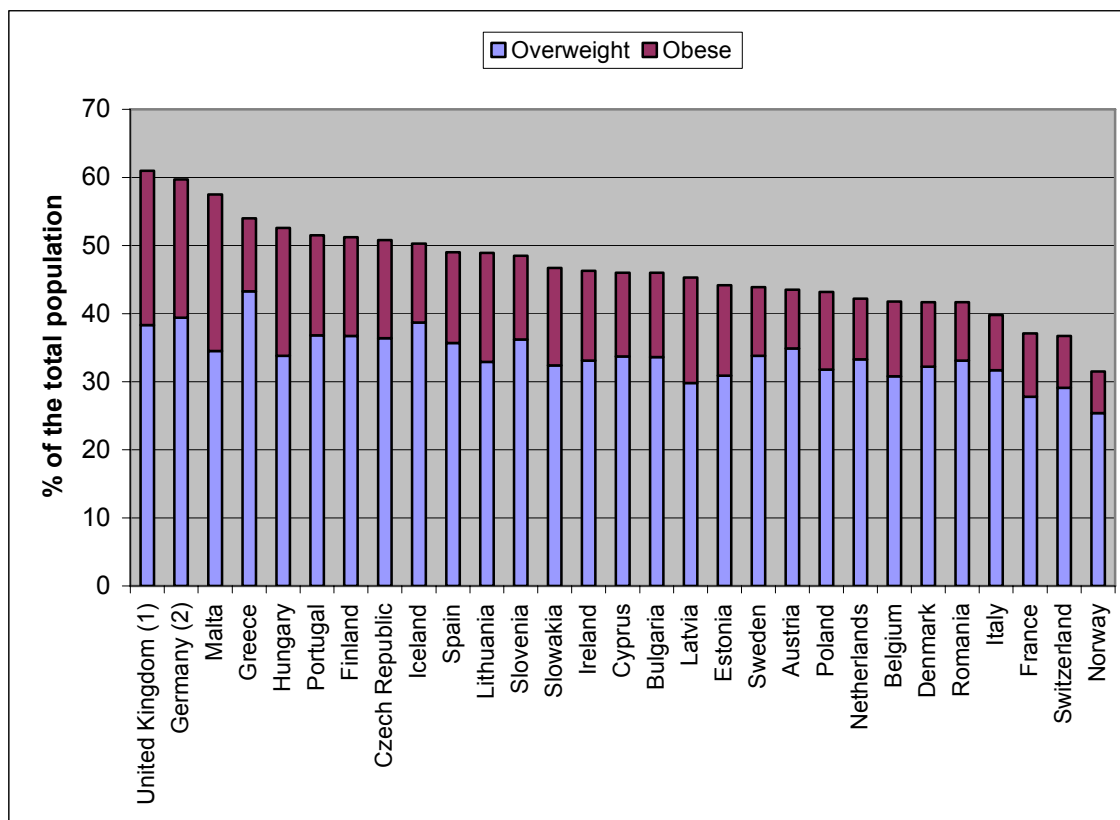
4.2.3 Overweight and obesity

The prevalence of overweight and obesity definitely differs in the selected European countries (Figure 13).

Data from national Health Interview Surveys (HIS) 2003 demonstrates that in a large number of European countries, namely England, Germany, Malta, Greece, Hungary, Portugal, Finland and Czech Republic more than 50% of the total population seem to be overweight or even obese. As shown in figure 13 the lowest overweight rates identified were in Norway, Switzerland, France and

Italy, where less than 40% of the total population exceed a BMI of 25 kg/m². Countries like Iceland, Lithuania, Slovenia, Slovakia, Ireland, Cyprus, Bulgaria, Latvia, Estonia, Sweden, Austria, Poland, the Netherlands, Belgium and Denmark reported a range between 41% in Romania and 49% in Spain. [EUROSTAT, 2008]

Figure 13: Percentage of overweight and obese people in relation to the total population by country, all ages [EUROSTAT-database, 2008]



(1) only England

(2) including ex-DDR since 1991

Overweight classified as BMI 25-30

Obese classified as BMI >30

Data from national Health Interview Surveys (HIS) Round 2004, 1999-2003 depending on the country

4.3 Analysis of European Cardiovascular Mortality

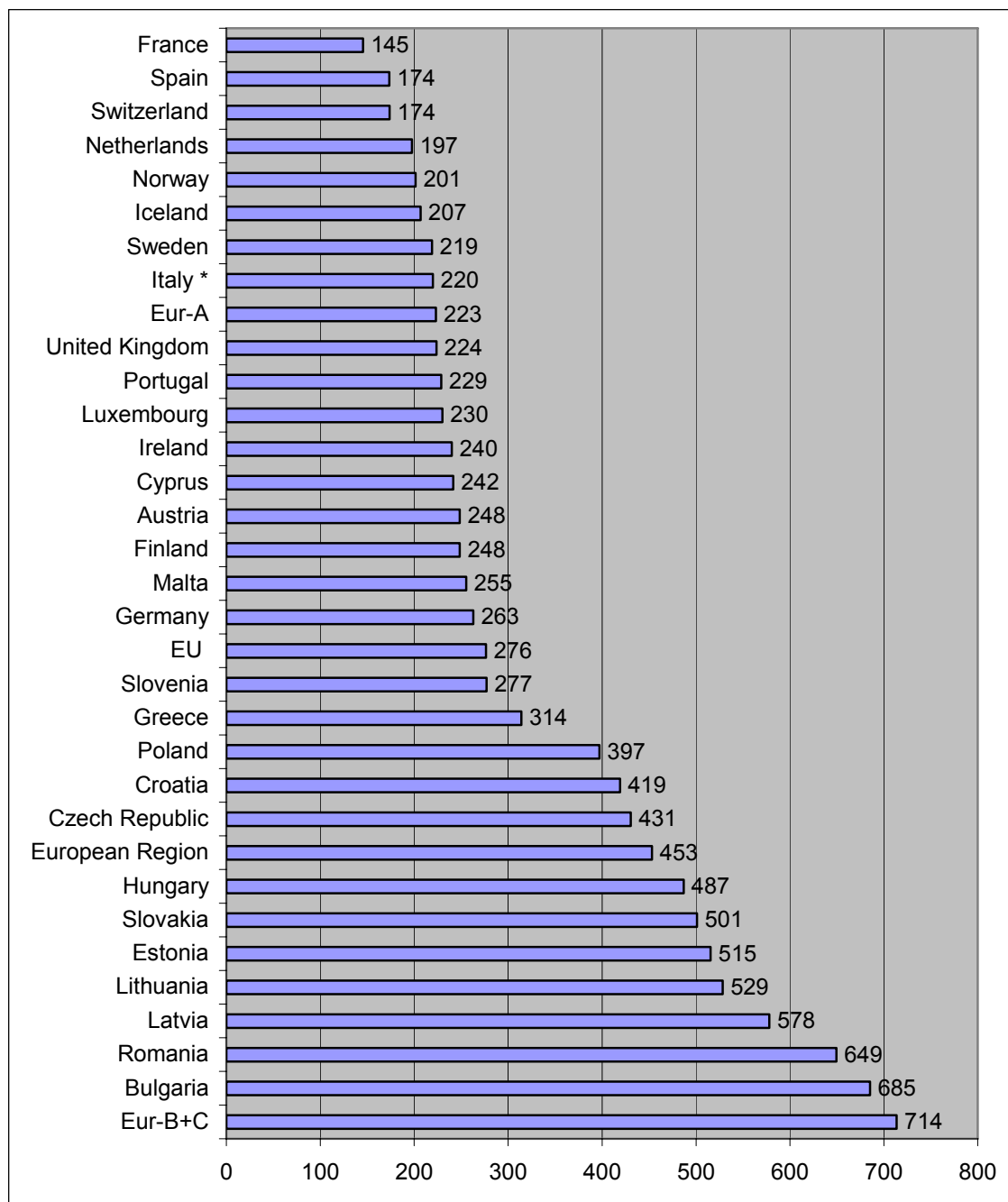
4.3.1 Cardiovascular Diseases Mortality statistics

An analysis of cardiovascular mortality by country reveals contrasting situations. There are remarkable inter-country differences in age-standardized cardiovascular death rates (Figure 14).

In 2004, France, Spain, Switzerland and the Netherlands reported values below 200 deaths per 100 000 per year inhabitants, whereas the country group Eur-B+C, Bulgaria and Romania exceeded annual cardiovascular mortality rates of 500 deaths per 100 000 persons. Furthermore, the Baltic States Latvia, Lithuania and Estonia are as well characterized by a high cardiovascular mortality burden. For a European citizen living in Bulgaria, the risk of dying because of CVD approximately is 4.5 times higher, compared to a French inhabitant.

Additionally it is conspicuous that geographical variations were apparent. For instance, in comparison to western and southern European countries, eastern nations showed statistically significant higher cardiovascular mortality rates ($p=0.004$, $\alpha=0.01$ for Western Europe and $p=0.022$, $\alpha=0.01$ for Southern Europe) In view of more similarities due to geographic neighbourhood, there were no obvious particularities. In Western Europe, Northern Europe as well as Southern Europe several countries were characterized by high cardiovascular death, while others had low or mean mortality rates.

Figure 14: Age-standardized death rates of cardiovascular diseases per 100 000 by country, 2004 [WHO HFA-DB, 2008b]



*Italy: data from 2002

European Region: 53 European countries included

EU: the 27 member states of the European Union

Eur-A: 27 countries in the WHO European Region with very low child and adult mortality

Eur-B+C: 26 countries in the WHO European Region with higher levels of mortality

4.3.2 Gender differences in CVD

Looking at gender specific differences of age-standardized cardiovascular deaths, a highly significant relationship could be determined ($p=0.004$, $\alpha=0.01$). Without exceptions, in 2005 cardiovascular mortality rates among European men were explicit higher compared to women. For instance, in the Baltic States and Finland women reported lower values by about 45%. In Latvia, men had approximately a double risk of cardiovascular death, compared to female Latvians. In contrary to these northern European countries, gender differences in Greece and Serbia obtained only percentage rates of 20%.

4.3.3 Trends in cardiovascular mortality

Regarding time trends of age-standardized cardiovascular mortality, the changes over the last 30 years among European countries show a diverse picture. Several northern European countries like Finland, Ireland and the United Kingdom demonstrated the most tremendous decline of cardiovascular mortality, reaching percentages of up to 62.8 % in Finland. Contrasting situations in trend analyses are shown in other northern European nations. For instance, in the Baltic States the decrease in cardiovascular deaths is much lower, showing values by about 10% in Lithuania to 29.3% in Estonia. Without exceptions, all Western European countries, where mortality data was available for the selected period, could halve their values. Among the southern countries, Greece occupies an exceptional position. Whereas in Italy, Malta, Portugal, Slovenia and Spain decreases of cardiovascular mortality rates score the 50% value, there was only a marginal decline of about 5% noticeable in Greece. Table 12 clearly shows that in contrast to other European countries, Greece had already low rates of cardiovascular mortality per year in the 1970s (311 deaths per 100 000 inhabitants). According to WHO mortality data in the 21st century the majority of countries as well have cardiovascular death rates below 300 per 100 000 annually.

Compared to other European nations, countries localized in the east could only lower cardiovascular mortality rates slightly (Romania, Poland and Slovakia) or

even an increase (Bulgaria) was perceivable. For instance, in the 1970s 583 persons per 100 000 died because of cardiovascular outcomes in Bulgaria, compared to the 21st century were on average 707 deaths per 100 000 were reported. Including all 53 countries of the European region, results in a decline of cardiovascular mortality rates by 12.5% for the last 3 decades.

Table 12: Time trends in age-adjusted cardiovascular mortality rates from 1970s to latest available years in 2000 [source of raw data: WHO-HFA-DB, 2008b, own calculations]

Countries	70s	2000	Trend in %
Finland	675,5	251,3	-62,8
Ireland	605,6	238,1	-60,7
United Kingdom	548,7	226,0	-58,8
Switzerland	440,1	183,9	-58,2
Austria	556,4	239,4	-57,0
Norway	458,9	199,5	-56,5
Luxembourg	550,4	240,8	-56,3
France	346,1	155,5	-55,1
Malta	599,4	272,1	-54,6
Iceland	434,7	197,5	-54,6
Spain	439,2	207,4	-52,8
Italy	478,4	227,7	-52,4
Netherlands	440,3	209,9	-52,3
Portugal	509,7	249,0	-51,1
Sweden	467,1	232,1	-50,3
Belgium³	488,5	253,3	-48,1
Slovenia¹	518,8	275,4	-46,9
Denmark	473,5	254,3	-46,3
Eur-A¹	403,8	227,5	-43,7
EU¹	448,9	281,0	-37,4
Czech Republic	651,6	437,1	-32,9
Estonia¹	737,0	521,8	-29,2
Germany²	385,0	278,5	-27,7
Croatia¹	586,0	425,2	-27,4
Hungary	681,0	499,2	-26,7
Latvia¹	710,4	573,6	-19,3
Poland	487,5	399,3	-18,1
Slovakia	594,1	512,0	-13,8
European Region	527,1	461,4	-12,5
Lithuania¹	596,9	537,0	-10,0
Romania	670,4	637,9	-4,8
Greece	311,0	297,4	-4,4
Eur-B+C¹	654,9	726,1	10,9
Bulgaria	582,9	707,5	21,4

age-adjusted mortality rates averaged for 3 years

¹ earliest data only available for 80s

² earliest data only available for 90s

³ data for trend calculation available for 70s and 90s

European Region: 53 European countries included

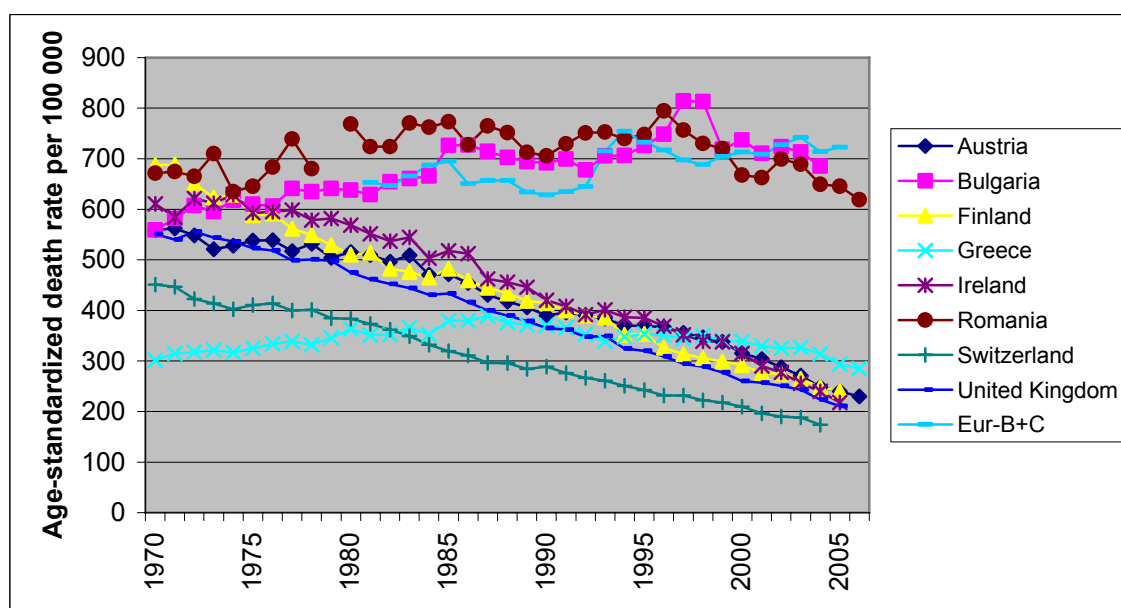
EU: the 27 member states of the European Union

Eur-A: 27 countries in the WHO European Region with very low child and adult mortality

Eur-B+C: 26 countries in the WHO European Region with higher levels of mortality

Figure 15 visualizes the evolution of cardiovascular diseases in selected European countries.

Figure 15: Evolution of cardiovascular mortality of selected European countries between 1970 and latest available year. [WHO HFA-DB, 2008b]



4.4 Relationship between dietary patterns and CVD in Europe

Table 13 presents the results of statistical analysis on the relationship between rates of total cardiovascular mortality, various types of cardiovascular outcomes like ischemic heart diseases and cerebrovascular diseases as well as mortality from all causes and several dietary patterns.

Table 13: Association between standardized death rates from cardiovascular-, ischemic- and cerebrovascular diseases and dietary patterns (simple correlation coefficients and p values) [Source of raw data: DAFNE, 2008; WHO HFA-DB, 2008b]

Food item	CVD	IHD	CeVD	total mortality
total added lipids	0.097	-0.379	0.478*	0.102
added lipids of animal origin	0.457*	0.294	0.004	0.551**
added lipids of vegetable origin	-0.292	-0.444*	0.332	-0.353
vegetable oils	-0.103	-0.415	0.456*	-0.129
olive oil	-0.277	-0.495*	0.140	0.491*
vegetable fats	0.193	0.429	-0.132	0.014
total meat	0.531*	0.238	0.593**	0.388
red meat	-0.079	-0.502*	0.511*	-0.122
meat products	0.656**	0.565**	0.237	0.542**
meat dishes	-0.359	0.107	-0.609**	-0.189
offals	0.462*	0.271	0.335	0.276
total fish and seafood	-0.585**	-0.381	-0.087	-0.453*
fruits	-0.419	-0.452*	0.075	-0.501*
vegetables	0.388	-0.42	0.438*	0.126

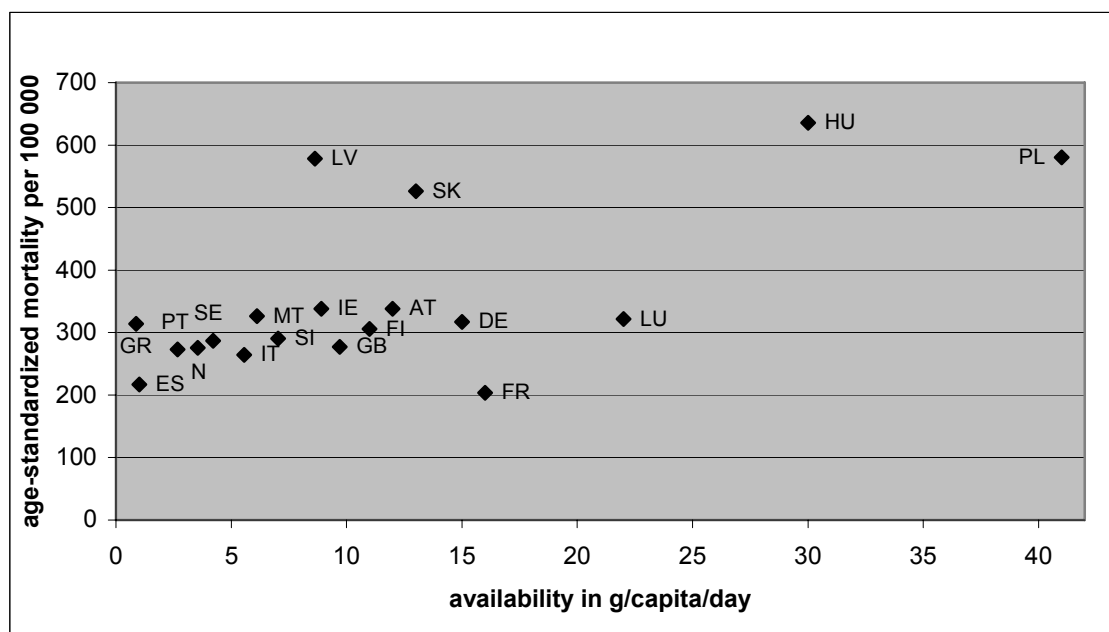
* $p < 0.05$; ** $p < 0.01$

IHD: Ischemic heart disease

CeVD: Cerebrovascular diseases

According to cardiovascular diseases, a positive significant association with various food groups, namely added lipids of animal origin, total meat, meat products and offals was identified among the observed 24 European countries. Figure 16 clearly presents the association between added lipids of animal origin and cardiovascular diseases as exposure variable. Furthermore, higher levels of fish availability, were significantly linked to lower cardiovascular mortality rates.

Figure 16: Association between added lipids from animal origin and age-standardized cardiovascular mortality rates per 100 000, latest available year [DAFNE, 2008, WHO HFA-DB, 2008b]



In view of ischemic heart diseases separately, the results vary. There was a statistical significant association with added lipids of vegetable origin, added olive oil, red meat, meat products and fruit. Whereas a higher availability of added lipids of vegetable origin, in particular olive oil, red meat and fruit were linked to a lower cardiovascular mortality, meat products were associated with an increased risk.

Regarding cerebrovascular diseases, a positive significant relationship between total added lipids, as well as added vegetable oils, total meat, red meat and vegetables available for consumption was determined in the observed European countries. Moreover, lower meat dishes availability was associated with higher cerebrovascular death.

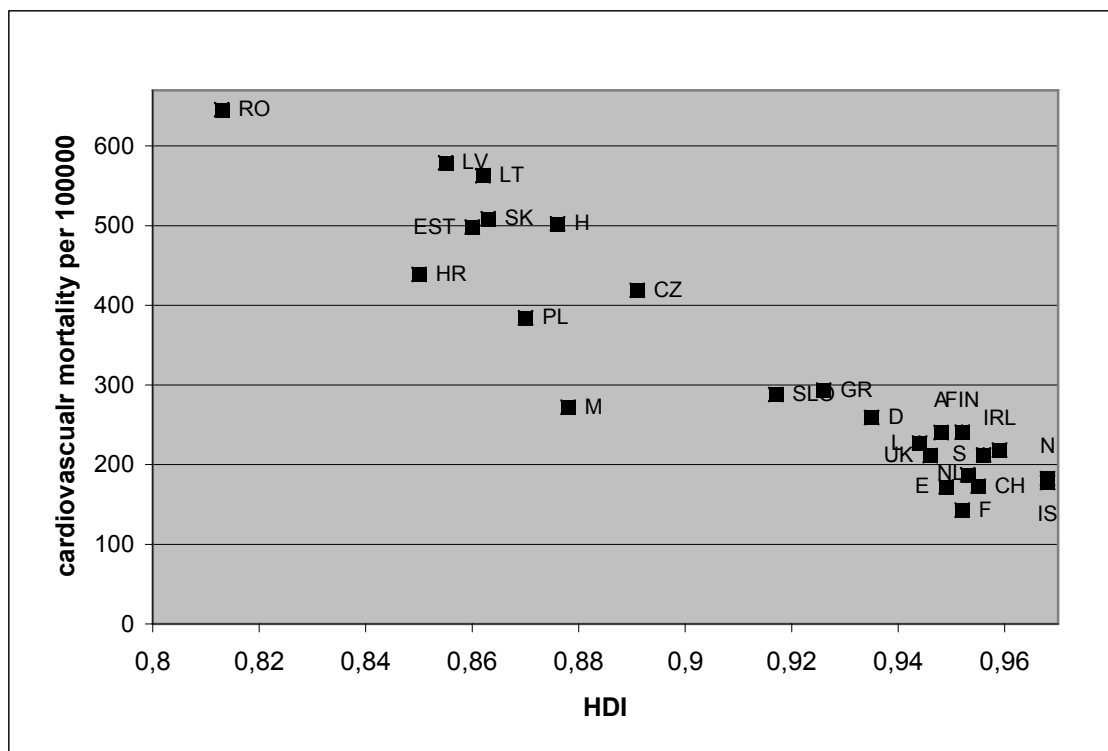
In analyses of mortality from all causes, the increased availability of added lipids of animal origin, added olive oil as well as meat products, was significantly linked to higher mortality rates. In contrast, total fish and seafood and fruit availability showed in general a negative statistically significant association with mortality.

Furthermore, if the observed European countries were classified regarding their number of cardiovascular mortality, some statistical correlations could be identified. The category of standardized cardiovascular mortality rates below 325 per 100 000 was significantly linked to lower availability of total meat ($p=0.012$), offals ($p=0.035$) and meat products ($p=0.014$). Besides, there was a strong inverse association between total fish and seafood availability and cardiovascular mortality ($p=0.023$).

4.5 Relationship between socioeconomic status and CVD in Europe

Considering the relation between diseases of the circulatory system and SES, the HDI was significantly inverse associated with age-standardized cardiovascular mortality ($p=-0.894$, $\alpha=0.01$). For instance, Romania, which reported the highest cardiovascular death rates (646 per 100 000), was characterized by the lowest value of HDI (0,813). Furthermore, the Baltic States reported low HDI levels compared to other European nations, thus attributed to a high cardiovascular burden. In opposition, high HDI levels in Norway and Iceland (both 0.968) were related to the lowest cardiovascular mortality rates of all studied European nations.

Figure 17: Relationship between age-standardized cardiovascular mortality and Human Development Index in 2005 [Source of raw data: WHO HFA-DB, 2008b]



Moreover, a correlation between gross domestic product in PPP in US \$ per capita and cardiovascular death was identified in the observed 25 European countries ($p=-0.817$, $\alpha=0.01$). Those countries with lower mean values of gross domestic product were significantly linked to higher cardiovascular mortality.

5 Discussion

Several limitations need to be considered, to interpret the findings of this study.

It is well established, that there exists no method for the evaluation of dietary intake without any errors. For specific interpretation of nutritional data, its strength and limitations have to be taken into consideration. [TRICHOPOULOU and NASKA, 2003]

The nutritional information, as estimated in FBS is by no means identical with actual intake of a person living in the observed country, but reflecting theoretical quantities of foods reaching the total population for consumption. [FAO, 2001] In general, FBS data overestimate actual food intake attributed to losses of edible foods during storage, preparation and cooking. [FAO, 2008] According to several authors, in case of fats and oils, food disappearance may not count to the reliable indicators for trend analyses. In food service establishments, especially fast food restaurants the waste (non-food) portion of fat from deep-frying can be high. [USDA, 2008] In addition, quantities of food fed to pets or thrown away, contribute to the assumption that the amounts actually consumed, tend to be lower than those estimated from FBS are. Besides non-resident people like tourists, refugees or illegal migrants are not generally included in this calculation, which may lead to some underestimations in the total consuming population, used for food supply estimations. [FAO, 2008] However, according to the fact that FBS are currently available from 1961 to 2003 they are a unique source for identifying overall trends in national food supply during the last four decades in many European countries. [ELMADFA et al., 2005]

In general, HBS data can provide a more precise and detailed information of dietary intake of the population than the FBS data from the FAO, and regarding the quality between FBS, and individual nutrition surveys. [ELMADFA et al, 2005]

Despite several advantages, some limitations of Household Budget surveys have to be taken into consideration. [NASKA et al, 2006]

Mean individual food availability is estimated without providing information on the proportion of waste and losses of food, including food spoiled or offered to domestic pets. [TRICHOPOULOU and LAGIOU, 1998] Additionally, data on eating at restaurants, canteens or elsewhere outside the household is lacking in most European countries, except the UK where information on the consumption outside the house is available. [TRICHOPOULOU et al., 2005] The growing importance of eating out may explain partly why compared to a Food Frequency Questionnaire the proportions of available food, estimated through HBS, were lower for the majority of food groups in a study carried out in Portugal. [RODRIGUES et al., 2007] Furthermore, concerning the distribution of food within the household, household budget surveys assume an equal individual availability during the measured period. [NASKA et al., 2007]

In principle, nutrition data derived from HBS tend to overestimate the consumption of certain food items compared to individual dietary surveys, particularly for those with higher wastage. [NASKA et al., 2007]

Moreover, the lack of periodicity in DAFNE data collection limits the undertaking of international comparison among the observed European countries. For instance, latest dietary information of Poland is available for 1988, whereas data for countries like Greece and Serbia is available for 2004.

Although the DAFNE databank does not provide information on total fat availability the *EPIC-Study* showed, that the consumption of added fats and oils provides an important contribution to total lipid intake. [LINSEISEN et al., 2002]

WHO mortality data also has its strengths and weaknesses. Therefore, international comparability and interpretation of data is limited, owing to variations in definitions and/or time periods, incomplete registration in several countries or other particularities in recording and processing health determinants. Especially in some central and eastern European countries, the coding for mortality data varies in comparison to other countries. Additionally, under-registration of deaths, which may be as high as 20% or even more, leads

to bias in data quality. However, mortality data may provide the most complete and comparable dataset in relation to other health determinants. [WHO HFA-DB, 2008c]

Early efforts in the association between cardiovascular diseases and dietary habits focused on the identification of single nutrients. The basic understanding that diet is shaped by various nutrients, interacting together in a complex manner in the atherogenic process lead to a shift of research, concentrating on the relationship between dietary patterns and cardiovascular diseases. [WAHRBURG and ASSMANN, 2006a]

The findings, that dietary patterns clearly differ in Europe were also obvious in the analysis of FBS fat supply as well as HBS added fats and oils availability and confirmed by several studies. [TRICHOPOULOU et al., 2002] [NASKA et al., 2006] A large number of studies confirm the findings that Southern European populations generally consume greater amounts of fruit and vegetables. According to several authors, the identified North/South gradient can be explained by varieties in climate, agriculture and economy in the corresponding populations. [TRICHOPOULOU et al., 2007] One of the most apparent, although expected, results refer to western and northern European countries, where the predominant source of fat usually derives from animal origin. In contrast, Southern European countries prefer vegetable fats instead.

Regarding trends in fruit and vegetables available for consumption, a favoured increasing evolution in the majority of European countries happened within the last 4 decades. Dietary energy supply as well as fat supply has steadily increased in industrialized countries since the 1960s, accompanied by a raise in animal fat supply [WHO, 2003]. The more noticeable raising tendency in animal fat supply in several southern European populations shows that the Mediterranean diet is converging towards a more Western diet, but still varies from other European regions. These results are consistent with several other studies, which found out, that the diet of some Mediterranean countries is

gradually shifting away from its traditional dietary patterns. [BALANZA et al., 2006] [GARCIA-CLOSAS et al., 2006]

Findings from various other studies also showed that there are remarkable country specific differences in cardiovascular mortality rates.

Results of this study fit well with findings from KROMHOUT, where a West-East gradient for coronary heart diseases and stroke was identified for both men and women. [KROMHOUT, 2001] Reasons for differences in European cardiovascular mortality include smoking, hyperlipidemia, diabetes, overweight, hypertension, socioeconomic factors, diet, alcohol intake, physical activity, medical care, genetic factors and environmental conditions. [MÜLLER-NORDHORN et al., 2007] Regarding the east-west gradient in Europe, dietary fat seems to play a major role. [KESTELOOT et al., 2000] [ZATONSKI and WILLETT, 2005] This suggests that in the observed European countries the source of dietary fat may play a major role in varieties of cardiovascular mortality. Southern European countries, where fat mainly derived from vegetable sources, reported lower cardiovascular deaths. In contrast, in western and northern nations high amounts of fat derived from animal origin, thus may be responsible for high saturated fat and cholesterol supply and therefore cardiovascular mortality. Additionally, a higher fruit and vegetable availability possibly contributes to the lower cardiovascular burden in Southern Europe.

In numerous studies, adherence to the traditional Mediterranean diet was associated with beneficial effects on cardiovascular health. [WILLETT WC, 2006] [TRICHOPOULOU et al, 2003] Adherence to the Mediterranean diet together with regular physical activity and avoidance of smoking was estimated to prevent 80% of coronary heart diseases and 70% of strokes. [WILLETT WC, 2006] The traditional Mediterranean diet is characterized by a high intake of vegetables, fruit, legumes, nuts and cereals, largely unrefined. Furthermore, a high intake of olive oil, but low intake of saturated lipids, a moderately high intake of fish, a low to moderate consumption of dairy products, a low intake of meat and poultry and a regular but moderate consumption of ethanol determine the typical Mediterranean habits. [WILLETT, 1995]

In this study, selected dietary patterns characteristic for the traditional Mediterranean diet like the availability of meat, added lipids of animal origin, fruit, vegetables and fish and seafood were significantly linked to cardiovascular mortality. With regard to the relationship between the observed food groups and increased cardiovascular deaths, study results suggest a strong evidence for the availability of added lipids of animal origin and meat, usually containing high amounts of saturated fatty acids and cholesterol. Fish and seafood as a major source for ω 3 fatty acids, indicate a positive influence on cardiovascular health. In view of single cardiovascular diseases like ischemic or cerebrovascular diseases the potential effects of selected food groups on mortality seem to vary. Whereas, a high availability of added lipids of vegetable origin, in particular olive oil, and fruit may reduce deaths attributed to coronary heart diseases. Additionally, red meat was inversely associated with CHD, which does not correspond with findings from a prospective cohort study on 6161 women with type 2 diabetes. In that, red meat as a major source of heme iron was linked to a 50% increased risk for CHD in women, who reported the highest consumption. [QI et al, 2007] A literature review by LI et al. pointed out that red meat, trimmed of the visible fat portion combined with a diet low in saturated fat, generally, cannot be linked to a raise in LDL-cholesterol and blood pressure, which belong to the classic cardiovascular risk factors. [LI et al., 2005] This may be the reason why red meat was inversely associated with cardiovascular mortality rates in the observed statistical analysis. A high share of lean red meat, which is low in saturated fat and cholesterol possibly contributes to the unexpected findings that a high availability of red meat was significantly related to lower death due to ischemic heart disease. For cerebrovascular diseases, the better quality of meat dishes may be responsible for the identified associations. Regarding the negative effects of vegetables and added vegetable oils on cerebrovascular deaths, results clearly differ from other studies, where investigators reported significant positive effects of the consumption of vegetables and vegetable oils on cardiovascular health. [HUNG et al., 2004] [ESMAILZADEH and AZADBAKHT, 2008] These opposed findings may be due to strengths and limitations of the study.

Although the effects of special food groups cannot be linked to a contained single nutrient directly, there is indication that they are responsible for effects on cardiovascular health.

In that context, a large number of epidemiological studies have demonstrated a strong association between diet, lifestyle variables and CVD. Scientific evidence is convincing that a high intake of TFAs is linked to increasing cardiovascular outcomes [DGE, 2006b] [WHO, 2003]. In view of the effects of SFAs on plasma lipoproteins and cardiovascular risk, study results are not that consistent, but there is a wide body of evidence suggesting that replacing SFAs in the daily diet by unsaturated fatty acids reduces CVD risk. [HU and WILLETT, 2002]

Furthermore, in the majority of different designed studies long-chain marine ω 3-fatty acids have influenced cardiovascular health positively. [WHELTON et al., 2004] [WANG et al., 2006], thus leading to convincing evidence for beneficial effects on the vascular system. [DGE, 2006b] [WHO, 2003]

Although there are a large number of existing epidemiological, metabolic and clinical studies on the influence of nutrition on cardiovascular disease, evidence for the effectiveness of single nutrients and foods resulted from randomized, controlled, intervention studies with clinical end-points are lacking. This may be due to an essential high number of participants, a limited compliance and a long observation period. Furthermore, diet's multiple interaction makes it difficult to analyse the effect of a single nutrient or food item, without being influenced or disrupted by other dietary variables. [WAHRBURG and ASSMANN, 2006a]

It was anticipated that a high HDI, as an index for measuring a country's socioeconomic status is related to lower cardiovascular mortality in the observed European countries.

A lower socioeconomic status, evaluated at different levels, was linked to an increase of cardiovascular risk factors in a large number of studies. [PANAGIOTAKOS et al., 2008] [NOCON et al., 2007]

It should be noted, that the HDI as a multidimensional index can be used as a rough indicator of a country's level of human development based on three key

objectives. For a more precise picture further human development indices and information is necessary. For instance, the HDI does not provide information on political participation or gender inequalities, which both fundamentally contribute to a nation's development. [United Nations Development Programme, 2008]

Furthermore, the study shows, that rapid changes in age-standardized cardiovascular mortality were identified in Europe over the last 40 years. The most impressive declines appeared in northern European populations, such as Finland, Ireland and the United Kingdom. Simultaneously, in Finland the largest increases in supply of vegetable and fruit as well as the highest decreases of animal fat supply were identified over the studied period, thus indicating a strong relationship between those food groups and mortality data.

In contrast, in Bulgaria mortality due to cardiovascular events increased within the observed period. This may be a result of declines in fruit supply and marginal increases of vegetable supply. Furthermore, compared to other European countries Bulgaria showed only slight decreases in animal fat supply. Causes for dynamics of cardiovascular mortality rates are complex, but changes in diet seem to play an important contribution. Additionally, declines in Western Europe can be linked to improvements in cardiovascular treatment. [KESTELOOT et al., 2006] In Poland, the dramatic declines of mortality due to coronary heart diseases by about one quarter in the 90s were attributed to a more beneficial ratio of polyunsaturated to saturated fat. [ZATONSKI and WILLETT, 2005]

However, a study conducted in 2004 estimated that the decline of overall mortality in the EU 15 was probably unrelated to diet and rather reflects increased wealth, the reduction in prevalence of tobacco smoking and more effective treatment of common diseases, in particular coronary heart diseases. [TRICHOPOULOU and LAGIOU, 2004]

Although international comparable data of obesity, physical activity and smoking prevalence is lacking in Europe, an alarming tendency is apparent.

According to the WHO, a smoking prevalence of 30% on average in European adults clearly shows that due to its dramatic effects on heart's health, it has become a major public health problem in Europe. An increasing tendency among women in high-income countries intensifies this concern. [WHO, 2004a]

In the observed European countries, several nations reported to be physically active only once a week.

It has to be mentioned, that findings from the Eurobarometer survey do not analyse whether the adults, who reported to undertake regular physical activity are active for the overall recommended 30 minutes or more to prevent cardiovascular diseases. Nevertheless, a study conducted by SJÖSTRÖM et al. estimates that in the European Union 15 two thirds of adults do not achieve a level of health-enhancing physical activity. On average, the prevalence of sufficient physical activity for optimal health benefits ranged from 44% in the Netherlands to 23% in Sweden. [SJÖSTRÖM et al., 2006]

In the majority of European countries, an overweight and obesity prevalence of 40-50% was apparent, which fits well with findings from the WHO. Additionally, results indicate an increasing trend in the prevalence of obesity in the European adult population as well as in children. [WHO, 2004a]

6 Conclusion

The incidence of cardiovascular disease (CVD) is the main cause of death and morbidity in European countries and is strongly associated with dietary habits as well as lifestyle factors. The underlying pathology of CVD is usually atherosclerosis, which is a complex chronic inflammatory disease. The process of atherosclerosis can take up to several decades until the occurrence of any clinical complications like coronary heart diseases (CHD), heart attack, stroke, peripheral circulatory disorder and aneurysms.

Unlike non-modifiable cardiovascular risk factors such as increased age, male sex and a positive family history, smoking, overweight and obesity, physical inactivity, lipometabolic disorders, diabetes mellitus, hypertension, and several psychosocial factors belong to the modifiable lifestyle-associated risk factors. In that context, scientific evidence indicates that an optimal diet has a high preventive potential in cardiovascular diseases.

Numerous studies have shown that dietary fat as well as the consumption of fruits and vegetables potentially influences the atherogenic progress and thus the formation of a cardiovascular event through multiple biological mechanisms.

In Europe, dietary patterns clearly differ and have continuously changed over time. Based on DAFNE availability data, compared to the rest of Europe the diet of southern European countries is determined by more beneficial effects on cardiovascular health. The higher availability of fruit and vegetables as well as a lipid profile of mainly vegetable origin, may be attributed to the observed lower cardiovascular deaths.

Within Europe, large differences exist in age-standardized mortality rates from cardiovascular diseases. In Eastern Europe, mortality caused by cardiovascular diseases was statistically significant higher than mortality rates in western and southern European regions.

A number of risk factors can possibly be responsible for the observed regional variations in age-standardized cardiovascular mortality within Europe. Explanations include differences between populations in socioeconomic factors and lifestyle varieties such as diet, smoking, physical activity as well as overweight and obesity.

In Europe, the number of smokers, overweight and obese people and those who are less physical active has reached an alarming dimension. Several European countries reported to be physically active only once a week, 50% of the population or more were overweight or even obese and exceeded a smoking prevalence of 30%.

There is evidence that although age-standardized cardiovascular mortality rates have steadily decreased over the last 4 decades in the majority of European countries, the crude, non-standardized mortality rates are marginal increasing, due to the gradual ageing of the European population. As a result, the cardiovascular burden remains high in Europe, shifting to the elderly. For that reason, effective strategies have to be implemented to reduce the epidemic of cardiovascular diseases in Europe. Additionally, the high number of regular daily smokers, physical inactive and/or overweight or obese people in Europe indicates immediate needs for the initiation of health strategies on a population basis.

In conclusion, among cardiovascular risk factors, the nutrition-related contribution and extent for the development of cardiovascular diseases is difficult to quantify, due to the fact, that they have a multifactor genesis. For that reason, effective strategies to prevent CVD have to be considered, which means that a combination of preventive approaches, can confer greater benefits than a single approach.

However, atherosclerosis and thus cardiovascular diseases are largely preventable by improving nutritional habits, in particular fat consumption as well

as lifestyle factors. Substantial evidence indicates that diets using unsaturated fats as the predominant form of dietary fat, an adequate intake of long chain ω 3 fatty acids, the avoidance of foodstuffs rich in TFAs and an abundance of fruit and vegetables can help to prevent the majority of cardiovascular diseases. Additionally, it is of high priority to aim for a healthy body weight, be physically active and avoid the use and exposure to tobacco products to reduce the continuing enormous burden of cardiovascular diseases in Europe.

7 Summary

Cardiovascular diseases (CVD) are the leading cause of death and disability among adults in Europe, accounting for over 4.3 million deaths annually. In summary, these chronic diseases are responsible for about 48% of all deaths, mainly formed by coronary heart disease and stroke.

Within Europe, CVD clearly show differences in mortality rates, with higher deaths in eastern European countries compared to southern and western European nations. In general, age standardized mortality rates are falling in most European countries, except several countries localized in the east, where increasing or slightly decreasing dynamics are apparent.

Due to large differences of dietary habits between countries, no valid overall, European diet can be defined. Whereas a higher availability of fruit, vegetables, and vegetable fat characterises a Southern European's diet, countries in the north and west of Europe primarily prefer fat from animal sources.

The underlying pathology of CVD is usually atherosclerosis, which is a complex chronic inflammatory disease. Modifiable, lifestyle-associated risk factors like smoking, overweight and obesity, physical inactivity, lipometabolic disorders, diabetes mellitus, hypertension, and several psychosocial factors belong to the risk factors, which have a high potential in CVD prevention.

Epidemiological studies and overall results of this study have shown a close relationship between dietary fat and CVD. Based on nutrients, a diet high in saturated fatty acids, trans fatty acids, cholesterol as well as dietary patterns like high availability of meat and added lipids of animal origin is associated with a general increased risk for CVD. In contrast, fruit, vegetables, fish and seafood and a high consumption of long-chain ω 3-polyunsaturated fatty acids contribute to prevent CVD.

Atherosclerosis and thus cardiovascular diseases are largely preventable by improving nutritional habits as well as lifestyle factors. Effective strategies to prevent CVD have to consider its multifactorial genesis.

8 Zusammenfassung

Herz-Kreislaufkrankungen sind mit einer Zahl von 4,3 Millionen Toten jährlich mit Abstand die führende Ursache für Tod und Behinderung von europäischen Erwachsenen. Zusammenfassend sind diese chronischen Erkrankungen für 48% aller Todesursachen verantwortlich, wobei die koronare Herzkrankheit und Schlaganfall den Hauptanteil ausmachen.

Bezüglich der Sterblichkeit an Herz-Kreislaufkrankungen innerhalb Europas existieren große Unterschiede in den einzelnen Ländern, mit höheren Mortalitätszahlen in Osteuropa, verglichen mit Nationen im Süden und Westen Europas. In den meisten Europäischen Ländern sinken die altersstandardisierten Mortalitätszahlen, mit Ausnahme von einigen europäischen Nationen im Osten, wo steigende oder nur geringfügige sinkende Trends auffällig sind.

Aufgrund eindeutiger Unterschiede im Ernährungsverhalten der einzelnen Länder kann keine allgemein gültige europäische Ernährung definiert werden. Während eine höhere Verfügbarkeit an Obst, Gemüse und pflanzliche Fette charakteristisch für die Ernährung der südeuropäischen Länder ist, bevorzugt der Norden und Westen Europas hauptsächlich Fett tierischen Ursprungs.

Eine chronisch entzündliche Erkrankung, die Atherosklerose, stellt üblicherweise die zugrunde liegende Pathologie der Herz-Kreislaufkrankungen dar.

Veränderbare Lebensstil- assoziierte Risikofaktoren wie Rauchen, Übergewicht, Adipositas, körperliche Untätigkeit, Fettstoffwechselstörungen, Diabetes Mellitus, Hypertonie und einige psychosoziale Faktoren zählen zu den Risikofaktoren mit einem hohen Präventionspotential.

Epidemiologische Studien und Ergebnisse dieser Arbeit haben eine enge Verbindung zwischen Nahrungsfett und Herz-Kreislaufkrankungen gezeigt. Basierend auf Nährstoffen, kann eine Ernährung hoch an gesättigten Fettsäuren, Trans-Fettsäuren, Cholesterin sowie eine hohe Lebensmittelverfügbarkeit von Fleisch und zugefügte Fette tierischen Ursprungs mit einem erhöhten Risiko für Herz-Kreislaufkrankungen assoziiert werden. Im Gegensatz dazu, tragen ein

hoher Verzehr an Früchten, Gemüse, Fisch und Meeresfrüchte sowie langkettige mehrfach ungesättigte ω 3- Fettsäuren zur Prävention bei.

Atherosklerose und folglich Herz-Kreislaferkrankungen sind größtenteils durch eine Verbesserung der Ernährungsgewohnheiten und Lebensstilfaktoren verhinderbar. Dabei müssen effektive Strategien zur Prävention ihre multifaktorielle Genese berücksichtigen.

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10 Curriculum Vitae

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Work experience

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2002-2007 Employer: Austrian Commerce Agency
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09/2006	<u>Employer:</u>	Department of Nutritional Sciences University of Vienna Althanstrasse 14, 1090 Vienna, Austria
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02/2007	<u>Employer:</u>	Consortium of Clinical Nutrition (AKE) Höfergasse 13/1, 1090 Vienna, Austria
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