D I S S E R T A T I O N

Epidemiology of obesity among Austrian adults between 1973 and 2006/07

Long-term trends in subpopulations, education-related social inequalities and obesity-associated diseases and disorders

submitted by

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for the Academic Degree of

DOCTOR OF MEDICAL SCIENCE

(Dr. scient. med.)

at the

Medical University of Graz

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2013

To my beloved family

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Graz, März 2013 ________________________________

Declaration

I hereby declare that this thesis is my own original work and that I have fully acknowledged by name all of those individuals and organisations that have contributed to the research for this thesis. Due acknowledgement has been made in the text to all other material used. Throughout this thesis and in all related publications I followed the guidelines of "Good Scientific Practice".

Graz, March 2013 ________________________________

Publications and presentations resulting from this dissertation

Publications

* Großschädl, F., Titze, S., Burkert, N. & Stronegger, W. J. (2013). Moderate- and vigorous-intensity exercise behaviour according to the Transtheoretical Model: associations with smoking and BMI among Austrian adults. *Wiener klinische Wochenschrift* [paper accepted on March 13, 2013].

* Groschädl, F. & Stronegger, W. J. (2012). Regional trends in obesity and overweight among Austrian adults between 1973 and 2007. *Wiener klinische Wochenschrift*, 124(11-12): 363-369.

* Groschädl, F. & Stronegger, W. J. (2012). Long-term trends in obesity among Austrian adults and its relation with the social gradient: 1973-2007. *European Journal of Public Health*, [EPub ahead of print].

* Groschädl, F., Haditsch, B. & Stronegger, W. J. (2012). Validity of self-reported weight and height in Austrian adults: sociodemographic determinants and consequences for the classification of BMI categories. *Public Health Nutrition*, 15(1): 20-27.

** = Publications listed in SCI/SSCI/Pubmed*

Presentations at scientific events

Großschädl, F., Burkert, N. & Stronegger, W. J. (2012). Long-term trends in obesity among Austrian adults according to region and educational status. *Kongress Essstörungen / Eating Disorders Alpbach*, Oct 18-20: Alpbach, Austria. [Poster]

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Großschädl, F., Burkert, N. & Stronegger, W. J. (2012). Trends in social inequalities for obesity across the Austrian population: 1973-2007. *European Congress of Epidemiology*, Sept 5-8: Porto, Portugal. [Poster]

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Großschädl, F. & Stronegger, W. J. (2010). Die Validität selbstberichteter Gewichts- und Größenangaben bei Erwachsenen in Österreich und Folgen für die Klassifikation unterschiedlicher BMI-Kategorien. *Individualisierte Prävention und Epidemiologie: Die Moderne Medizin. DGSMP/DGEpi/EUMASS-Tagung*, Sept 21-25: Berlin, Germany. [Poster]

Contents

Abbreviations

AC	Absolute change
AF	Aetiologic fraction
AS	Age-standardised
AT-HIS	Austrian Health Interview Survey
B	Regression coefficient
B0	Intercept
BMI	Body mass index
CI	Confidence interval
CT	Computer tomography
DXA	Dual energy x-ray absorptiometer
IASO	International Association for the Study of Obesity
M	Measured
MRI	Magnetic resonance imaging
NHANES	National Health and Nutrition Examination Survey
OECD	Organization for Economic Co-operation and Development
OR	Odds ratio
Pf	Prevalence of the first year
Pl	Prevalence of the last year
RII	Relative index of inequality
RR	Relative risk
SD	Standard deviation
SR	Self-reported
T	Time period in years
WC	Waist circumference
WHO	World Health Organization
WHR	Waist-to-hip ratio

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Zusammenfassung

Einleitung: Adipositas zählt zu den zehn führenden Risikofaktoren für Gesundheitsprobleme und gilt als das am raschest wachsende Gesundheitsrisiko. Es ist bedeutend Trends dieser Erkrankung zu untersuchen, um gefährdete Subpopulationen aufzuzeigen und zielgruppenspezifische Interventionen planen zu können. Für Österreich fehlte es an empirischer Evidenz zur epidemiologischen Entwicklung der Adipositas und ihrer Komplikationen in der Erwachsenenpopulation. Daher war es das Ziel dieser Studie, Langzeittrends in der Adipositasprävalenz für unterschiedliche Subpopulationen (Alter, Bildung, Region) bei Frauen und Männern in Österreich zu untersuchen. Des Weiteren wurde das Ausmaß der sozialen Ungleichheit für Adipositas dargestellt und Untersuchungen zu adipositasassoziierten Erkrankungen und Beschwerden (Diabetes mellitus, Rückenbeschwerden, Hypertonie, Schlafstörungen, Depression und Kopfschmerzen) durchgeführt.

Methoden: Als Datengrundlage dienten fünf bestehende national repräsentative Querschnittstudien, in denen selbstberichtete Daten in den Jahren 1973, 1983, 1991, 1999 und 2006/07 erhoben wurden. Dazu wurden Interviews in österreichischen Privathaushalten und Langzeitpflegeeinrichtungen durchgeführt. Die Studienpopulation umfasste Personen ab dem 20. Lebensjahr (n = 178.818). Auf Basis einer Vorstudie, in welcher die Validität selbstberichteter Gewichts- und Größenangaben untersucht wurde, wurden die BMI-Angaben für diese Studie korrigiert. Adipositas wurde gemäß der WHO als BMI $\geq$ 30 kg/m² definiert. Trends in der Prävalenz zu Adipositas und im Hinblick auf adipositasassoziierte Erkrankungen und Beschwerden wurden durch das attributable Risiko und durch den attributablen Risikoanteil beschrieben. Zur Darstellung des Ausmaßes der sozialen Ungleichheit für Adipositas wurde der Relative Index of Inequality basierend auf dem Bildungslevel berechnet.

Ergebnisse: Die altersstandardisierte Adipositasprävalenz betrug für die gesamte Studiendauer 10,9% und war bei Frauen höher als bei Männern (Frauen: 11,4%, 95% CI: 10,8 – 12,1; Männer: 9,9%, 95% CI: 9,3 – 10,5; $p < 0{,}001$). Der höchste Anteil an Personen mit Adipositas und die höchsten BMI-Mittelwerte hatten Personen im Alter zwischen 55 und 74 Jahren, jene mit niedrigem Bildungslevel und Menschen lebend im

Osten Österreichs. Der Anstieg in der Adipositasprävalenz, dargestellt durch das attributable Risiko, war am höchsten für Frauen und Männer die älter als 55 Jahre alt waren und ein niedriges Bildungslevel aufwiesen (p < 0,001). In Anbetracht der regionalen Unterschiede gab es die höchsten Werte zum attributalen Risko bei Frauen in Zentralösterreich und bei Männern in Westösterreich (p < 0,001). Relative Ungleichheiten in der Adipositasprävalenz waren für Frauen höher als für Männer. Eine steigende Tendenz in der sozialen Ungleichheit zeichnete sich in den letzten Dekaden nur bei Männern ab. Des Weiteren zeigte diese Studie einen Aufwärtstrend in der Prävalenz ausgewählter adipositasassoziierten Erkrankungen und Beschwerden während der Studienperiode. Eine Ausnahme stellte das Symptom „Kopfschmerzen“ dar. Für diese Beschwerde nahm die Prävalenz im Untersuchungszeitraum leicht ab. Die höchsten Zunahmen in der Prävalenz adipositasassoziierter Erkrankungen und Beschwerden gab es bei adipösen Personen, vor allem bei adipösen Frauen.

Schlussfolgerungen: Zwischen 1973 und 2006/07 gab es unter Österreichs Erwachsenen einen deutlichen Anstieg in der Adipositasprävalenz. Besondere Beachtung sollte älteren Personen mit niedrigem Bildungslevel geschenkt werden, da diese Gruppe die höchste Prävalenz und den rasantesten Anstieg von Adipositas aufwies. Diese Ergebnisse zeigten auch, dass Adipositas einen signifikanten Faktor der zunehmenden Komorbidität untersuchter Erkrankungen und Beschwerden darstellt. Dies sollte bei Behandlungs- und Präventionsprogrammen berücksichtigt werden. Es wird empfohlen, dass in Österreich der Entwicklung von Strategien zur Gewichtserhaltung und –reduktion eine höhere Priorität zugeschrieben wird, speziell im Hinblick auf bestimmte Subgruppen. Weitere Forschung sollte die Kausalität zwischen Adipositas und kulturellen sowie Lifestyle-Determianten untersuchen, um die Entwicklung dieser Erkrankung besser verstehen zu können. Regelmäßige Monitorings wären von großer Bedeutung, um Risikogruppen beobachten zu können und die Effektivität gesundheitsfördernder Maßnahmen in Österreich aufzuzeigen.

Schlüsselwörter: Adipositas, BMI, Langzeittrends, soziale Ungleichheit, adipositasassoziierte Erkrankungen und Beschwerden, Erwachsene, Österreich.

Abstract

Introduction: Obesity is one of the ten leading risk factors for health problems and the fastest growing health risk worldwide. It is important to examine trends in obesity to identify affected subpopulations and to plan target-group specific interventions. There is little evidence for the epidemiological development of obesity and its complications in Austria. Therefore, the present study investigated long-term trends in the prevalence of obesity across different subpopulations (age, education, region) among women and men in Austria. This study aimed determining relative inequalities for obesity and investigated obesity-associated diseases and disorders (diabetes mellitus, hypertension, back pain, sleep disorder, depression and headache) in Austria and for different subpopulations.

Methods: Self-reported data were derived from five nationally representative cross-sectional interview surveys, which were conducted in the years 1973, 1983, 1991, 1999 and 2006/07. The interviews took place in Austrian private homes and long-term care facilities. Persons aged 20 years and older were included in the study sample ($n = 178{,}818$). Based on results of a preliminary study which investigated the validitiy of self-reported weight and height, data correction factors for BMI were applied to this study. Obesity was defined accordingly to the WHO as BMI ≥ 30 kg/m². Absolute changes and aetiologic fractions were calculated to measure trends in the prevalence of obesity and obesity-associated diseases and disorders. To quantify the extent of social inequality for obesity, the relative index of inequality was computed on basis of the educational level.

Outcomes: The age-adjusted prevalence of obesity was 10.9% during the study period and higher among women than men (women: 11.4%, 95% CI: 10.8 – 12.1; men: 9.9%, 95% CI: 9.3 – 10.5; $p < 0.001$). Obesity and a high mean BMI were most prevalent among subjects aged 55-74 years, with a low educational level and living in Eastern Austria. The absolute change in obesity prevalence during the study period was highest among women and men aged 55 years and older with a low educational level ($p < 0.001$). Considering regional differences, the highest absolute change was found among women in Central Austria and men in Western Austria ($p < 0.001$). Education-related inequalities for obesity were higher among women than men. However, inequalities showed a tendency to increase within the last decades only among men. Furthermore, this study showed that there was a rise in the selected obesity-associated diseases and disorders during the study period, with exception of headache, for which the prevalence slightly decreased within the investigation period. The highest increase in the prevalence of obesity-associated diseases and disorders was found among obese subjects, especially obese women.

Conclusions: There was a clear increase in the prevalence of obesity between 1973 and 2006/07 among Austrian adults. Particular emphasis should be put on persons of retirement age with low education, because this subgroup showed the highest prevalence and the greatest increase in the prevalence of obesity. Furthermore, these results showed that obesity is a significant factor in increasing comorbidity of investigated diseases and disorders, which should be taken into account for planning of treatment and prevention programs. This data suggests that the development of strategies for weight maintenance and reduction must become a higher priority in Austria, especially for certain subgroups. Further research is needed to investigate the causality of obesity with factors, such as cultural and lifestyle determinants to get a better understanding of the development of this disease. Furthermore, regular monitoring of obesity would be important to control risk groups and study effectiveness of health promoting policies in Austria.

Keywords: obesity, BMI, long-term trends, social inequality, obesity-associated diseases and disorders, adults, Austria.

1. Introduction

There are approximately 1 billion adults overweight worldwide. At least 300 million of them are obese. The World Health Organization reported that obesity now kills more people than underweight (WHO, 2012a).

1.1. Background

Obesity is defined as an abnormal excess in body fat, which represents a risk to health. It is one of the ten leading risk factors for health problems (WHO, 2013) and is considered as the fastest growing health risk worldwide (Kiefer & Kunze, 2004). Overweight and obesity are now even epidemic in Europe and responsible for 10 to 13% of deaths and 2 to 8% of health expenditures (WHO, 2013).

Epidemiological surveys indicate that the prevalence of obesity has clearly risen in the last decades. This was especially the case in industrialized countries (Gallus et al., 2012; Ljungvall & Zimmerman, 2012; Sturm & Hattori, 2012; Finucane et al., 2011; Ford et al., 2011; Cámara & Spijker, 2010; Diouf et al., 2010; Howel, 2010; Schneider, Dietrich & Venetz, 2010; Kilmer et al., 2008; Chrzanowska, Koziel & Ulijaszek, 2007). In 2008, the worldwide age-standardised prevalence of obesity was 14% among women and 10% among men (Finucane et al., 2011). If this upward trend continues, 50% of the population in America and Europe will be obese by the year 2040 (Kiefer & Kunze, 2004). Due to the fast increasing prevalence of this chronic disease, obesity is considered to be a global health problem (WHO, 2013; James, 2008), which results in an increased biomass. This has an important impact on the global resource requirements and the general ecological footprint of humanity (Walpole et al., 2012).

A wide range of determinants that influence the development of obesity exist. Age has an important influence on an individuals' weight status. International studies report very high obesity prevalence, especially in the age group of 55 to 65 year old women and men (Gallus et al., 2012; Doak et al., 2011; Low, Chin & Deurenberg-Yap, 2009; Klumbiene et al., 2006; Andersen et al., 2004). Furthermore, it is demonstrated, that subjects with a low socioeconomic status are more often obese (Fleischer, Diez Roux & Hubbard, 2012; Grabner, 2012; Sassi et al., 2009; Delva, Johnston & O´Malley, 2007; Larrañaga et al., 2007; Sulander & Uutela, 2007; Ball & Crawford, 2005). Few studies have shown that there are also regional differences in the prevalence of obesity among adults (Berghöfer et al., 2008; Lidstone, Wilkinson & Bailey, 2005; Panagiotakos et al., 2004). Considering geographic variations in European countries, the highest obesity prevalence is reported in Eastern Europe (Berghöfer et al., 2008; Raben, 2003).

Compared to indivuals with normal weight, obese women and men more often self-report a poorer health status (Ali & Lindenstroem, 2006). Obesity is also known as a major risk factor for metabolic syndrome (Crawford et al., 2010) and for a number of chronic conditions, such as type 2 diabetes mellitus, cardiovascular diseases, asthma, adipohepatic, dyslipidemia and malignant tumors (WHO, 2012a; Barnes, 2011; Ng et al., 2011; Díaz et al., 2009; Peytremann-Bridevaux & Santos-Eggimann, 2008; Schulte et al., 2001). These diseases cause increased mortality (Franco et al., 2012; Faeh et al., 2011; Ha do et al., 2011; Klenk et al., 2009; Olshansky et al., 2005). It is observed that anyway the mortality risk rises with increasing body mass index (BMI kg/m²) among adults of all age groups (Adams et al., 2006, Komlos & Baur, 2004). Persons affected suffer physical as well as psychological consequences which can severely affect their quality of life and life expectancy (Burkert et al., 2012a; Gallon & Wender, 2012; Garner et al., 2012; Sirtori et al., 2012).

In addition, these obesity-associated sequelae cause very high costs. Therefore, obesity is one of the largest initiator of health care budgets. In Europe, it is responsible for about 6% of the health care costs in adults. Furthermore, the indirect costs, caused by loss of human lives and productivity, are at least twice as high (Knai et al., 2007). Reasons for high health care costs caused by obese subjects are also a higher per-head consumption of medications among obese subjects compared to those with normal body weight (Finkelstein, Fiebelkorn & Wang, 2003). Furthermore, a high body weight is associated with more frequent use of medical services (Burkert et al., 2012a) and spending more days in hospitals (Wulff & Wild, 2011).

In Germany, 530 million euros per year are spent on obesity. Considering the obesity-associated diseases this sum increases to five billions of health care costs per year (Medizinauskunft, 2005). The translation of international cost estimates on the Austrian population indicates that direct health care costs associated with obesity vary from 227.7 to 1,138.5 million euros per year. This corresponds to 0.1% to 0.5% of the gross domestic product. By a decrease of 1% in the prevalence of obesity it would be possible to save, 3.3% of health care costs in Austria (Kiefer et al., 2006). Obesity is also a major avoidable factor of the health care costs in the United States. A weight loss of 10% in obese individuals in the United States would economize 2,200 to 5,300 Dollar per head and could raise the expectancy of life (Rosin, 2008; Oster et al., 1999).

Obesity is preventable (Samaranayake et al., 2012; WHO, 2012a) and therefore, it is important to examine existing long-term trends in the prevalence of obesity in order to identify the factors behind obesity affected populations and to plan target-group-specific preventive measures. Furthermore, the monitoring of secular obesity trends can be utilised for evaluation of prevention strategies (OECD, 2012; Doak et al., 2011; Flegal, 1999; Kiefer et al., 1998).

1.2. Structure of the thesis

This thesis is divided into nine main chapters.

After the introduction the aims of this study are presented in chapter two.

The state of the literature as well as the scientific background of this dissertation are reported in chapter three. At the beginning of this section obesity is defined and various methods for measuring obesity among adults are presented. Furthermore, difficulties with self-reported weight and height data are pointed out in this chapter. Sociodemographic determinants associated with obesity among adults are described; summarizing demographic and sociocultural factors. Results from studies investigating the prevalence and trends for obesity in different countries will be reported. Previous results for Austria and selected European countries and countries all over the world are considered in detail. Obesity-associated disease and disorders are also described in this chapter. Finally, open questions that have emerged from the literature search will be summarized.

The specific research questions of this study are presented in chapter four.

Chapter five describes the aims, methods, results and conclusions of a preliminary study in which the validation of self-reported BMI was investigated for Austrian adults.

Chapter six focuses on the method of this study. In addition to the data source and subjects, different variables investigated in this study are presented in this section. Furthermore, the data analysis and ethical concerns are described in this chapter.

In chapter seven the study results are presented. First of all the long-term trends in BMI and obesity are described for the whole study population and separately for women and men between 1973 and 2006/07. After that, long-term trends among different age groups, educational groups and geographic areas in Austria are presented. Education-related inequalities for obesity are shown for subgroups by computing the relative index of inequality. The outcomes for the prevalence and trends for selected obesity-associated diseases and disorders (diabetes mellitus, hypertension, back pain, sleep disorder, depression and headache) are presented at the end of chapter seven. Long-term trends in the prevalence of the diseases and disorders are described for the whole study population and stratified by sex, age and obesity.

Chapter eight includes the discussion of this study. At the beginning of this chapter the main findings are presented. Subsequently the findings are discussed and compared with relevant literature. Implications for further research and health promotion are also described in this chapter. Finally the strengths and limitations of this study are pointed out.

The conclusions are described in chapter nine, by highlight the key points of the study. Recommendations for further studies are given as well.

Literature which was used for this thesis is listed in the respective chapter `references´.

2. Study aims

The purpose of this study is to demonstrate the changes in obesity among the Austrian adult population between 1973 and 2006/07. Long-term trends in the prevalence of obesity should be presented for Austria as a whole and for different subpopulations (based on age, educational level and region) for Austrian female and male adults. This study also aims identifying possible risk groups by assessing associations of obesity with collected variables.

A further objective is to present the magnitude of inequalities for obesity between educational groups. Analyses will be conducted for the whole adult population and for different subgroups (based on age, educational level and region).

Furthermore, the prevalence and trends of selected obesity-associated diseases and disorders (diabetes mellitus, hypertension, back pain, sleep disorder, depression and headache) will be determined for the period 1973 to 2006/07 for Austria as a whole and for obese and non-obese women and men in various age groups.

3. State of research

3.1. Defining and measuring obesity among adults

The most widely used definition of obesity was created by the WHO and is described in the section below. To assess obesity among adults several methods for direct and indirect measurements exist. Some methods are quite cost-intensive and complex but very accurate while other measurements of obesity are cheap, easy to perform but less precise. The various methods for measuring obesity are described in section 3.1.2. Furthermore, the best suited measurement for large-scale population surveys is mentioned. Finally the validity of self-reported data on body weight and height is described.

3.1.1. Definition of obesity

According to the WHO (2013) obesity is defined as an abnormal excessive body fat accumulation in adipose tissue, posing a risk to health.

Adipose tissue consists of fat cells, called adipocytes, and is an essential part of the human body and the largest energy reservoir (Frayn, 2010). The adipocytes store and mobilise essential and non-essential lipids. Proteins secreted by the adipocytes are important in the control of fat storage and total body energy balance (Frayn, 2010; Leff & Granneman, 2010).

Obesity has been classified as a disease for more than 60 years (IASO, 2010). It is an interaction between genetic disposition and environmental factors (Wilkinson & Pickett, 2009; Lechleitner, 2004). Obesity is a serious, complex and multifactorial chronic disease occurring in all age groups worldwide. The proportion of excessive body fat, the consequent diseases and disorders and its distribution vary between individuals affected. But obesity is not only an individual problem it is also a problem on population level. This chronic disease reflects the social, economic and cultural issues which countries are facing (Wilkinson, 2005; WHO Consultation on Obesity, 2000).

However, obesity is preventable mainly through changes in lifestyle (Samaranayake et al., 2012; WHO Consultation on Obesity, 2000).

3.1.2. Measuring obesity

Direct methods

To quantify the amount of visceral body fat, a number of laboratory methods can be used. Methods such as the underwater weighing (hydro-densitometry), the dual energy x-ray absorptiometer (DXA), the bioelectric impedance, the magnetic resonance imaging (MRI), the air displacement plethysmography or the computed tomography (CT) allow a very precise description of human adipose tissue and are even able to differentiate between subcutaneous and visceral abdominal fat (Hu, 2008; Sobol et al., 1991; Gray et al., 1991; Seidell et al., 1987).

The disadvantages of these direct measuring methods are that they are quite cost-intensive, with limited access and that the measurements must be taken by trained medical professionals. Furthermore, an implementation in epidemiological studies is usually very difficult and therefore these laboratory methods are not suitable for screening large groups of subjects (Hu, 2008).

Indirect methods

The internationally most widely used method of measuring and identifying obesity among adults is the BMI, also called Quetelet´s index (Garrow & Webster, 1985). The BMI is calculated by dividing body weight in kilograms by the square of body height in meters (kg/m^2). BMI values are the same for all adult age groups and both sexes. It provides a simple, cheap and reliable measurement tool, especially in large-scale population surveys (Garrow & Webster, 1985). It is commonly used to classify underweight, overweight, normal weight and obesity in adults, accordingly to the WHO. A BMI of 30 kg/m² and above is used as a cut-off point for obesity among adult women and men (WHO, 2012a; WHO Consultation on Obesity, 2000) (table 1).

Table 1: The international classification of underweight, normal weight, overweight and obesity according to BMI among adults

Classification	BMI cut-off points
Underweight	< 18.5
Normal weight	18.5 - 24.9
Overweight	25.0 - 29.9
Obese	≥ 30.0
Obese class 1	30.0 - 34.9
Obese class 2	35.0 - 39.9
Obese class 3	≥ 40.0

Source: WHO (2006)

The WHO BMI classifications for obesity are often used by the research community (Seidell et al., 2001). That makes it possible to compare obesity prevalence between different populations and countries. However, there were suggestions that lower cut-off points should be used in specific populations, for example among Asian populations. Due to the different associations between BMI, body fat percentage and health risks, compared to the European populations. But studies did not indicate a clear threshold for the Asian population for overweight or obesity. Therefore, the expert consultation of the WHO agreed that the BMI cut-off points should be kept as international classifications for the whole adult population (WHO expert consultation, 2004).

Nevertheless, alternative thresholds for BMI are used in some studies to assess obesity among adults (Fritz & Elmadfa, 2008; Kim et al., 2007; Sabbah et al., 2007; Hwang, Bai & Chen, 2006; Tian, Bárdos & Adany, 2006; Yoon, Oh & Park, 2006). The disadvantage is that comparisons with these study results are limited. Classifications of obesity should be standardised on an international basis using the WHO BMI cut-off points, to ensure the possibility of comparing populations, in order to predict obesity-associated health risks and to target und evaluate interventions regarding obesity (WHO, 2012a; WHO Consultation on Obesity, 2000).

While the BMI is a simple, relatively inexpensive and easily available measurement for obesity it should be considered that the distribution and amount of the individuals' body fat are also very important determinants, especially in the view of obesity-associated diseases. The visceral fat, particularly in the abdominal region, correlates very strong with cardiovascular risk factors and illnesses. Information on the visceral fat are stronger associated with diseases such as type 2 diabetes mellitus and cardiovascular disease than weight / height indexes, such as the BMI (Hu, 2008).

Further anthropometric methods for measuring obesity among adults includes the measurement of the skinfold thickness, the sagittal diameter, the waist-to-hip ratio (WHR) and the waist circumference (WC) (Hu, 2008; van der Kooy & Seidell, 1993). For getting more robust indices of obesity-associated diseases it is recommended to measure theWHR and the WC instead of the BMI alone. (Mathus-Vliegen et al., 2012; Lean et al., 1995; Björntorp, 1993; Seidell et al., 1988). WHR and WC are also more recommended for assessing the risk of mortality, instead of the BMI (Pischon et al., 2008).

The WHR was initially used in 1983 in the United States (Hartz et al., 1983) and Sweden (Krotkiewski et al., 1983). It is a useful method in epidemiological studies but the WHR as a ratio is hard to interpret. On the one hand there is the waist measurement, which includes visceral organs and abdominal fat and on the other hand the hip measurement which reflects fat mass, muscle mass and skeletal frame (Molarius and Seidell, 1998). For the hip measurement the relative size of peripheral muscle may contribute to ill health, such as higher risk for type 2 diabetes, since individuals with a high WHR may be at greater risk due to a broad waist or because of narrow hip circumference (Seidell et al., 1997).

The method of the WC alone may be a better indicator for measuring abdominal body fat and predicting obesity-associated illness (Wannamethee et al., 2010; Lean et al., 1995; Pouliot et al., 1994; Seidell et al., 1988). It strongly correlates with visceral body fat (Rankinen et al., 1999) but only weakly with body height (Han et al., 1997). According to the WC, abdominal obesity is classified as waist circumference of 88 cm and more in women and 102 cm and more in men. Seidell et al. (2001) recommended using the bone landmarks as references for measuring the WC.

Summing up the BMI is an easy and cheap measurement tool to measure obesity in adults and is therefore often used in large-scale population surveys to present the prevalence and long-term trends for obesity (Pigeyre et al., 2011; Lathi-Koski et al., 2010). Nevertheless, the WC is the best anthropometric indicator for the classification of abdominal fatness, which is preferred to be measured when investigating obesity-associated diseases. However, there is no valid standardised method for measuring the WC, which makes it difficult for comparison with other studies (Hu, 2008).

3.1.3. Self-reported data on weight and height

Many population-based surveys, investigating the BMI, utilize self-reported instead of anthropometric measured data on body weight and height. Self-reported data can be obtained through collection methods which consume less time, efforts and money compared to direct measurements of weight and height (Peytremann-Bridevaux & Santos-Eggimann, 2008; Sherry, Jefferds & Grummer-Strawn, 2007; Jackson et al., 2005). The disadvantage of self-reported data is that the information may be incorrect. Studies from different countries have found that subjects tend to overreport their body height (Faeh et al., 2008; Ezzati, Martin & Skjold, 2006; Taylor, Dal Grande & Gill, 2006; Visscher, Viet & Kroesbergen, 2006; Cullum, McCarthy & Gunnell, 2004; Spencer, Appleby & Davey, 2002; Kuczmarksi, Kuczmarksi & Najjar, 2001; Nawaz et al., 2001; Flood et al., 2000; Santillian & Camargo, 2003; Glaesmer & Brähler, 2002; Connor Gorber et al., 2007) and underreport their body weight (Faeh et al., 2008; Ezzati, Martin & Skjold, 2006; Taylor, Dal Grande & Gill, 2006; Visscher, Viet & Kroesbergen, 2006; Cullum, McCarthy & Gunnell, 2004; Spencer, Appleby & Davey, 2002; Kuczmarksi, Kuczmarksi & Najjar, 2001; Nawaz et al., 2001; Flood et al., 2000; Santillian & Camargo, 2003; Glaesmer & Brähler, 2002; Connor Gorber et al., 2007; Kovalchik, 2008; Rossouw, Senekal & Stander, 2000).

The validity of self-reported BMI values may differ between populations. It was found that the determinants sex and age have a significant interaction effect on the deviations between reported and measured BMI values (Grouven, Bender & Ziegler, 2007; Glaesmer & Brähler, 2002). Especially older subjects overestimate their height (Taylor, Dal Grande & Gill, 2006; Kuczamarski, Kuczmarski & Najjar, 2001; Glaesmer & Brähler, 2002). Women in particular assess their weight lower than it actually is (Faeh et al., 2008, Rossouw, Senekal & Stander, 2000), while men more often overreport their body height (Spencer, Appleby & Davey, 2002; Glaesmer & Brähler, 2002). Some studies have shown that in contrast to anthropometric measurements, the obesity prevalence in self-reported data is usually lower (Faeh et al., 2008; Ezzati, Martin & Skjold, 2006; Visscher, Viet & Kroesbergen, 2006; Santillian & Camargo, 2003).

It should be noted that there are limitations when using self-reported weight and height data. Self-reported data may lead to a misclassification of BMI values and they may induce bias in studies investigating the prevalence of obesity. Therefore, correction for self-reported weight and height should be carried out in studies which assess the prevalence of obesity (Shiely et al., 2010; Faeh et al., 2008).

3.2. Sociodemographic determinants of obesity

Nutrition and physical activity are the most direct factors associated with obesity (Eckert, 2012). The cause of the obesity epidemic lies in the fact that an increased intake of fat, sweet, salty and energy-dense food and a high consumption of sugar-sweetened beverages exists. The availability of these products has risen considerably. Another factor for the obesity epidemic is the decrease in physical activity (Lagerros & Rössner, 2013; Garcia, Sunil & Hinojosa, 2012; Stuckler et al., 2012; Mozaffarian et al., 2011; Wadden, Brownell & Foster, 2002).

However, obesity is influenced by a wide range of determinants which must be taken into account when assessing the causes of time trends in various settings (Sassi et al., 2009). Demographic factors (sex, age, ethnicity, region), sociocultural factors (education, family situation), biological factors (genetics, the effect of menopause) as well as lifestyle determinants such as alcohol consumption (Seidell & Flegal, 1997) and smoking habits (Rásky, Stronegger & Freidl, 1996) are associated with BMI and obesity.

Biological factors alone, including genes, cannot describe the rise in obesity. Obesity prevalence increased too fast in the last decades to be explainable alone in evolutionary terms (Philipson & Posner, 2008).

The following subchapters give a summary on the determinants sex, age, educational level and region. These factors have been often associated with obesity and have been investigated in the present study.

3.2.1. Sex

In most countries worldwide the obesity prevalence tends to be higher in women than in men. This is especially true for women aged 50 years and older (Gallus et al., 2012; Ljungvall & Zimmerman, 2012; von Ruesten et al., 2011; Howel, 2010; Ng et al., 2010; Zaninotto et al., 2009; Stam-Moraga et al., 1999).

The proportions of obesity in men have been growing faster in the last decades (Sassi et al., 2009). It is also known that men are more often overweight (BMI cut-off points for overweight: 25.0 to 29.9 kg/m^2) compared to women and have a higher average BMI (Gallues et al., 2012; Großschädl & Stronegger, 2012b; Marques-Vidal, Paccaud & Ravasco, 2011; Howel, 2010; Ng et al., 2010; Schneider, Dietrich & Venetz, 2010).

There are several reasons and assumptions for higher obesity prevalence among women than men. Case and Menendez (2007) found that women who suffered from starvation during their childhood have a greater risk of becoming obese in their adulthood. This effect was not found for men. Furthermore, body compositions vary between women and men. Women for example have in general a lower amount of skeletal muscle mass and a greater amount of visceral fat which means a decrease in metabolic rate (Chau et al., 2008). Studies also showed that socioeconomic slopes in obesity are more rapid among women than men (Branca et al., 2007; Wardle, Waller & Jarvis, 2003).

Gender differences are important to learn in order to understand the genesis of obesity. The interaction between sex and characteristics such as socioeconomic conditions has to be taken into account (Wang, Volkow & Fowler, 2009).

3.2.2. Age

Getting older is associated with changes in body composition and metabolism which have an impact on the BMI. Due to condensation in vertebral bodies and kyphosis older subjects lose body height. This leads to a change in the relationship between BMI and body fat. (Zamboni et al., 2005). Furthermore, the fat mass raises and the muscle mass decreases when subjects are getting older. The visceral fat, which is mainly located in the abdominal area and creates a higher risk for the development of fatal diseases, increases when subjects are getting older. This is more common among women than men. Between the age of 25 and 65 years the visceral fat increases on average by more than 300% (Chau et al., 2008; Hunter et al., 2005). The lower amount of skeletal muscle mass in older individuals leads to a decline of the basal metabolic rate of 4% per decade after the age of 50 years. This is about 150 kilocalories per day (Chau et al., 2008).

Obesity and ageing are marked by hormonal changes and by a low-grade inflammatory state. The inflammatory load increases due to inflammatory adipokines which is produced by central and visceral fat (Schrager et al., 2007). Higher obesity proportions among older subjects are mostly explained by loss of lean body mass, higher proportions of visceral fat and sedimentation of body fat in muscles, liver and pancreas (Waters et al., 2010; Florez & Troen, 2008; Kennedy, Chokkalingham & Srinivasan et al., 2004).

International cross-sectional studies have shown that especially in the age group of 55- to 65-year-olds morbidity prevalence of obesity are very high (Gallus et al., 2012; Doak et al., 2011; Low, Chin & Deurenberg-Yap, 2009; Klumbiene et al., 2006; Anderson et al., 2004; Grabauskas et al., 2003). Stam-Moraga et al. (1999) reported that the increase of BMI with age tends to continue longer among women than men.

After the age of 70 years there is a parallel decrease of fat-free mass and fat mass (Lim et al., 2011). Therefore, the prevalence of malnourished subjects strongly increases among elderly people aged 70 years and older (Verbrugghe et al., 2012).

3.2.3. Educational level

Within societies the social status plays a major role in populations' health (Wilkinson, 2005).

It was observed that individuals with a low socioeconomic status (measured by income, occupation-based social class or educational level) tend to be obese more likely, whereas the prevalence of obesity decreases with increasing socioeconomic status (Burkert et al., 2012b; Fleischer, Diez Roux & Hubbard, 2012; Gallus et al., 2012; Grabner, 2012; Sassi et al., 2009; Delva, Johnston & O´Malley, 2007; Larrañaga et al., 2007; Papadimitriou et al., 2007; Sulander & Uutela, 2007; Galobardes et al., 2006; Deutch, Pedersen & Hansen, 2005; Seidell, 2005; Wardle & Griffith, 2001).

Amarasinghe et al. (2009) reported that a lower income, which more often concerns subjects with lower education, poses a high risk for obesity. One reason for higher obesity prevalence among subjects with lower educational status is that they more often consume cheaper food, which is usually very caloric rich in sugar, salt, saturated fats and with low nutritional value (Lakdawalla, Philipson & Bhattacharya, 2005). However, higher-educated people are more likely to establish higher standards in nutrition and pay more attention to eating healthy food (Wilkinson, 2005).

It was found in particular that the negative association of low educational status and obesity rather concerns women than men (Sassi et al., 2009; McLaren, 2007; Wilkinson, 2005; Wardle & Griffith, 2001). Morris (2006) reported that there exists a difference regarding the physical activity between female and male adults with low socioeconomic status. The jobs of men with lower educational level are more often physically demanding compared to the jobs of women with lower educational level.

The higher magnitude of social inequalities for obesity among women than men was especially found for education-related inequalities (Devaux & Sassi, 2012; Tchicaya &

Lorentz, 2012; Singh-Manoux et al., 2009; Wilkinson & Pickett, 2009; Wilkinson, 2005). Mackenbach et al. (2008) investigated education-related inequalities in 22 European countries. He found that inequality is largest for women and countries in Southern Europe.

In general, health inequalities differ from period to period and from country to country (Wilkinson, 2005). It is believed that inequalities in education and income indicate a major factor in the prevalence of obesity (Wilkinson & Pickett, 2009).

3.2.4. Region

Until now, few studies have examined geographic differences in the prevalence of obesity among adults. Nevertheless, evidence exists that the region where individuals live has an impact on their BMI (Gallus et al., 2012; Berghöfer et al., 2008; Mensink, Lampert & Bergmann, 2005; Lidstone, Wilkinson & Bailey, 2005; Panagiotakos et al., 2004).

Obesity is a major health problem especially in Western and industrialized countries (Finucane et al., 2011), but there was also a rapid growth in the prevalence of obesity in developing countries in the last decades (Kelly et al., 2008; Philipson & Posner, 2008). An issue in the fight against obesity also shows that in some countries and cultures a fat body is still considered as a beauty ideal. This is for example the case in some Arab countries (Kandela, 1999) as well as urban Afro-American communities, where thinness is considered as a sign of poverty, welfare dependency or drug addiction (Wilkinson & Pickett, 2009).

Considering geographic variation in Europe, the highest obesity prevalence is reported in Eastern countries and the lowest in Western countries (Berghöfer et al., 2008; Raben, 2003). Thus, the highest increase in mean BMI has taken place in Western Europe (Finucane et al., 2006).

In Austria so far regional trends for obesity were only observed in different subpopulations, e. g. male adolescents (Schober et al., 2007; Rami et al., 2004; Kirchengast et al., 2003), patients in primary care setting (Schwarz, 2007) or farmers (Dorner et al., 2004). Except Schwarz (2007) all authors reported that the highest obesity prevalence was in the flat area, the Eastern parts of Austria and the lowest in Western Austria. Schwarz

(2007) also found an east-west decrease in the prevalence of obesity for men. However, for women there were no significant differences in the prevalence of obesity in Austrian regions.

Several studies found that in the past obesity proportions were higher in urban than rural areas (Chin & Deurenberg-Yap, 2009; Yadav & Krishnan, 2008; Chhabra & Chhabra, 2007; Sabbah et al., 2007; Jackson et al., 2005; Andersen et al., 2004; Grabauskas et al., 2003). However, in contrast to these results urbanisation is no longer seen as a risk factor for greater intake of unhealthy commodities, with exception of soft drinks (Stuckler et al., 2012; Esteghamati et al., 2010).

There is a lack of national representative studies for Europe which concern regional differences in the field of obesity. Information on geographic variations in obesity are important implications for public health planning to face structural challenges for the respective country (Berghöfer et al., 2008).

3.3. Prevalence and long-term trends in obesity among adults

In this section the prevalence of obesity and its long-term trends among adults living in Austria, selected European countries and countries all over the world is presented.

When selecting the prevalence studies it was taken into account, that outcomes from countries comparable to Austria, especially western countries and countries with economic growth, have been chosen. Additionally only studies were included, which analyzed adult samples representative of the population of the respective country.

In order to compare various cross-sectional studies which examined the prevalence of obesity the same definition and assessment for obesity is necessary. Thus, the selected studies introduced in the sections below used definition and measurement for adult obesity according to the WHO (BMI ≥ 30 kg/m²). Surveys with measured as well self-reported BMI data were included in this overview. However, it must be taken into account that self-reported BMI data may result in lower obesity prevalence compared to measured data (Shiely et al., 2010; Faeh et al., 2008).

3.3.1. Austria

Only a few studies on the prevalence of obesity in Austria are available so far. These studies illustrated the prevalence of obesity for certain years and in very specific subgroups, such as conscripts (Schober et al., 2007; Kirchengast et al., 2004; Rami et al., 2004), individuals with certain diseases (Fritz & Elmadfa, 2008; Vierhapper, 2001), individuals living in a certain Austrian province (Singh & Kirchengast, 2011; Kirchengast & Schober, 2006; Pakesch et al., 1992; Ulmer et al., 2001), patients in primary care settings (Schwarz, 2007), migrants (Kirchengast & Schober, 2008) or farmers (Dorner et al., 2004). In these surveys information regarding body weight and height mostly bases on self-reported BMI data. The main results of some of these studies are mentioned in chronological order below.

A representative cross section of persons aged 15 years and older living in Vienna (n = 1,435) was investigated in 1986. 9.3% of the female and 7.8% of the male subjects self-reported to be obese, with highest prevalence among subjects with low educational level (Pakesch et al., 1992).

Vierhapper (2001) investigated data of 15,439 euthyroid patients in Austria. There was no significant increase in the prevalence of obesity between 1992 and 1999 for this specific subgroup. In 1999 the prevalence of obesity was 17.2% overall.

In 1999/2000 health data of Austrian farmers (n = 11,144) were collected. The prevalence for obesity in this specific subpopulation was 15.2%. It was highest among subjects aged 60 to 69 years and those living in Eastern Austria, with the highest prevalence in Vienna and Burgenland (Dorner et al., 2004).

Measured BMI data from four birth cohorts of 18 year old male Austrian conscripts (n = 180,716) were analyzed for the period 1985 to 2000 to present long-term trends in the prevalence of obesity. The results showed that obesity prevalence increased significantly during the study period with the highest prevalence among conscripts with low educational level living in Eastern Austria (18.6%) (Schober et al., 2011; Kirchengast et al., 2004; Rami et al., 2004).

In 2007 Schwarz (2007) investigated data from patients of primary care physicians. Measured data on WC, body weight and body height were collected in a representative sample (n = 1.054). The data covered individuals aged 30 to 74 years. In that study the prevalence of obesity was higher among men (23.3%) than women (20.8%).

However, for Austria there is a lack of describing the prevalence of obesity among the whole adult population and of representing long-term trends for women and men in different subpopulations. Therefore it is difficult to compare results with other countries.

3.3.2. Europe

National European studies have reported that 10% to 20% of men and 10% to 25% of women are obese (Kiefer & Kunze, 2004). It is assumed that in the 27 EU countries, about 200 million people are overweight or obese. That is almost half of the population within the European Union (IASO, 2008). Figure 1 shows the proportion of overweight and obese male and female subjects.

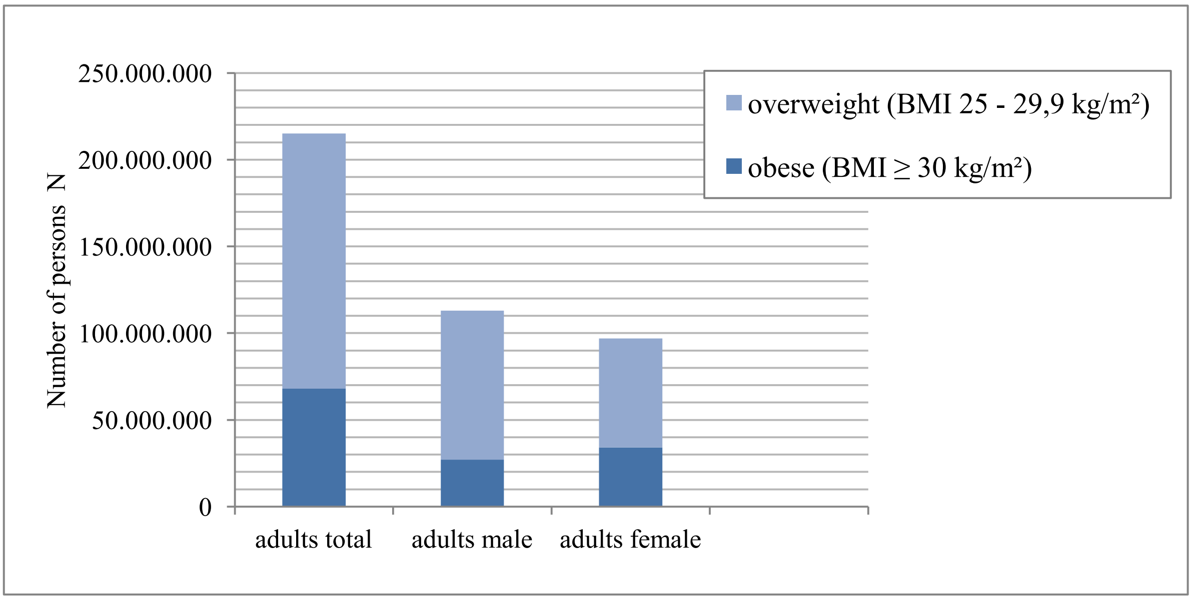


Figure 1: Frequency of overweight and obese people in Europe

Subsequently trends for European countries with short duration (maximum study period of 19 years) and long-term trends (study period of 20 years and longer) are described.

Short-term trends

Within Europe, very high prevalence of obesity was reported for Great Britain (Howel, 2010; Mackin, Bishop & Watkinson, 2007; Wardle & Griffith 2001). Between 1993 and 2004 there was a strong increase in the prevalence of obesity among adults living in Great Britain. Based on measured BMI data obesity increased from 16.9% to 24.4% among women and 13.6% to 24.0% among men (Zaninotto et al., 2009).

In other northern European countries lower obesity prevalence was reported, which is especially true for Scandinavian countries, with the exception of Finland (Pietinen et al., 1996). Data from the Swedish National Registry were investigated for the years 2004 to 2008. It was found that there were no changes in the prevalence of obesity among Swedish adults. The prevalence was about 11% for women and men (Johansson, 2010). Self-reported weight and height data among the Danish adult population were analyzed for the period 1987 to 2001. In women the prevalence of obesity increased from 5.4% to 12.5% and in men from 5.6% to 11.8% (Bendixen et al., 2004). For Luxembourg two population surveys with self-reported data were available to present trends in obesity among adults for a 12-year period. Between 1995 and 2007 the prevalence of obesity increased from 14.3% to 17.8%. In 2007 the prevalence for obesity was almost equally high among women (13.6% - 17.7%) and men (15.1% - 17.9%) (Tchicaya & Lorentz, 2012).

When considering the neighbouring countries of Austria, high prevalence was reported for adults living in Germany. Trends in obesity were investigated for the period 1985 to 2002 among the adult German population. Helmert and Strube (2004) analysed data from four national health surveys based on self-reported and measured data from 13,630 women and 12,984 men. Among women the prevalence raised from 20.7% to 31%. Among men the prevalence of obesity was 17.7% in 1985 and rose to 27.7% in 2002. Mensink, Lampert and Bergmann (2005) analysed representative telephone health surveys among adults in West- and East-Germany. They used self-reported data and corrected them based on a preliminary study in which they compared self-reported and measured BMI data. They also found an increase in the obesity prevalence among women and men living in West- and

East-Germany, with higher prevalence in those living in the Eastern part. In 2003 17.5% of the women and 17.6% of the men living in West-Germany were obese, while 25.2% of the women and 23.6% of the men in East-Germany suffered from obesity.

Comparatively low prevalence of obesity was reported for Switzerland. Self-reported data from the Swiss National Health Surveys were analyzed for subjects aged 15 years and older. Between 1992 and 2007 the obesity prevalence raised from 4.7% to 7.7% among women and 6.1% to 8.6% among men (Schneider, Dietrich & Venetz, 2010). Marques-Vidal et al. (2010) also analysed data from the Swiss National Health Survey and reported very similar prevalence for the adult population in Switzerland. Recently published outcomes for obesity prevalence are available for Italy. Self-reported data from a representative adult Italian population indicated a prevalence of 9.4% for women and 8.5% for men for the year 2010 (Gallus et al., 2012).

Short-term trends in the prevalence of obesity conducted in countries situated in Western and Southern Europe also showed that there was an increase in the amount of obese subjects. To investigate the prevalence trend for obesity in Spain, self-reported BMI data of 21,680 Spanish adults who were representative of the population were analysed. It was found that the age-adjusted prevalence of obesity rose from 8.9% to 12.1% among women and from 7.6% to 12.2% among men within ten years (Gutiérrez-Fisac et al., 2000). Guallar-Castillón et al. (2007) also examined data of Spanish adults. In the 1990ies measured weight and height data were collected from 33,542 female and male adults. Compared to the study of Gutiérrez-Fisac et al. (2000) they reported a more than twice as high obesity for the adult Spanish population (women: 27.7%; men: 27.6%). Ten-year trends in the adult Portuguese population also showed an increase in the prevalence of self-reported obesity. In 1995 12.6% of the women and 10.3% of the men were obese. By 2005 the prevalence increased to 16.0% for women and 14.1% for men (Marques-Vidal, Paccaud & Ravasco, 2011).

Nevertheless, population-based trend analyses for European countries mostly exist for a maximum period of ten years (Gallus et al., 2012; Marques-Vidal, Paccaud & Ravasco, 2011; Schneider, Deitrich & Venetz, 2010; Czernichow et al., 2009; Charafeddine, Van Oyen & Demarest, 2009; Zaninotto et al., 2009; Charles, Eschwége & Basdevant, 2008; Sulander & Uutela, 2007; Grabauskas et al., 2003; Gutiérrez-Fisac et al., 2000). The main reason is that only in very few countries health surveys are conducted in a systematic and regular way over several decades, which allow it to present trends in the prevalence of obesity. Furthermore, a comparison of such studies is often limited due to their differences in methodology (for example: different measurements of obesity by BMI or WHR), study population (for example: different age groups were investigated) and definition of obesity (for example: variations in the BMI cut-off-points) (James, 2008).

Long-term trends

There exist only a small number of long-term trend analyses surveyed the population-based development of obesity in European countries over a period of at least 20 years. These studies are presented in table 2. In table 2 the prevalence of obesity is stated for the beginning and the end of the respective study period.

Considering the outcomes of the selected long-term trend analyses an increase in the prevalence of obesity was observed in all countries.

The lowest proportion was reported for Italian adults. Between 1983 and 2004 the prevalence for obesity calculated from self-reported BMI data, increased very slowly among adults in Italy (7.4% to 8.2%) with higher rates for women (Gallus et al., 2006).

Long-term trends for the Netherlands showed that the obesity prevalence increased in the adult population, with higher proportions among women as well (Schokker et al., 2006; Visscher, Kromhout & Seidell, 2002). Based on self-reported and measured BMI data, 12% of the female and 10% of the male population in the Netherlands were obese in 2004 (Schokker et al., 2006).

Self-reported as well measured BMI data for the Swiss adult population were observed from Faeh et al. (2008) for the study period 1977 to 2004 and showed higher obesity prevalence among men. In 2004 the age-standardised prevalence was 14.5% for female and 17.1% for male subjects.

Between 1986 and 2006 precise data based on measured body weight and height were collected within the adult French population. In 1986 the prevalence was higher among women (15.9%) than men (15.0%). This changed within the next 20 years. In 2006 17.2% of the women and 18.4% of the men were considered obese in France (Pigeyre et al., 2011). Singh-Manoux et al. (2009) analysed self-reported BMI data for the adult population in France between 1970 and 2003. In 1970 the self-reported prevalence of obesity was 6.5% among women and 6.3% among men. In 2003 they still reported slightly higher prevalence for the female study population (10.2% versus 10.0%). Compared to the study of Pigeyre et al. (2011), in which measured data were used, the prevalence for the French population based on self-reported data (Singh-Manoux) was slightly lower.

For Finland a high obesity prevalence was reported. Based on self-reported and measured data investigated for the period 1978 to 2001, the obesity prevalence rose from 17.9% in women and 11.3% in men to 24.1% or rather 20.7% (Lahti-Koski et al., 2010).

In most of these studies the number of analyzed persons, however, does not suffice in order to conduct detailed long-term trends in various subgroups. Furthermore, in some studies only limited age groups among the adult population were considered (for example: Visscher, Kromhout & Seidell, 2002).

Table 2: Prevalence of obesity (BMI ≥ 30 kg/m²) among adults in the general population and its long-term trends from selected studies investigating European countries

Country	Investigation Period	Age (years)	N	SR / M[1]	Prevalence Women	Prevalence Men	Prevalence Total	Reference
France	1986-2006	35-64	10,694	M	1986:15.9 2006: 17.2	1986: 15.0 2006: 18.4		Pigeyre et al. (2011)
Finland	1978-2001	≥ 30	13,844	SR + M	1978: 17.9 2001: 24.1	1978: 11.3 2001: 20.7		Lahti-Koski et al. (2010)
France	1970-2003	25-54	About 40,000 per year	SR	1970: 6.5 2003: 10.2	1970: 6.3 2003: 10.0		Singh-Manoux et al. (2009)
Switzerland	1977-2004	34-74	34.162	SR + M	1977: 6.4 2004: 14.5	1977: 7.2 2004: 17.1		Faeh et al. (2008)
Italy	1983-2004	≥ 15 (till 1994) ≥ 18	About 50,000 between 1983 -2003; 2004: 2,932	SR	1983[2]: 7.6 2004: 8.9	1983[2]: 7.1 2004: 7.4	1983[2]: 7.4 2004: 8.2	Gallus et al. (2006)
Netherlands	1981-2004	20-70	n. a.[3]	SR + M	1981: 6.0 2004: 12.0	1981: 4.0 2004: 10.0		Schokker et al. (2006)
Netherlands	1976-1997	37-43	29,141	M	1976: 6.2 1997: 9.3	1976: 4.9 1997: 8.5		Visscher, Kromhout & Seidell (2002)

[1]SR/M = Self-reported data / Measured data; [2]Population aged 15 years or older; [3]n. a. = not available

3.3.3. Worldwide

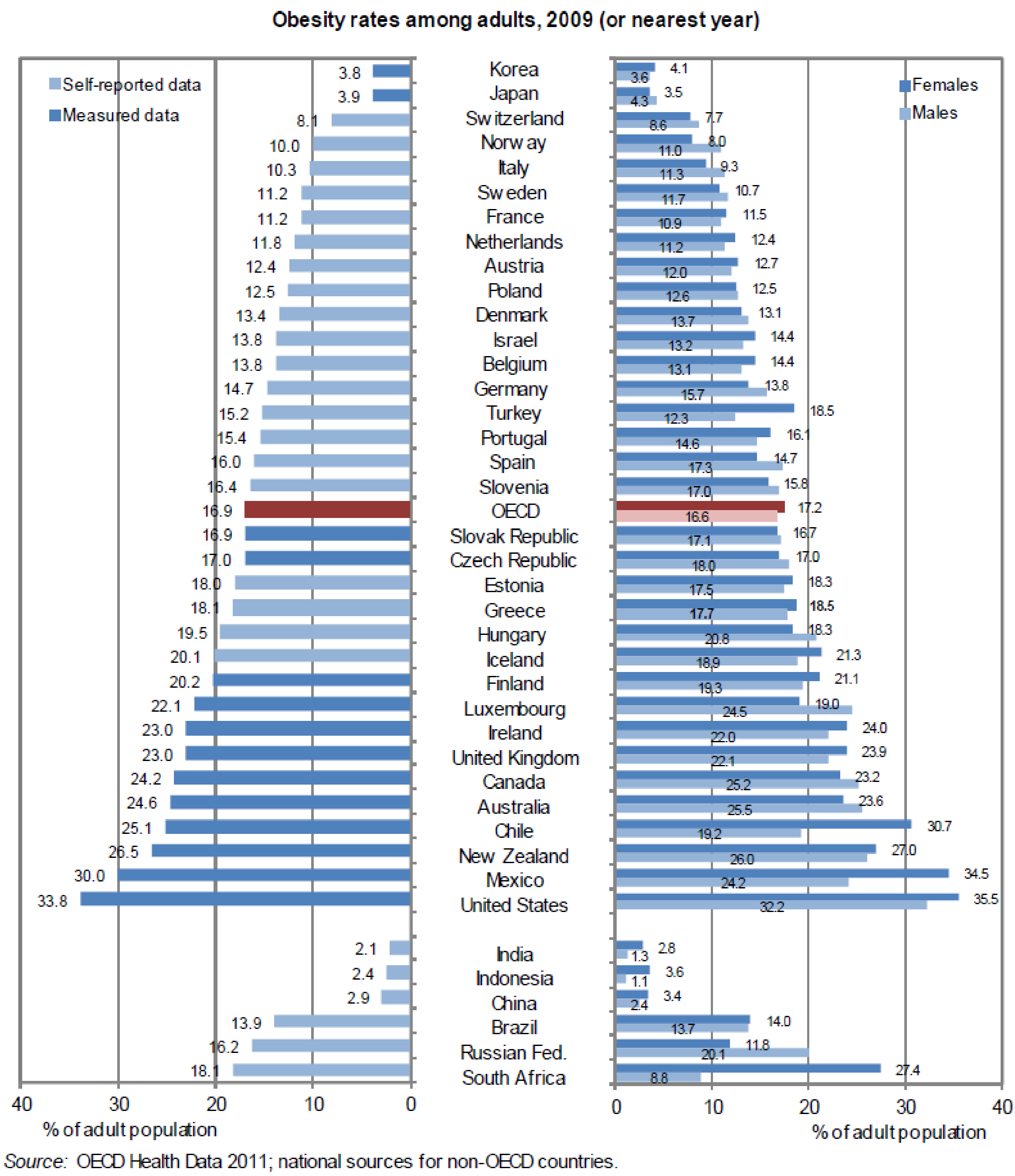
Kelly et al. (2008) estimated the overall prevalence of obesity worldwide based on data from representative population samples of 106 countries. In 2005 9.8% of the world´s adult population was obese. The estimated total number of obese adults was 396 million individuals. The prevalence of obesity was 11.9% among women and 7.7% among men. Finuncane et al. (2001) also estimated worldwide age-standardised prevalence for the year 2008. They stated that worldwide approximately 14% women and 10% men were going to be obese.

If the recent secular trends continue undiminished the number of obese subjects aged 20 years and older could increase to a total of 1.12 billion people in 2030. That would be 20% of the worlds´ adult population (Kelly et al. 2008).

Kelly et al. (2008) indicated that the highest obesity prevalence is in the established market economies and the lowest in India. However, all prognoses show that by 2030 China will overstep the established market economies in the total number of overweight and obese subjects.

The OECD (2010) investigated the prevalence of overweight and obesity for adults in OECD countries and non-OECD countries. They compared representative population surveys conducted between 2005 and 2009 based on self-reported or measured BMI data. Therefore, comparison of these countries is limited due to the different methods in the data collection.

In countries belonging to the OECD the highest prevalence, with more than 30% obese subjects, was reported for women and men living in the United States. The lowest prevalence was found for Korea (3.8%). In the selected non-OECD countries the prevalence for women was highest in South Africa (27.4%) and lowest in India (2.8%). For men the highest proportions were reported in Brazil (13.7%) and the lowest in Indonesia (1.1%). The average prevalence in OECD countries was 17.2% for women and 16.6% for men. For Austria the prevalence was estimated slightly lower than the OECD average for obesity. Based on the data of the Austrian Health Interview Survey (AT-HIS 2006/07) a prevalence of 12.7% was reported for women and 12.0% for men (OECD, 2010). The precise proportions for the selected countries are presented in figure 2.



Source: OECD (2012)

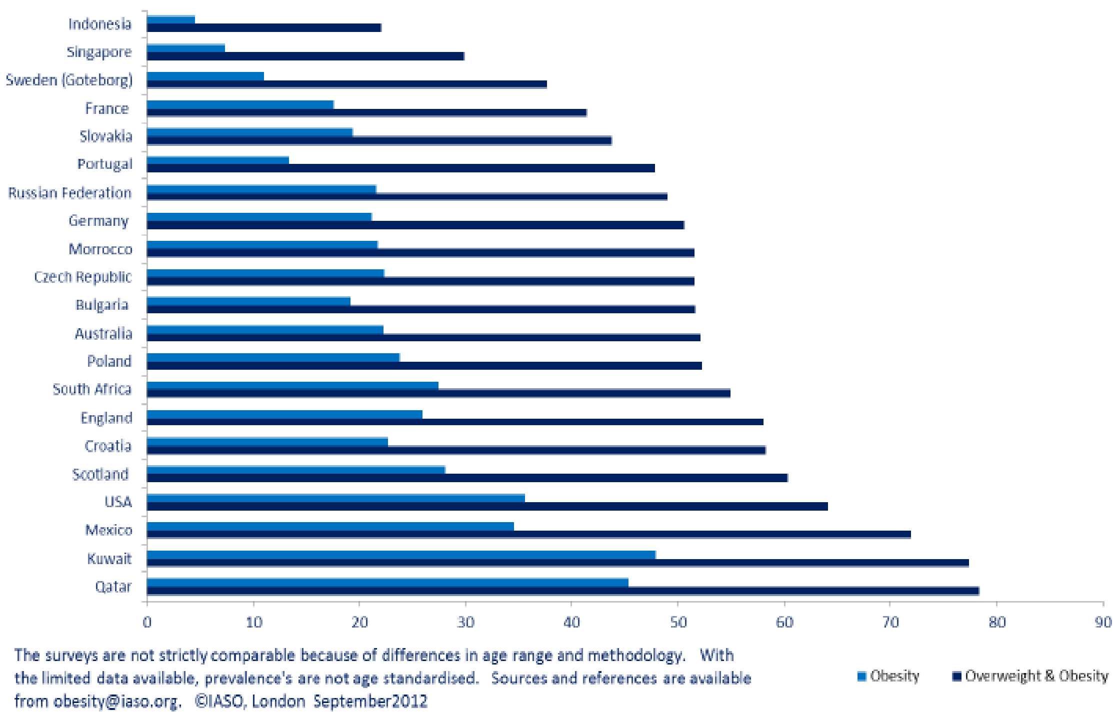
Figure 2: Prevalence of overweight (BMI 25-29.99 kg/m²) and obesity (BMI ≥ 30 kg/m²) in adults from OECD countries and non-OECD countries

An update of this OECD study was made in 2012. The latest data showed that the obesity epidemic increased most of all in Ireland, Canada and the United States. Modest increases were found for Spain and France. However, within this short duration a slowdown or stabilization in the prevalence of obesity was observed for the following countries: South Korea, Switzerland, Italy, Hungary and Great Britain. Data for Austria were not available for the update in 2012 (OECD, 2012).

The International Association for Obesity Studies (IASO, 2012) tried to compare the prevalence of obesity in adults from 21 selected countries or rather continents all over the world. However, due to the different methods used comparison between the countries is limited.

The prevalence for overweight and obesity from selected countries is presented separately for women (figure 3) and men (figure 4) according to the IASO (2012).

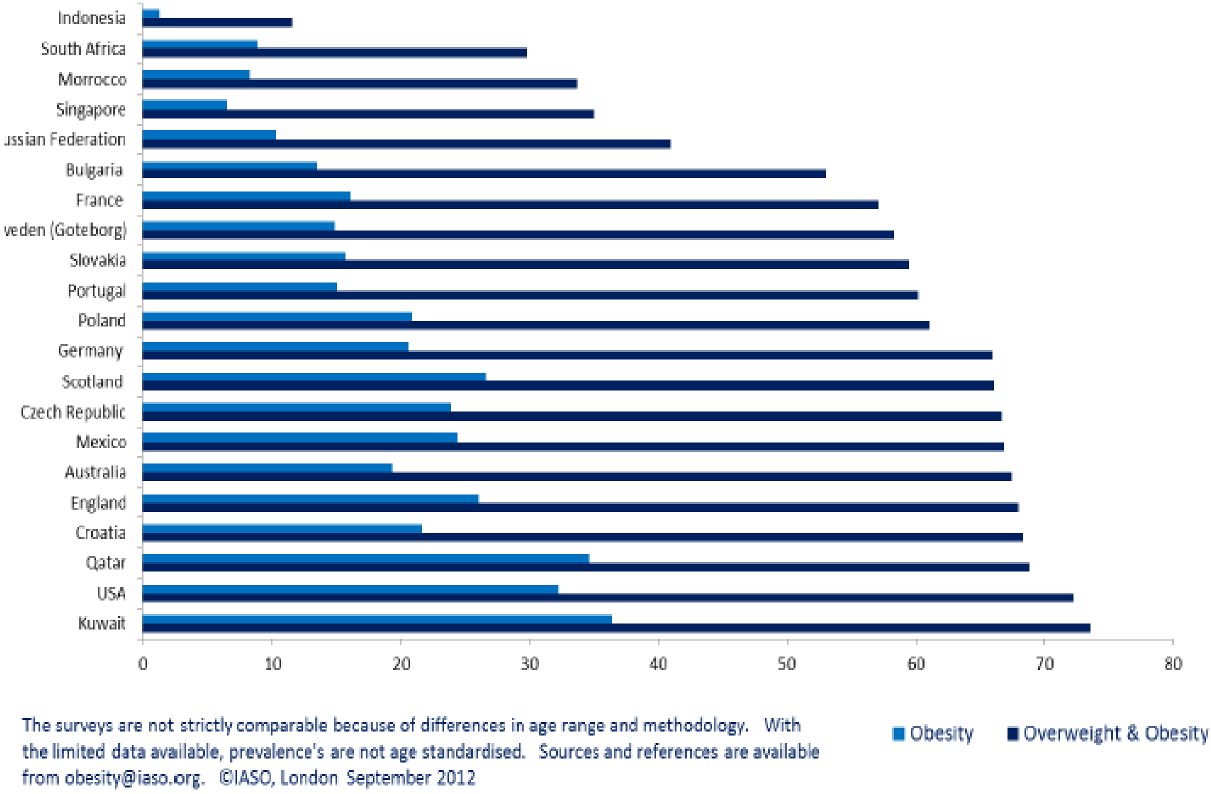
For women, the highest prevalence was found among those living in Kuwait. Almost 50% of women in Kuwait are suffering from obesity. Very high prevalence was also found for women in Qatar, the United States and Mexico. The lowest prevalence was reported for female adults from Indonesia and Singapore (IASO, 2012).



Source: IASO (2012)

Figure 3: Prevalence of overweight (BMI 25-29.99 kg/m²) and obesity (BMI ≥ 30 kg/m²) in adult females from selected countries around the world

For male adults the highest prevalence of obesity was also reported for those living in Kuwait. It was found that more than 35% of men in Kuwait are obese. For Qatar and the United States the prevalence of obese man was also very high. The lowest prevalence of obesity was reported for men in Indonesia and Singapore (IASO, 2012).



Source: IASO (2012)

Figure 4: Prevalence of overweight (BMI 25-29.99 kg/m²) and obesity (BMI ≥ 30 kg/m²) in adult males from selected countries around the world

For the United States representative data of very high quality for the prevalence of obesity is available. Since the early 1960s regular surveys focusing on the health and nutritional status of different population groups are conducted. The unique program combines interviews and physical examinations and is called `National Health and Nutrition

Examination Survey´ (NHANES). The NHANES program allows monitoring obesity over the last decades in the United States (Center for Disease Control and Prevention, 2013).

Outcomes of the NHANES showed a strong increase in the prevalence of obesity among adults in the last decades with a continued upward trend. Results from the first NHANES in the 1960ies indicated that 14.3% of all adults in the United States aged 20 to 74 years were obese. In the NHANES 2007 to 2008 the age-adjusted prevalence of obesity among adults was already 40.3% with a very high prevalence of subjects with extreme obesity (BMI $\geq$ 40 kg/m²). The highest prevalence was reported for Non-Hispanic black individuals living in the United States (Ljungvall & Zimmerman, 2012; Odgen & Carroll, 2010).

Especially in countries with economic growth the prevalence of obesity has increased very fast. In the Arabian Gulf region obesity prevalence is very high among men and much higher among women (Ng et al., 2010). There was also a rapid growth in the prevalence of obesity among Iran adults. Data of three cross-sectional surveys, conducted between 1999 and 2007, were analyzed by Esteghamati et al. (2010). The prevalence of obesity increased from 13.6% (1999) to 19.6% (2005) to finally 22.3% (2007). This fast and high increase was seen among both sexes.

3.4. Obesity-associated diseases and disorders

Ali and Lindenstroem (2006) indicated that obese subjects more often self-report poorer health, compared to women and men with normal weight.

A higher BMI is frequently associated with poorer health. Studies found that obesity is a major risk factor for a number of non-communicable diseases, such as diabetes mellitus type 2, cardiovascular diseases, hypertension or malignant tumours which enhance mortality significantly and represent the greatest health threat for European countries (IASO, 2013; Franco et al., 2012; Barnes, 2011; Faeh et al., 2011; Ha do et al., 2011; Ng et al., 2011; Khan & Kraemer, 2009; Cuevas et al., 2008; Fontaine et al., 2003). Complex pathophysiological processes especially posed by the visceral, abdominal fat underlie the associations with obesity and the mentioned diseases (Kiefer et al., 2006).

While the prevalence of obesity increased, there was also a clear parallel increasing trend in the prevalence of obesity-associated diseases. This is especially true for diabetes mellitus type 2 and cardiovascular diseases (WHO, 2012a; Barnes, 2011; Kortelainen & Porvari, 2011; Ng et al., 2010; Villalpando et al., 2010; van Wye et al., 2008; Flegal et al., 2007; Pereira et al., 2005). BMI is seen as one of the strongest predictors of diabetes mellitus type 2 (Hjellvik, Sakshaug & Strøm, 2012). Avoiding obesity could inhibit or delay the genesis of diabetes mellitus type 2 (Stadler & Prager, 2012). A strong relationship between BMI and mortality from cardiovascular diseases was also found (Dudina et al., 2011; Berrington de Gonzales et al., 2010). Crawford et al. (2010) reported that the direct association between BMI and the prevalence of diabetes mellitus type 2, hypertension and hyperlipidemia are consistent for women and men from the United States across all racial and ethnic groups.

Apart from non-communicable diseases, there are also a variety of health disorders that are more common in obese than non-obese women and men. It was found that there is a strong association between obesity and sleep disturbance (Dixon, Schachter & O´Brian, 2001). Pillar and Shehadeh (2008) reported that obesity and sleep disorder form a vicious cycle in which each leads to a worsening the other. Busch et al. (2010) investigated the association between obesity and medically diagnosed depression in a representative sample of German adults. It was found that obese subjects had a higher risk for depression, than non obese subjects. It was also reported that among obese individuals the prevalence of migraine is much higher (Yu et al., 2012) compared to individuals with normal weight. There is also an association between obesity and chronic daily headache (Bigal & Rapoport, 2012). Outcomes of the European Study on the Epidemiology of Mental Disorders indicated that obese subjects were more likely to have one or more mental disorders (mood, anxiety, alcohol disorders), compared to individuals with normal weight (Bruffaerts et al., 2008). Obesity is also a major risk factor for low back pain, which is a widespread ailment among adults (Shiri et al., 2012; Shiri et al., 2010).

However, as well as obesity, nutrition-related diseases are largely preventable (Ng et al., 2010).

3.5. Summary of literature-derived open questions

The literature search showed that there is a lack of long-term trend analyses surveying the population-based development of obesity in European countries. Long-term trend analyses mainly exist for certain population groups mostly restricted to limited age groups (e.g. adolescents, conscripts). Therefore the extents to which population groups are affected by long-term increases in the prevalence of obesity are mainly unknown.

For Austria as a whole, there is not enough information in order to illustrate long-term trends in the prevalence of obesity among adults. Longitudinal data on disease proportions of people suffering from obesity in representative samples collected over a period of several decades would allow a more accurate assessment of developments in the obesity epidemic (Ritzer & Stronegger, 2007). Studies should focus especially on the question which subgroups in a population are really concerned by obesity. Therefore, the factors behind obesity affected populations can be identified and target-group specific preventive measures can be planned in the future (OECD, 2012; Doak et al., 2011; Flegal, 1999).

Obesity is influenced by a number of determinants which must be taken into account when assessing the causes of time trends in various settings (Sassi et al., 2009). Previous studies concluded that especially the education of an individual plays an important role in the status of her / his BMI status (Wilkinson & Pickett, 2009). Education-related inequalities for the prevalence of obesity were still higher among women than men (Devaux & Sassi, 2012; Tchicaya & Lorentz, 2012; Wilkinson & Pickett, 2009; Wilkinson, 2005). Until now no evidence-based results of trends for social inequalities in the prevalence of obesity for various subgroups in the Austrian population exist.

Furthermore, there is a lack of information regarding the prevalence and long-term trends of obesity-associated diseases and disorders in the Austrian adult population. By the representation of long-term trends for obesity-associated diseases and disorder the extending could be demonstrated within Austria. The investigation of subgroups would furthermore allow to identify persons with special risk for a specific disease or disorder. This would facilitate the planning of public health measurements and reduce the amount of subjects with obesity-related diseases and disorders in future (Ng et al., 2010).

4. Research questions

The specific research questions which will be analyzed in this study are as follows:

1. Which are the overall epidemiological long-term trends in the prevalence of obesity among Austrian female and male adults between 1973 and 2006/07?

1.1 Which long-term-trends in the prevalence of obesity can be identified considering socio-demographic indicators (age, educational level and region) among women and men?

1.2 Which long-term trends exist in education-related inequalities for the prevalence of obesity among subpopulations (based on age, educational level and region)?

2. Which long-term trends exist in selected obesity-associated diseases and disorders (diabetes mellitus, hypertension, back pain, sleep disorder, depression and headache) among obese and non-obese women and men of different age groups?

5. Preliminary study: Validation of self-reported BMI in Austria

This chapter of the thesis is withdrawn from a research paper from Großschädl, Haditsch and Stronegger (2012) and was adapted for the present study.

Since the obesity prevalence is often lower in self-reported than measured data (c.f. chapter 3.1.3.) a preliminary study was done in advance, in which the validity of self-reported values on body weight and heigt was assessed for the first time among Austrian adults. This validation study was conducted because the available BMI data for the main study were collected by self-reporting.

5.1. Aims

The purpose of the validation study was to evaluate the validity of self-reported body weight and height among adults in Austria and to determine whether the validity depends upon readily available individual characteristics such as age, sex, educational level and smoking behaviour. In addition the accuracy of self-reported data and its influence on the classification of different BMI categories in comparison with measured data was assessed.

5.2. Methods

The validation study was conducted between January and February 2010 in a publicly accessible out-patient clinic at the Institute of Preventive Medicine in Graz, in which adult

Austrian residents attended a health check. The health checks are open to all Austrian residents aged 18 years and older. Subjects who attended a health check were asked beforehand to fill in an anonymous single-sheet questionnaire, providing information such as their actual height in centimeter (without shoes) and their actual weight in kilograms (without clothes) as well as information regarding their lifestyle and socio-demographic characteristics. The questionnaire of the validation study is presented in the appendix. Participation in the study was voluntary. The participants were previously informed that their data would not be disclosed to third parties and would be kept anonymous.

After completing the questionnaire the subjects started the health check, carried out in examination rooms by different physicians (in total six) who took the height and weight measurements. Body height and weight were measured in a standardised procedure with participants wearing underwear and no shoes. Body weight was measured using a digital scale to the nearest 1 kilogram. Body height was measured with the participants standing without shoes and feet together, to the nearest 1 centimeter. After completing the health checks the physician noted the measured data on body weight and body height on the respective questionnaire.

A total of 595 questionnaires were distributed to persons who attended the health examination at the out-patient unit of the Institute of Preventive Medicine in Graz. 553 persons participated (257 women; 277 men; 9 failed to specify their gender) thus yielding a response rate of 92.9%. 80 of those adults were excluded from statistical analysis because of missing data on their weight and/or height and their gender. Thus 473 participants were eligible for analysis (53.3% male). The mean ± SD age of the subjects was 46.2 ± 15 years (women: 45 ± 15 years; men: 47 ± 14 years), with age overall ranging from 20 to 84 years. The highest educational level of the participants was a vocational school degree (42.5%). The majority reported that they had never smoked (44.8%), followed by those who had given up smoking (27.9%).

For statistical analyses multiple linear regression analysis was used to identify factors associated with the difference between self-reported and measured BMI. The model included the following independent variables: sex (with the female as reference), age group (with the youngest age group of less than 35 years as reference), educational level (with primary school as reference) and smoking behaviour (with smoking occasionally as reference). In addition, agreement between self-reported and measured BMI was assessed using the Bland-Altman method (Grouven, Bender & Ziegler, 2007; Bland & Altman, 1999). In assessing the agreement between two methods of measurement differences are of importance. The Bland-Altman plot considers these two aspects and provides an easy way to represent and quantify the conformity of measurement methods. All observed outliers were included in the analysis, because their underlying reported and measured weight and height values were in a plausible range.

Paired sample t tests were conducted in order to detect significant differences between measured and self-reported data. For comparing reported with measured prevalence of different BMI categories the nptrend procedure of Stata/SE was applied, which performs Cuzick´s non-parametric test for trends across ordered groups. This test is an extension of the Wilcoxon rank sum test (Cuzick, 2006). A p-value of 0.05 was used in this validation study for statistical significance.

All statistical analyses were conducted using the statistical software packages SPSS® for Windows version 17.0 (SPSS Inc., Chicago, IL, USA) and Stata/SE for Windows version 1.1 (StatCorp., College Station, TX, USA).

5.3. Results

The outcomes of the validation study showed that self-reported mean weight was significantly lower than measured mean weight ($p < 0.001$). The means in differences in self-reported versus measured weight and height stratified by sex and age are presented in table 3.

Table 3: Comparison of self-reported (SR) and measured (M) body weight and height among women and men of different age groups

		Weight SR (kg)	Weight M (kg)	Difference for weight (kg)			Height SR (cm)	Height M (cm)	Difference for height (cm)		
		Mean (SD)	**Mean (SD)**	**Mean (SD)**	**95% CI**	**p-value***	**Mean (SD)**	**Mean (SD)**	**Mean (SD)**	**95% CI**	**p-value***
Women	< 35 years	61.1 (10.7)	61.2 (10.2)	-0.11 (3.8)	-1.07, 0.86	0.826	167.7 (6.9)	167.0 (6.9)	0.69 (1.6)	0.28, 1.11	0.001
(N = 221)	35 – 44 years	66.1 (12.2)	66.6 (12.7)	-0.52 (1.5)	-0.93, -0.11	0.013	168.8 (7.7)	168.8 (8.1)	0.02 (1.3)	-0.34, 0.38	0.916
	45 – 54 years	65.6 (9.3)	66.2 (9.6)	-0.62 (1.9)	-1.20, -0.04	0.035	165.3 (4.6)	164.4 (5.2)	0.89 (1.9)	0.32, 1.46	0.003
	≥ 55 years	66.6 (9.6)	67.7 (10.4)	-1.06 (2.9)	-1.86, -0.26	0.011	162.2 (7.0)	160.1 (7.0)	1.44 (2.0)	0.90, 2.01	0.000
	Total	64.7 (11.07)	65.3 (11.3)	-0.53 (2.8)	-0.89, -0.16	0.005	165.89 (7.3)	165.11 (7.6)	0.77 (1.8)	0.54, 1.01	0.000
Men	< 35 years	81.6 (10.7)	81.4 (11.0)	0.22 (2.0)	-0.32, 0.76	0.410	180.6 (7.1)	179.7 (7.1)	0.87 (1.7)	0.42, 1.32	0.000
(N = 252)	35 – 44 years	82.4 (12.5)	82.8 (13.2)	-0.35 (2.7)	-0.99, 0.29	0.283	178.3 (6.7)	177.6 (6.6)	0.68 (1.8)	0.26, 1.10	0.002
	45 – 54 years	85.2 (14.1)	86.0 (15.1)	-0.73 (2.5)	-1.40, -0.06	0.034	176.6 (7.4)	175.8 (7.5)	0.85 (1.3)	0.52, 1.19	0.000
	≥ 55 years	82.4 (11.3)	82.6 (12.0)	-0.17 (2.8)	-0.87, 0.52	0.616	174.1 (5.6)	172.6 (6.8)	1.46 (3.1)	0.69, 2.23	0.000
	Total	82.9 (12.4)	83.1 (13.1)	-0.25 (2.5)	-0.56, 0.06	0.113	177.2 (7.1)	176.3 (7.3)	0.96 (2.1)	0.70, 1.22	0.000
Total	< 35 years	70.7 (14.8)	70.6 (14,6)	0.05 (3.1)	-0.52, 0.61	0.871	173.7 (9.5)	172.9 (9.4)	0.78 (1.6)	0.47, 1.08	0.000
(N = 473)	35 – 44 years	74.6 (14.7)	76.0 (15.2)	-0.42 (2.3)	-0.82, -0.02	0.042	174.3 (8.5)	173.9 (8.4)	0.40 (1.6)	0.11, 0.69	0.007
	45 – 54 years	76.4 (15.6)	77.1 (16.2)	-0.68 (2.2)	-1.12, -0.24	0.003	171.5 (8.4)	170.7 (8.7)	0.87 (1.6)	0.56, 1.18	0.000
	≥ 55 years	75.1 (13.2)	75.7 (13.5)	-0.58 (2.9)	-1.10, -0.06	0.030	168.6 (8.8)	167.1 (9.19)	1.45 (2.6)	0.98, 1.93	0.000
	Total	74.4 (14.9)	74.8 (15.2)	-0.38 (2.6)	-0.62, -0.14	0.002	171.9 (9.1)	171.1 (9.3)	0.88 (2.0)	0.70, 1.05	0.000

*according to the paired-samples T test

(withdrawn from Großschädl, Haditsch & Stronegger, 2012)

In table 4 mean values and differences for self-reported and measured BMI values are shown.

Table 4: Comparison of self-reported (SR) and measured (M) BMI among women and men of different age groups

		BMI SR (kg/m^2)	BMI M (kg/m^2)	Difference for BMI (kg/m^2)		
		Mean (SD)	Mean (SD)	Mean (SD)	95% CI	p value*
Women	< 35 years	21.7 (3.1)	21.9 (3.0)	-0.23 (1.5)	-0.61, 0.15	0.238
(N = 221)	36 – 44 years	23.1 (3.2)	23.3 (3.4)	-0.19 (0.6)	-0.37, -0.02	0.033
	46 – 54 years	24.0 (3.0)	24.5 (3.3)	-0.50 (0.8)	-0.74, -0.25	0.000
	≥ 55 years	25.4 (3.6)	26.2 (4.0)	-0.87 (1.1)	-1.17, -0.56	0.000
	Total	23.5 (3.6)	23.9 (3.8)	-0.43 (1.1)	-0.58, -0.28	0.000
Men	< 35 years	25.0 (2.9)	25.2 (3.1)	-0.18 (0.9)	-0.43, 0.06	0.143
(N = 252)	36 – 44 years	25.9 (3.3)	26.2 (3.6)	-0.31 (1.2)	-0.59, -0.04	0.026
	46 – 54 years	27.3 (3.9)	27.8 (4.2)	-0.49 (0.9)	-0.74, -0.24	0.000
	≥ 55 years	27.2 (3.3)	27.7 (3.6)	-0.53 (1.1)	-0.81, -0.25	0.000
	Total	26.4 (3.5)	26.8 (3.9)	-0.38 (1.1)	-0.51, -0.25	0.000
Total	< 35 years	23.2 (3.4)	23.4 (3.4)	-0.21 (1.3)	-0.43, -0.06	0.078
(N = 473)	36 – 44 years	24.7 (3.5)	25.0 (3.8)	-0.26 (1.0)	-0.59, -0.09	0.003
	46 – 54 years	25.8 (3.9)	26.3 (4.1)	-0.49 (0.9)	-0.67, -0.32	0.000
	≥ 55 years	26.3 (3.6)	27.0 (3.9)	-0.68 (1.1)	-0.89, -0.48	0.000
	Total	25.0 (3.8)	25.4 (4.1)	-0.40 (1.1)	-0.50, -0.30	0.000

*according to the paired-samples T test

(withdrawn from Großschädl, Haditsch & Stronegger, 2012)

The mean BMI values calculated from self-reported data were lower than the measurement-based BMI values. Self-reported weight and height resulted in a mean BMI of 25.04 kg/m^2, while measurements showed a mean BMI of 25.44 kg/m^2. In total a difference of -0.40 kg/m^2 was found between reported and measured BMI values ($p < 0.001$). The greatest deviations between self-reported and measured BMI emerged among study participants aged 55 years and older. The deviations were higher among female than male adults (women: -0.87 kg/m^2, $p < 0.001$; men: -0.53 kg/m^2, $p < 0.001$).

To identify determinants of validity a multiple linear regression analysis was performed with sex, educational level, smoking behaviour and age group as independent variables and differences between self-reported and measured BMI as dependent variable. The outcomes of the multiple linear regression analysis are shown in table 5.

Table 5: Determinants of the difference of self-reported (SR) and measured (M) BMI

Variable	B (kg/m^2)	95% CI for B	SD	p-value
Intercept	-0.129	-0.78, 0.53	0.33	0.699
Sex				
Female^ref				
Male	-0.04	-0.28, 0.20	0.12	0.74
Age group				
< 35 years^ref				
35 – 44 years	-0.12	-0.44, 0.20	0.16	0.46
45 – 54 years	-0.39	-0.74, -0.05	0.18	0.03
> 55 years and older	-0.70	-1.05, -0.36	0.18	0.00
Educational level				
Primary school^ref				
Vocational school	-0.08	-0.48, 0.32	0.20	0.69
Commercial or professional school	-0.10	-0.56, 0.36	0.23	0.67
Secondary school with school completion examination	-0.24	-0.70, 0.22	0.23	0.30
University of higher education	-0.22	-0.71, 0.27	0.25	0.37
Other education after school completion examination	-0.17	-1.05, 0.70	0.44	0.70
Smoking behaviour				
Occasionally^ref				
Up to 10 cigarettes daily	-0.06	-0.68, 0.55	0.31	0.84
11 to 20 cigarettes daily	-0.10	-0.70, 0.49	0.30	0.73
More than 20 cigarettes daily	0.07	0.73, 0.86	0.40	0.87
Given up smoking	0.14	-0.36, 0.63	0.25	0.59
Never smoked	0.18	-0.31, 0.66	0.25	0.48

B = regression coefficient

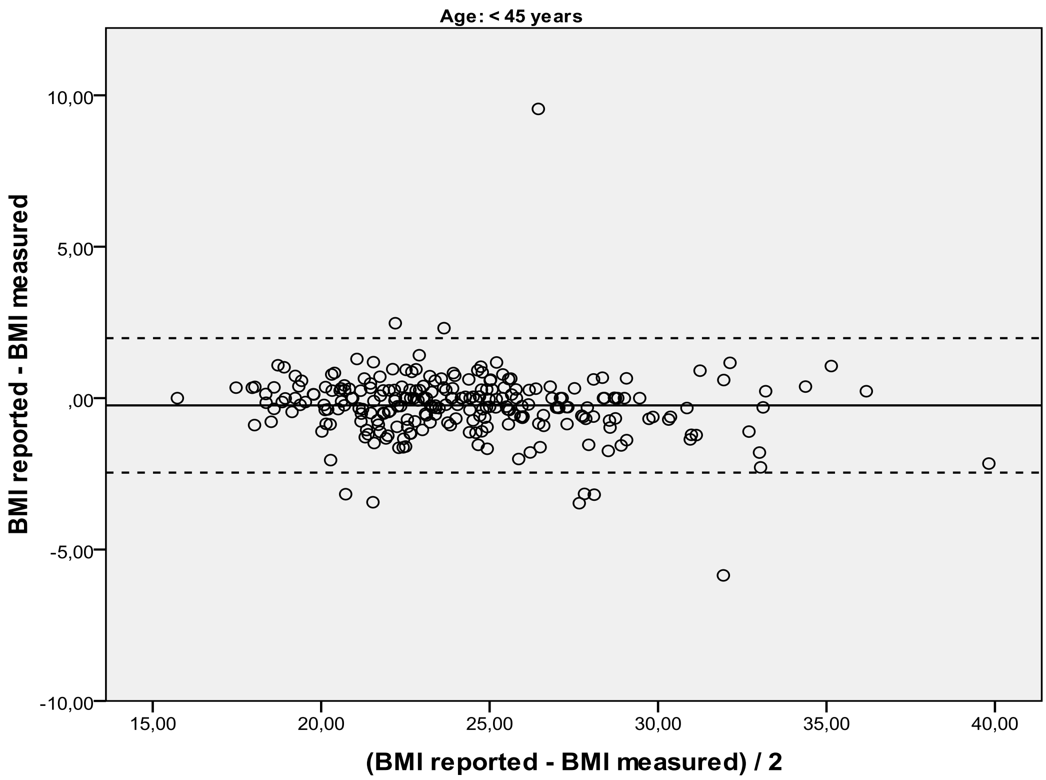
ref = reference category

(withdrawn from Großschädl, Haditsch & Stronegger, 2012)

Age (up to 45 years of age) was the only predictor that was statistically significantly associated with the difference between measured and reported BMI. The difference of self-reported and measured BMI in the two older age groups increased significantly ($p < 0.05$).

The agreement between self-reported and measured BMI is presented by Bland-Altman plots. Figure 5 illustrates Bland-Altman plots in which the agreement between self-reported and measured BMI is shown separately for participants up to 45 years of age and participants 45 years and older. The solid line in the plots represents the mean difference between BMI measurements and the mean of both measurements. The dashed lines represent the 95% limits of agreement (Bland & Altman, 1999).

The mean differences in the plots are close to zero, indicating a very good agreement between self-reported and measured BMI data at population level. The ranges of misreported BMI values are also quite small. This means good agreement at the individual level. The 95% CI for the BMI values in younger adults indicate that individual variability between the two BMI measurements was between -2.46 kg/m^2 and +1.98 kg/m^2. The mean bias was -0.24 kg/m^2. The comparison of the plots shows that the agreement between reported and measured BMI is lower in older study participants (mean difference: -0.60 kg/m^2; 95% CI: -2.64, 1.44 kg/m^2).



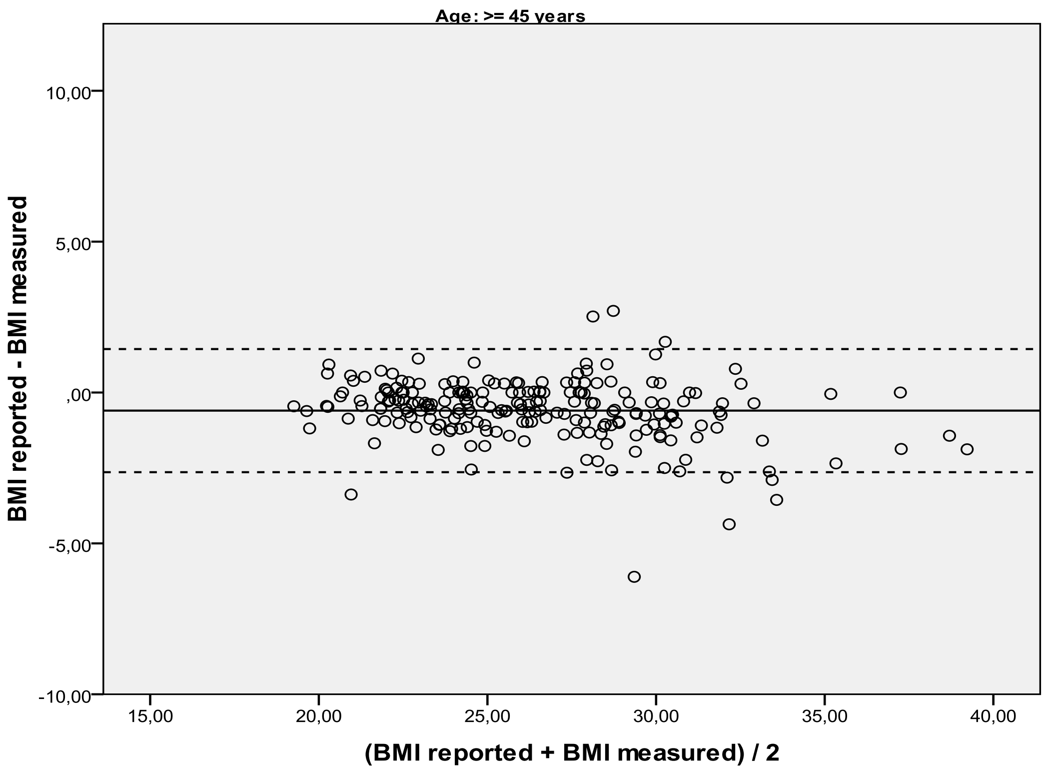


Figure 5: Bland-Altman plot for analysis of agreement between self-reported (SR) and measured (M) BMI in subjects younger than 45 years (above) and 45 years and older (below): ——— represents mean difference; ------- represent upper and lower limits of agreement (mean difference ± 2 SD)

(withdrawn from Großschädl, Haditsch & Stronegger, 2012)

Consequences of self-reporting on BMI categories (according to the WHO (2006)) are shown in table 6 for the whole study population and separately for adults younger than 45 years and adults older than 45 years as well as women and men.

Table 6: Proportion of subjects classified in different BMI categories according to the self-reported (SR) and measured (M) BMI, separately for younger and older subjects and for women and men

	Total ($p^a < 0.001$; $z^b = 18.65$)			
	BMI category based on self-reported BMI		*BMI category based on measured BMI*	
	N	% (95% CI)	N	% (95% CI)
Underweight	6	1.3 (0.3, 2.3)	7	1.5 (0.0, 2.6)
Normal weight	231	48.8 (44.3, 53.4)	217	45.9 (41.4, 50.4)
Overweight	177	37.4 (33.0, 41.8)	176	37.2 (32.8, 41.6)
Obesity (class 1)	50	10,6 (7.8, 13.4)	60	12.7 (9.7, 15.7)
Obesity (class 2)	9	1.9 (0.1, 0.3)	11	2.3 (1.0, 3.7)
Obesity (class 3)	0	0	2	0.4 (0.2, 1.0)
	Subjects younger than 45 years ($p^a = 0.425$; $z^b = 13.25$)			
	BMI category based on SR BMI		*BMI category based on M BMI*	
	N	% (95% CI)	N	% (95% CI)
Underweight	6	2.3 (0.5, 4.2)	7	2.7 (0.7, 4.7)
Normal weight	144	56.3 (50.1, 62.3)	142	55.5 (49.3, 61.6)
Overweight	86	33.6 (27.8, 39.4)	83	32.4 (26.7, 38.1)
Obesity (class 1)	16	6.3 (3.3, 9.2)	20	7.8 (4.5, 11.1)
Obesity (class 2)	4	1.6 (0.03, 3.1)	3	1.2 (0.1, 2.5)
Obesity (class 3)	0	0	1	0.4 (0.4, 1.1)
	Subjects 45 years and older ($p^a < 0.001$; $z^b = 12.84$)			
	BMI-category based on self-reported BMI		*BMI category based on measured BMI*	
	N	% (95% CI)	N	% (95% CI)
Underweight	0	0	0	0
Normal weight	87	40.1 (33.5, 46.6)	75	34.6 (28.2, 40.9)
Overweight	91	41.9 (35.3, 48.5)	93	42.9 (36.2, 49.5)
Obesity (class 1)	34	15.7 (10.8, 20.5)	40	18.4 (13.2, 23.6)
Obesity (class 2)	5	2.3 (0.3, 4.3)	8	3.7 (1.1, 6.2)
Obesity (class 3)	0	0	1	0.5 (0.4, 1.4)
	Women ($p^a < 0.001$; $z^b = 12.20$)			
	BMI category based on self-reported BMI		*BMI category based on measured BMI*	
	N	% (95% CI)	N	% (95% CI)
Underweight	6	2.7 (0.56, 4.87)	6	2.7 (0.6, 4.9)
Normal weight	152	68.8 (62.6, 74.9)	141	63.8 (57.4, 70.2)
Overweight	47	21.3 (15.9. 26.7)	51	23.1 (17.5, 28.7)
Obesity (class 1)	14	6.3 (3.1, 9.6)	19	8.6 (4.9, 12.3)
Obesity (class 2)	2	0.9 (0.4, 2.2)	3	1.4 (0.2, 2.9)
Obesity (class 3)	0	0	1	0.5 (0.4, 1.3)
	Men ($p^a = 0.063$; $z^b = 13.72$)			
	BMI category based on self-reported BMI		*BMI category based on measured BMI*	
	n (%)	% (95% CI)	N	% (95% CI)
Underweight	0	0	1	0,4 (0.4, 1.2)
Normal weight	79	31.3 (25.6, 37.1)	76	30,2 (24.5, 35.9)
Overweight	130	51.6 (45.4, 57.8)	125	49,6 (43.4, 55.8)
Obesity (class 1)	36	14.3 (10.0, 18.6)	41	16,3 (11.7, 20.8)
Obesity (class 2)	7	2.8 (0.7, 4.8)	8	3,2 (1.0, 5.3)
Obesity (class 3)	0	0	1	0,4 (0.4, 1.1)

[a]according to the Cuzick test for trend; [b]according to the Cuzick test for trend

According to the measured data 45.9% of the participants were categorized as having normal weight status. Anthropometric measurements showed that 12.5% of the subjects were obese. The prevalence of underweight and obesity was underestimated when based on self-reported BMI. Especially among subjects 45 years and older, the prevalence of obesity was underestimated in the self-reporting procedure ($p < 0.001$). In the younger age groups no significant differences in BMI categories were found (table 6) (withdrawn from Großschädl, Haditsch & Stronegger (2012).

5.4. Conclusion

The results of the preliminary validation study indicated that prevalence proportions of obesity are probably underestimated for Austrian female and male adults when using self-reporting BMI data. The deviations from the measured weight and height data clearly increased with age.

In this preliminary study the setting could have present a disadvantage regarding the representativeness of the study. It seems likely that inidividuals attending a health check rather inform their true body weight and height. Maybe there would have been less agreement between self-reported and measured BMI data in other settings, as for example in telephone surveys. A strength of the validation study was that the measurements were performed via a standardised procedure by trained physicians. Between the self-reporting and measurements there was a maximum time interval of only 3 hours.

In conclusion it must be taken into account that there are limitations regarding the use of self-reported weight and height data especially for older adults, because self-reported BMI may induce bias in prevalence studies about obesity.

The results of this validation study were considered when calculating the prevalence of obesity for the main study. Correction for self-reported BMI data was made and is described in detail in the following chapter concerning the methods of the main study.

6. Methods

In this study a secondary data analysis based on cross-sectional health surveys in Austria was made.

6.1. Data source and subjects

Data were derived from five representative cross-sectional health surveys carried out in Austria with comparable methodology. Since 1973, five nationwide health surveys have been conducted at irregular time intervals. Health data were collected through the Austrian Microcensus in 1973, 1983, 1991 and 1999. The Microcensus is a nationwide survey conducted by the federal statistical office `Statistik Austria´. In this survey the participants are obliged to give full information for the baseline survey portion. The last health survey was conducted between March 2006 and 2007 as a replacement of the former Microcensus surveys on health and is called Austrian Health Interview Survey (AT-HIS 2006-07). For each survey a random sample was drawn from the Austrian population register. For the sake of representation, the sample was stratified by the 32 administrative Austrian districts. The data of the surveys were weighted using age, sex and region specific weights to ensure representativeness of the sample (Statistik Austria, 2007; Statistik Austria, 1999; Friedl, 1994; Österreichisches Statistisches Zentralamt, 1983).

Data were obtained through standardised face-to-face interviews of individuals aged 15 years and older in private homes or long-term care facilities (such as nursing homes) by trained interviewers of `Statistik Austria´ using interviewer questionnaires. The raw data were screened for errors (Statistik Austria, 2007; Statistik Austria, 1999; Friedl, 1994; Österreichisches Statistisches Zentralamt, 1983).

The data analysis for this study was limited to adults aged 20 years and older since most adolescents are still in education and their educational level could change. Therefore, data of 64,052 subjects were not analysed because they were younger than 20 years at the time of the survey. Furthermore, cases with missing data regarding gender (n = 4,124) and BMI (n = 25,585) were not included. Cases with implausible BMI values (BMI $\leq$ 10 kg/m², BMI $\geq$ 75 kg/m², n = 11,457) were also removed from the data base. This reduced the total sampling frame from originally 284,036 to 178,818 individuals.

The proportion of individuals which were included in the analysis was 63% in total. 53.7% of the participants were female. The mean ± SD age of the individuals was 47.7 ± 17.5 years, which refers only to the first four surveys since the AT-HIS survey rather concerned entire age groups (5-year-intervalls) than the exact age level. The subjects included in this study were between 20 and 99 years old.

The number of participants and the participation rate are presented separately for each survey in table 7. Furthermore the distribution of different subgroups (sex, age groups, educational level and region) is described in table 7.

Table 7: Percentage distribution of the five survey samples included in the study

	1973	1983	1991	1999	2006/07	Total
Individuals in sampling frame (n)	90,308	63,083	56,002	59,169	15,474	**284,036**
Individuals with missing data for sex (n)	3,700	0*	0*	424	0**	**4,124**
Individuals with missing data for BMI (n)	5,199	9,633	10,550	203	0**	**25,585**
Individuals under 20 years of age (n)	25,442	14,446	10,036	14,128	0	**64,052**
Individuals with implausible BMI values (n)	126	169	323	9,683	1,156	**11,457**
Individuals included in sample (n)	55,841	38,835	35,093	34,731	14,318	**178,818**
Proportion of included individuals in sample (%)	61.8	61.6	62.7	58.7	98.2	**63.0**
Sex n (%)						
Female	30,699 (55.0)	20,915 (53.9)	18,634 (53.1)	18,313 (52.7)	7,456 (52.1)	**96,017 (53.7)**
Male	25,142 (45.0)	17,920 (46.1)	16,459 (46.9)	16,418 (47.3)	6,862 (47.9)	**82,801 (46.3)**
Age groups n (%)						
20 – 34 years	14,099 (25.2)	11,899 (30.6)	11,341 (32.3)	9,613 (27.7)	3,557 (24.8)	**50,509 (28.2)**
35 – 54 years	20,377 (36.5)	13,491 (34.7)	12,211 (34.8)	12,950 (37.3)	5,637 (39.4)	**64,666 (36.2)**
55 – 74 years	17,242 (30.9)	10,280 (26.5)	8,713 (24.8)	9,186 (26.4)	3,691 (25.8)	**49,112 (27.5)**
≥ 75 years	4,123 (7.4)	3,166 (8.2)	2,827 (8.1)	2,982 (8.6)	1,433 (10.0)	**14,531 (8.1)**
Educational level n (%)						
Low education	-***	32,356 (83.3)	29,517 (84.1)	28,103 (80.9)	10,518 (73.5)	**100,494 (56.2)**
Middle education	-	3,765 (9.7)	3,894 (11.1)	4,424 (12.8)	2,358 (16.5)	**14,441 (8.1)**
High education	-	1,224 (3.2)	1,681 (4.8)	2,204 (6.3)	1,255 (8.8)	**6,364 (3.6)**
Missing data	-	1,491 (3.8)	0	0	187 (1.2)	**1,678 (32.1)**
Region n (%)						
Western Austria	7,835 (14.0)	6,041 (15.6)	6,527 (18.6)	6,115 (17.6)	2,694 (18.8)	**29,212 (16.3)**
Central Austria	21,835 (39.1)	15,259 (39.2)	13,897 (39.6)	13,951 (40.2)	5,458 (38.1)	**70,400 (39.4)**
Eastern Austria	26,171 (46.9)	17,535 (45.2)	14,669 (41.8)	14,665 (42.2)	6,166 (43.1)	**79,206 (44.3)**

*Missing cases for sex were deleted from Statistik Austria

**Computer-assisted assessment of data required answers for sex and weight and/or height.

*** No data on educational status were collected in the first Microcensus 1973

6.2. Variables

Demographic and socioeconomic characteristics, as well as health data were collected in each health survey using an interviewer questionnaire.

Body height and weight were self-reported in all surveys. No measured data were available. The participants were asked to indicate their body height (without wearing shoes) in centimetres and their body weight (without wearing clothes) in kilograms. The BMI for each subject was calculated by dividing body weight in kilograms by the square of body height in meters (kg/m^2). According to the WHO (2012a), obesity was defined as a BMI greater than 30.

To stratify the outcomes by age, adult subjects were categorized into the following four age groups: 20-34 years, 35-54 years, 55-74 years and 75 years and older.

Educational level was measured as the highest school level reached. It was assigned into three categories: (1) primary school or vocational school (low education), (2) secondary school with general qualification for university entrance (middle education), and (3) university or college for higher education (high education). In the first Microcensus (1973) no data on educational level was collected. Thus, analyses that include the variable educational level refer only to the years 1983 to 2006/07.

To analyse regional variation within Austria three regions were defined: Western Austria, Central Austria and Eastern Austria. Western Austria comprises the federal provinces Salzburg, Tyrol and Vorarlberg, with its international borders Italy, Germany, Switzerland and Lichtenstein. The Western region of Austria is characterized as less populated, rural and mountainous. The region Central Austria consists of the federal provinces Styria, Upper Austria and Carinthia and shares international borders with Italy, Germany, Slovenia and the Czech Republic. It is also known to be an industrial region. The second and third largest cities, Graz and Linz are located in this area. Eastern Austria comprises the three federal provinces Vienna, Lower Austria and Burgenland and borders Hungary, Slovakia and the Czech Republic. Eastern Austria is a flat and agricultural region with smaller cities apart from Vienna, the capital of Austria (Großschädl & Stronegger, 2012b).

In every health survey the presence of various diseases and disorders was queried. Based on the literature search for this study, diseases and disorders which were associated with obesity were selected in every survey. However, not all of the selected obesity-associated diseases and disorders were collected according to the same procedure in all five surveys.

When collecting the data in the the Microcensus surveys (1973, 1983, 1991 and 1999) participants were shown a list with different diseases. The participants were asked if they suffered from one or more of the listed diseases at the time of the survey or rather within the 12 months before the survey was conducted. This means, that suffering from the disease was no requirement at the time of the interview. Data about disorders were collected similar in the Microcensus but in contrast to the diseases, only the present existences of the disorders were queried. In the AT-HIS 2006/07 data for diseases as well disorders were collected by asking the participants if they suffered from the disease / disorder within the last 12 months.

Data of the following obesity-associated diseases and disorders were available for all five health surveys: diabetes mellitus, hypertension, back pain, sleep disorder, depression and headache. Diabetes mellitus and hypertension were equally queried in the Microcensus and the AT-HIS. Therefore, it was possible to present trends for diabetes mellitus and hypertension for the whole study duration. For the obesity-associated disorders back pain, sleep disorder, depression and headache the questions regarding the existence of these disorders were not the same in the Microcensus and the AT-HIS. Moreover, depression was queried together with anxiety state in the AT-HIS, while in the surveys of the Micorcensus depression was collected solely. For this reason the data for depression, sleep disorder and headache were only taken from the Microcensus and presented for the study period 1973 to 1999. The data for back pain were taken from all five surveys (1973 to 2006/07). Despite the different collection methods in the Microcensus and the AT-HIS it can be assumed that back pain is often chronic and that there is no great difference in the prevalence for back pain at the time of the survey or rather within the 12 months before. Besides, the data for back pain from the AT-HIS 2006/07 did not seem conspicuous and were similar, compared with the data of the Microcensus surveys for back pain.

In this study a dichotomous variable was formed for every selected obesity-associated disease and disorder.

6.3. Correcting for self-report bias

Based on the results of the preliminary validation study, described in chapter five, correction factors for BMI were applied only to women and men 45 years and older.

The correction factors for women were as follows:

- 45 to 59 years old: +0.41 kg/m² ($p = 0.000$)
- 60 years and older: +1.09 kg/m² ($p = 0.000$)

Among men aged 45 years and older the correction factors for BMI were:

- 45 to 59 years old: +0.50 kg/m² ($p = 0.000$)
- 60 years and older: +0.54 kg/m² ($p = 0.001$)

6.4. Data analysis

First of all the data of the five surveys were screened concerning variables to be examined. After that the selected variables of the five surveys were fed into a common database using the analytical software program IBM SPSS® Statistics for Windows version 19.0 (IBM Corp., Armonk, New York).

For descriptive analysis, BMI mean values and obesity prevalence calculations were stratified by sex, age, educational group and region. The mean BMI values were reported ± SD, while for the prevalence of obesity the 95% CI was computed. Due populations may differ strongly in composition, especially with regard to age, crude prevalence was adjusted for age (Jekel et al., 2007). Age-standardised prevalence values were calculated using the new European standard population for direct standardization according to the WHO (1993) (table 8).

Table 8: New European standard population according to the WHO for subjects aged 20 years and older

Age groups	Population
20-24	7,792
25-29	7,871
30-34	7,528
35-39	7,212
40-44	6,860
45-49	5,865
50-54	5,876
55-59	5,553
60-64	5,245
65-69	4,680
70-74	2,932
75-79	2,897
80-84	1,606
85+	1,305

Source: WHO (1993)

Changes in mean BMI values per year were presented by calculating linear regression analyses. The regression analyses were calculated for the period 1983 to 2006/07, since the prevalence of obesity increased only from the survey 1983 onwards. Linear trends were tested separately for each sex, age group, educational level and region using linear regression models with BMI as dependent variable and the survey period as predictor. The correction variable for regressions of sex, educational status and region was age (in intervals of 5 years). The course of the obesity prevalence between 1973 or rather 1983 and 2006/07 among men and women in different subgroups was charted by line diagrams created with Microsoft® Office Excel 2007.

In order to quantify trends in the prevalence of obesity the percentages of absolute changes (AC) were assessed. The magnitude of increase in the obesity prevalence was calculated by comparing the prevalence of the first and the last year (Pf – Pl) estimated by logistic regression analyses. By calculating the AC from the logistic regression, the results of all surveys were considered. The aetiologic fraction (AF), a ratio measure, was computed to represent the subgroup with the greatest relative risk for obesity. The AF denotes the percentage portion of the disease risk. It is defined as (Pl – Pf) / Pl estimated by logistic regression models. It is another form to indicate the relative risk (RR) (Olsen et al., 2010). For calculating the AC and AF among women and men in different subgroups, binary logistic regression analyses were charged for the period 1983 to 2006/07, due to the increase in the obesity prevalence only from 1983 onwards. The regression analyses were carried out with the dichotomous variable obesity (yes/no) as dependent variable and the survey period as predictor. Age adjustment was made by including the variable representing the five year age groups into the model. The formulas for AC and AF are shown in figure 6.

$$AC = 1 / (1 + \exp [- (B0 + B * T)]) – 1 / (1 + \exp [– B0])$$

$$AF = (RR – 1) / RR$$

B = Regression coefficient

B0 = Intercept

T = Time period in years

RR = Relative risk = (1 + exp [- (B0)]) / (1 + exp [- (B0 + B * T)])

Figure 6: Formulas for computing the absolute change (AC) and the aetiologic fraction (AF)

The magnitude of inequalities for obesity between educational groups was measured for each period by sex, age group and region separately, by calculating the relative index of inequality (RII). The RII describes the percentage of the predicted rate for the lowest in the hierarchy with relation to the predicted rate for the highest in the hierarchy. The size of the population and the relative socioeconomic position of the different groups are observed by calculating this index. A larger RII in a population group gives a hint that there is a greater socioeconomic gradient in health and / or a greater inequality in the distribution of the subjects in the different socioeconomic groups (Regidor, 2004; Mackenbach & Kunst, 1994).

Due to the lack of data for educational level in 1973 the RII for the prevalence of obesity was computed for the periods 1983 to 2006/07. First of all the variable educational level was transformed into the variable `fractional rank´, by ranking the study population by educational level. By that the population of each educational level is allocated a modified rigid score, which is based upon the mid of the range in the cumulative spread of the population in the respective group. For example, the first educational category includes 20% of the study population, means a range from 0 to 0.20. Each subject in that category is allocated a value of 0.1 (= 0.2/2). Assumed the second category would comprise 40% of the study population (range from 0.20 to 0.60), the subjects in that group are assigned a value of 0.4 (=0.2 + ([0.4/2]) and so on.

By regressing the dichotomous variable obesity with the fractional rank the exponentiation of the regression coefficient represents the RII. Adjustment for age was made by including the variable representing the five year age groups into the regression model. The correction variable for the regions was the five year interval of age and gender. To obtain more stable values for the RII in different age groups the subjects were categorized into the following three categories: 20 – 49 years, 50 – 74 years and 75 years and older.

The exponentiation of the regression coefficient, the RII, represents the frequency or odds forecasted at the lowest point of the education hierarchy divided by the frequency or odds forecasted at the highest point of the education hierarchy. The index is interpreted very often by that way. However, the disadvantage of this interpretation is that persons, who are not familiar with this index, could paraphrase it as a measure of association, both an odds ratio or an frequency ratio. Therefore, it is recommended to constitute the RII as a percentage (Regidor, 2004).

In this study the RII is expressed as a percentage in the results section by subtracting one from the relative index of inequality and multiplying the result by 100 (c. f. figure 7).

$$\text{RII in \%} = (\exp(B) - 1) * 100$$

B = Regression coefficient

Figure 7: Formula for computing the relative index of inequality (RII)

To present the results of the obesity-associated diseases and disorders the prevalence was computed for the selected diseases and disorders, stratified by sex, obesity (yes/no) and age groups. For diabetes mellitus, hypertension and back pain the prevalence was calculated for each survey. For sleep disorder, depression and headache the prevalence was calculated only for the period 1973 to 1999, due to the non-comparable data from the AT-HIS 2006/07.

Age-standardised prevalence based on the whole study population was reported for the selected diseases and disorders by using the European standard population (c. f. table 8). Chi square tests were calculated to analyse the statistical significance for the whole study population and stratified by sex, obesity and age groups. Figures representing the course of the prevalence of the respective disease or disorder stratified by sex and obesity between 1973 and 1999 or rather 2006/07 were created by Microsoft® Office Excel 2007. Trends for obesity-associated diseases and disorders were presented by calculating the AC and AF using Pf and Pl estimated by logistic regression models (c. f. figure 6). Binary logistic regression analyses were calculated for the respective study period with the dichotomous variable of each disease and disorder (yes / no) as dependent variable and the survey period as predicators. The correction variable for regressions was age (in intervals of 5 years).

All statistical analyses were conducted using IBM SPSS® Statistics for Windows version 19.0 (IBM Corp., Armonk, New York) and Stata/SE for Windows version 11.2 (StataCorp., College Station, TX, USA). Figures and tables were created with Microsoft® Office Excel 2007 and Microsoft® Office Word 2007.

6.5. Ethical approval

This study was approved by the Ethics Committee of the Medical University of Graz. The EK-number for this study was 23-172 ex 10/11.

7. Results

7.1. Long-term trends in BMI and obesity among adults

Between 1973 and 2006/07 the highest mean BMIs among Austrian women and men were measured in the latest survey. In 2006/07 the age-standardised mean BMI for Austrian adults was 25.7 kg/m². The lowest BMI values were found for the surveys conducted in 1983 and 1991. During the study period the mean BMI was higher among men than women. In 2006/07 the age-standardised mean BMI was by about 1 kg/m² higher for men, compared to the values for women (table 9).

Between 1973 and 2006/07 the age-adjusted prevalence of obesity was 10.9% (95% CI: 10.3 – 11.5) and higher in women (11.4%; 95% CI: 10.8 – 12.1) than men (9.9%; 95% CI: 9.3 – 10.5).

The highest obesity prevalence was found in 2006/07. The age-standardised prevalence was 15% among women and 13.8% among men. The lowest obesity proportion was observed in 1983, with an age-standardised prevalence of 9.4% (table 9).

In figure 8 the crude and age-standardised prevalence during the study period is illustrated separately for women and men. Within the first two surveys there was a downward trend in obesity, for women as well men. Especially up to 1991 there was a strong increase in the prevalence of obesity among Austrian adults. In women an almost linear trend is discernible from 1991 onwards.

Table 9: Mean BMI and the prevalence of obesity in five health surveys stratified by sex

	1973 (n = 55,841)		1983 (n = 38,835)		1991 (n = 35,093)		1999 (n = 34,731)		2006/07 (n = 14,318)	
Sex	BMI mean (SD)	Obesity % (95% CI)	BMI mean (SD)	Obesity % (95% CI)	BMI mean (SD)	Obesity % (95% CI)	BMI mean (SD)	Obesity % (95% CI)	BMI mean (SD)	Obesity % (95% CI)
Total (178,818)	25.6 (3.9)	11.8 (11.2, 12.4)	25.0 (3.9)	9.5 (8.9, 10.1)	25.0 (4.0)	9.6 (9.0, 10.2)	25.5 (4.8)	12.9 (12.2, 13.6)	25.8 (4.3)	15.2 (14.5, 16.0)
Total AS*	25.2 (5.4)	10.8 (10.2, 11.6)	25.0 (5.3)	9.4 (8.8, 10.0)	25.0 (5.2)	9.5 (8.9, 10.1)	25.4 (5.3)	12.6 (12.0, 13.3)	25.7 (5.3)	14.5 (14.0, 15.3)
Women										
Total (96,017)	25.4 (4.2)	13.3 (12.9, 13.7)	24.7 (4.3)	10.5 (10.0, 11.1)	24.5 (4.3)	10.5 (10.0, 11.1)	25.0 (5.2)	13.4 (12.9, 14.0)	25.4 (4.7)	16.0 (15.0, 17.0)
Total AS*	24.9 (2.3)	11.5 (11.1, 11.8)	24.5 (3.5)	10.0 (9.4, 10.4)	24.4 (3.5)	10.1 (9.5, 10.6)	24.8 (4.29)	12.8 (12.2, 13.3)	25.1 (6.1)	15.0 (14.1, 16.0)
Men										
Total (82,801)	25.8 (3.5)	10.0 (9.6, 10.3)	25.5 (3.4)	8.3 (7.8, 8.8)	25.5 (3.6)	8.4 (7.9, 9.0)	26.1 (4.1)	12.4 (11.8, 13.0)	26.3 (3.8)	14.3 (13.2, 15.3)
Total AS*	25.6 (2.2)	9.5 (9.2, 9.9)	25.5 (3.2)	8.5 (7.9, 9.0)	25.6 (3.5)	8.5 (8.0, 9.1)	26.0 (3.7)	12.1 (11.5, 12.6)	26.2 (5.5)	13.8 (12.7, 14.8)

*AS = age-standardised

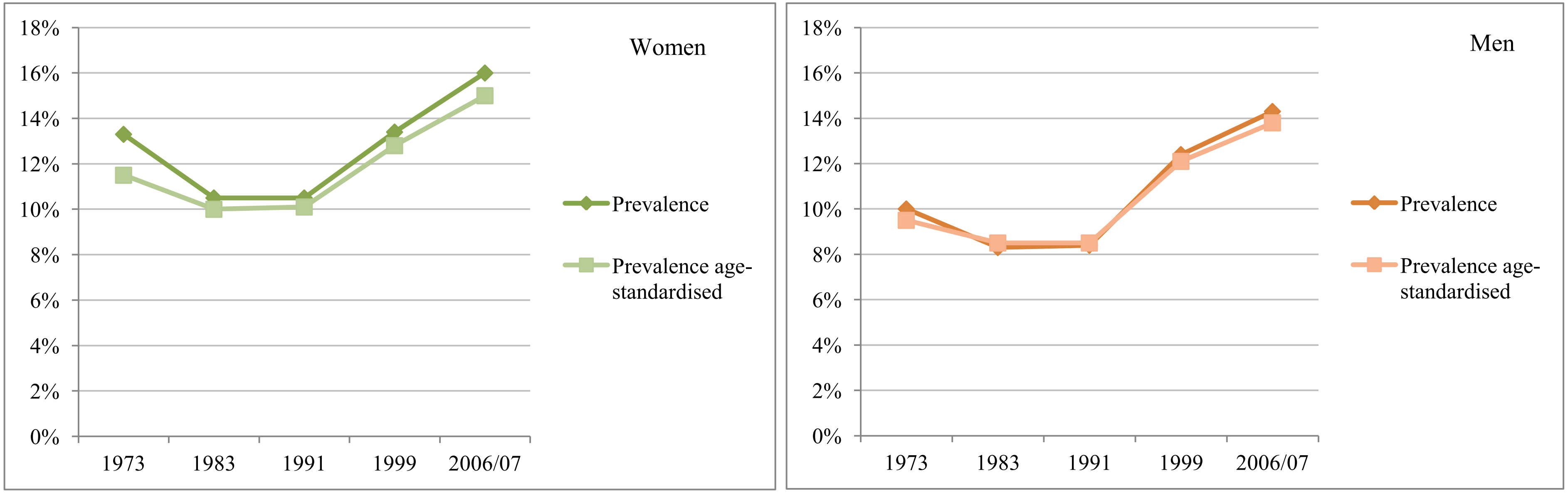


Figure 8: The crude and age-standardised prevalence of obesity between 1973 and 2006/07 in women and men

Linear regression analyses were calculated for the period 1983 to 2006/07, since the obesity prevalence for adult women and men increased only from 1983 onwards. For the whole study population the increase in mean BMI per year was 0.035 kg/m² from 1983 to 2006/07. There was a significantly higher increase in mean BMI per year among men than women (table 10).

The trends for the prevalence of obesity are also presented for the period 1983 to 2006/07, due to the increase in the obesity prevalence in 1983. Among the Austrian adult population an absolute change (AC) of 4.9% for obesity prevalence was found. The AC for the prevalence of obesity was higher among men than women. A greater dynamic in the prevalence of obesity was also observed among men, which indicates that the risk for getting obese was greater for male adults (table 10).

Table 10: Linear regression estimates of BMI-change per year, absolute changes (AC) and aetiologic fractions (AF) of obesity prevalence during the period 1983 to 2006/07 by sex (adjusted for age)

Predictor	**B BMI kg/m² (95% CI)**	**P value**	**AC obesity in %**	**AF obesity in %**
Total	0.035 (0.032, 0.038)	0.000	4.9	40.62
Women	0.031 (0.026, 0.035)	0.000	4.7	36.3
Men	0.039 (0.035, 0.043)	0.000	5.3	47.1

The detailed results for the prevalence of obesity among subjects in different age groups, educational levels and geographic regions are described in the following sections.

7.1.1. Age

Between 1973 and 2006/07 the highest mean BMI values were found among subjects aged 55 to 74 years, while subjects aged 20 to 34 years had the lowest mean BMIs. The mean BMI remained relatively constant in the younger age groups but increased for subjects aged 55 years and older in the interval between the five surveys. Comparing women and men, the BMI values for individuals younger than 54 years were higher among men. Thus, for subjects aged 55 years and older the mean BMIs between 1973 and 2006/07 were higher for women, with the exception for subjects between 55 and 74 years of age who were surveyed in 2006/07. In the last survey the mean BMI in that age group was equal for both sexes (table 11).

In 2006/07 the highest obesity prevalence was observed among adults aged 55 to 74 years old, with more women being affected. The least prevalence of obese subjects was among the youngest age group with similar prevalences for female and male adults in the latest survey (table 11).

Figure 9 shows that the prevalence slightly decreased in the 1980s in nearly all age groups but steadily increased in the subsequent periods, across all age groups in both sexes. A continuous increase during the study period was seen among men aged 55 to 74 years. Between 1991 and 2006/07 a very steep increase in the prevalence of obesity was found for women in the oldest age groups (+10.6%). For 35- to 54-year-old women the obesity prevalence was lower at the end than at the beginning of the study period. Compared to men, the prevalence of obesity was twice as high in 2006/07 among women aged 75 years and older. In 2006/07 obesity was more prevalent among male adults in the two youngest age groups, compared to female adults.

Table 11: Mean BMI and the prevalence of obesity in five health surveys stratified by sex and age groups

	1973 (n = 55,841)		1983 (n = 38,835)		1991 (n = 35,093)		1999 (n = 34,731)		2006/07 (n = 14,318)	
Sex	BMI	Obesity	BMI	Obesity	BMI	Obesity	BMI	Obesity	BMI	Obesity
Age group (n)	mean (SD)	% (95% CI)	mean (SD)	% (95% CI)	mean (SD)	% (95% CI)	mean (SD)	% (95% CI)	mean (SD)	% (95% CI)
Women										
20 – 34 (25,140)	22.8 (3.3)	3.4 (3.0, 3.9)	22.2 (3.4)	2.8 (2.1, 3.4)	22.0 (3.2)	2.7 (2.1, 3.3)	22.6 (4.5)	5.2 (4.4, 6.0)	23.0 (4.1)	6.8 (5.3, 8.3)
35 – 54 (33,168)	24.7 (4.0)	13.5 (12.8, 14.1)	24.8 (4.2)	9.8 (8.9, 10.8)	24.6 (4.1)	9.4 (8.5, 10.3)	24.7 (4.8)	10.8 (10.0, 11.7)	24.8 (4.5)	12.5 (11.0, 14.0)
55 – 74 (27,967)	26.8 (4.2)	20.2 (19.4, 21.1)	26.7 (4.0)	18.4 (17.2, 19.6)	27.0 (4.1)	20.3 (18.9, 21.7)	27.3 (5.4)	23.8 (22.5, 25.1)	27.7 (4.6)	26.5 (24.3, 28.7)
≥ 75 (9,742)	25.5 (4.1)	12.8 (11.5, 14.1)	25.4 (4.0)	11.6 (9.8, 13.4)	25.4 (3.9)	11.9(10.0, 13.8)	26.0 (4.7)	16.1 (14.3, 18.0)	27.1 (4.2)	22.5 (19.2, 25.8)
Men										
20 – 34 (25,368)	24.6 (3.2)	5.2 (4.7, 5,7)	24.1 (3.0)	3.3 (2.6, 4.1)	24.1 (3.2)	3.7 (3.0, 4.3)	24.4 (3.4)	5.7 (4.8, 6.5)	24.5 (3.4)	6.9 (5.2, 8.5)
35 – 54 (31,498)	26.4 (3.4)	12.3 (11.7, 13.0)	26.1 (3.2)	10.2 (9.3, 11.1)	26.2 (3.6)	10.3 (9.3, 11.4)	26.4 (4.1)	13.8 (12.8, 14.9)	26.6 (3.6)	14.3 (12.6, 15.9)
55 – 74 (21,146)	26.2 (3.5)	12.1 (11.3, 12.8)	26.6 (3.4)	13.2 (11.9, 14.1)	26.7 (3.4)	13.0 (11.7, 14.2)	27.4 (4.4)	18.2 (16.8, 19.4)	27.7 (3.8)	22.8 (20.4, 25.1)
≥ 75 (4,789)	25.0 (3.6)	7.3 (5.9, 8,7)	25.1 (3.4)	5.2 (3.5, 6.8)	25.3 (3.5)	7.0 (4.8, 9.2)	26.0 (4.0)	9.9 (7.9, 11.8)	26.4 (3.3)	11.2 (7.4, 14.9)

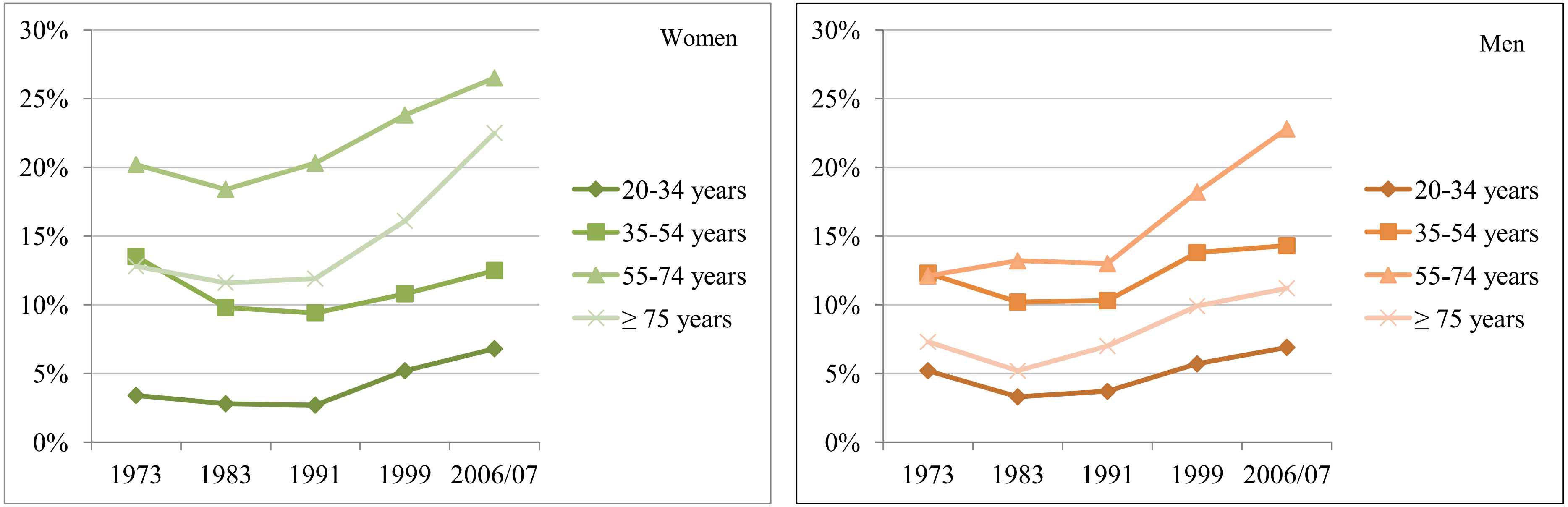


Figure 9: The prevalence of obesity between 1973 and 2006/07 by age groups in women and men

Figure 9 shows that there is an upward trend in the prevalence of obesity from 1983 to 2006/07 for most age groups among women and men. Therefore the linear regression estimates of BMI-change and the absolute change (AC) and aetiologic fraction (AF) were calculated for the period 1983 to 2006/07. The highest increase in mean BMI per year was found among subjects 75 years and older, with higher values for women than men. In contrast, in the younger age groups the increase in mean BMI values per year were still higher for men than women. For women aged 20 to 34 years the mean BMI per year decreased slightly during the study period (table 12).

The strongest increase in obesity prevalence represented by the AC was found among women in the oldest age group. A considerable increase among female adults aged 55 to 74 years old could be observed as well. Among men, the highest AC was calculated for those aged 55 to 74 years. The AF was highest among women in the youngest age group and men aged 75 years and older. A great AF was also found for 20- to 34-year old men (table 12).

Table 12: Linear regression estimates of BMI-change per year, absolute changes (AC) and aetiologic fractions (AF) of obesity prevalence during the period 1983 to 2006/07 by sex and age groups

Predictor	**B BMI kg/m² (95% CI)**	**P value**	**AC obesity in %**	**AF obesity in %**
Women				
20-34 years	-0.003 (-0.007, 0.001)	< 0.001	2.8	64.2
35-54 years	0.001 (-0.006, 0.008)	< 0.001	2.3	21.3
55-74 years	0.037 (0.029, 0.045)	< 0.001	7.4	32.4
≥ 75 years	0.066 (0.053, 0.078)	< 0.001	8.0	50.5
Men				
20-34 years	0.018 (0.012, 0.024)	< 0.05	2.8	55.6
35-54 years	0.020 (0.014, 0.026)	< 0.001	4.4	35.1
55-74 years	0.053 (0.045, 0.061)	< 0.001	7.8	45.4
≥ 75 years	0.061 (0.046, 0.075)	< 0.001	4.9	56.7

7.1.2. Educational level

Data concerning education were only collected in the surveys between 1983 and 2006/07. During that time the crude and age-standardised mean BMI increased by about 1 kg/m² in all educational groups for both sexes. Women and men with the lowest educational level had the highest mean BMI during the whole study period. Comparing subjects with middle and high educational level, no great differences in mean BMI values could be observed. In the latest survey, the crude and age-adjusted mean BMI was slightly lower for high-educated than middle-educated women. In total, the mean BMI values were higher among men than women in all educational groups (table 13).

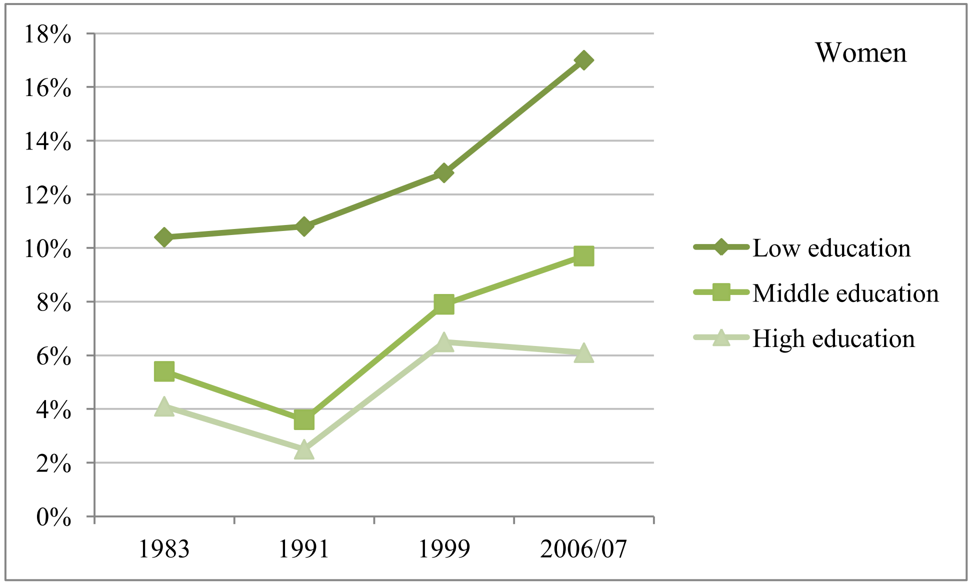
The prevalence of obesity was highest among women and men with the lowest educational level. Subjects with a high educational level had the lowest obesity prevalence (table 13).

Figure 10 represents the age-standardised prevalence for women and men in different educational groups. Among women with a low educational level there was a constant increase from 1983 to 2006/07. In 1991 a decrease in the prevalence of obesity was found among women with a middle or high educational level. Towards the end of the 1990s the prevalence increased rapidly among women in these two educational groups. While the prevalence of obesity in women with a middle educational level jumped to 9.7% in 2006/07, it fell to 6.1% in the highly-educated. There was a constant increase in men with the highest and lowest educational level. Among middle-educated men, obesity prevalence decreased between 1983 and 1991 and then started to rise until 2006/07.

Table 13: Mean BMI and the prevalence of obesity in four health surveys stratified by sex and educational status

	1983 (n = 38,835)		1991 (n = 35,093)		1999 (n = 34,731)		2006/07 (n = 14,318)	
Sex	BMI	Obesity	BMI	Obesity	BMI	Obesity	BMI	Obesity
Educational Status (n)	mean (SD)	% (95% CI)	mean (SD)	% (95% CI)	mean (SD)	% (95% CI)	mean (SD)	% (95% CI)
Women								
Low education (54,498)	25.0 (4.3)	11.3 (10.7, 11.9)	24.9 (4.3)	11.9 (11.2, 12.5)	25.3 (5.2)	14.8 (14.1, 15.4)	26.1 (4.8)	19.0 (17.8, 20.3)
Low education AS*	24.7 (5.0)	10.4 (9.8, 11.1)	24.6 (5.0)	10.8 (10.2, 11.5)	25.0 (5.1)	12.8 (12.2, 13.5)	25.5 (5.2)	17.0 (16.5, 17.8)
Middle education (7,009)	22.6 (3.5)	3.8 (2.6, 5.1)	22.4 (3.3)	2.5 (1.7, 3.3)	23.6 (4.9)	7.7 (6.4, 8.9)	23.6 (4.3)	8.0 (5.9, 10.1)
Middle education AS*	23.4 (5.0)	5.4 (4.9, 5.9)	23.2 (4.7)	3.6 (2.3, 1.5)	23.7 (4.8)	7.9 (7.6, 2.8)	24.3 (4.9)	9.7 (9.1, 10.3)
High education (2,779)	22.4 (3.5)	3.8 (1.1, 6.6)	22.3 (3.8)	2.3 (1.3, 3.8)	23.7 (4.3)	6.9 (5.3, 8.5)	23.2 (3.7)	5.5 (3.0, 8.0)
High education AS*	22.8 (4.6)	4.1 (3.5, 4.9)	22.9 (4.7)	2.5 (1.9, 2.7)	23.6 (4.8)	6.5 (5.9, 7.1)	23.6 (4.8)	6.1 (5.5, 6.7)
Men								
Low education (45,995)	25.7 (3.4)	8.9 (8.3, 9.5)	25.8 (3.6)	9.1 (8.5, 9.8)	26.3 (4.2)	13.5 (12.8, 14.2)	26.7 (3.8)	16.5 (15.2, 17.9)
Low education AS*	25.6 (5.6)	8.9 (8.3, 9.4)	25.7 (5.6)	9.0 (8.4, 9.6)	26.1 (5.5)	11.5 (10.9, 12.3)	26.4 (5.6)	15.5 (14.9, 16.3)
Middle education (7,432)	24.5 (3.2)	5.7 (4.2, 7.2)	24.5 (3.2)	5.3 (4.0, 6.6)	25.3 (3.9)	8.7 (7.4, 10.0)	25.4 (3.4)	8.7 (6.6, 10.9)
Middle education AS*	25.0 (5.4)	6.9 (9.6, 3.1)	25.0 (5.4)	6.5 (5.9, 7.0)	25.3 (5.5)	8.7 (8.1, 9.3)	25.8 (5.5)	10.4 (9.9, 11.1)
High education (3,586)	24.7 (3.0)	4.5 (2.7, 6.4)	24.7 (2.9)	4.8 (2.9, 6.8)	25.1 (3.6)	6.4 (4.7, 8.0)	25.5 (3.3)	7.6 (5.1, 10.1)
High education AS*	24.6 (5.3)	4.7 (4.1, 5.3)	24.7 (5.2)	5.1 (4.5, 5.3)	25.0 (5.3)	6.2 (5.6, 6.7)	25.3 (5.4)	6.8 (6.2, 7.2)

*AS = age-standardised



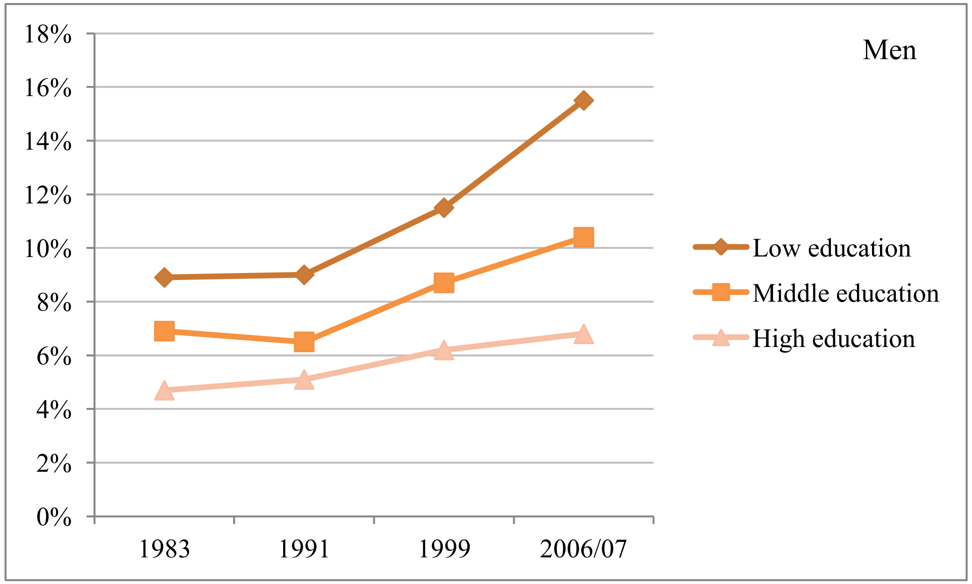


Figure 10: The age-standardised prevalence of obesity between 1983 and 2006/07 by educational status in women and men

Results of the linear regression analyses calculated for the period 1983 to 2006/07 showed that there was the highest increase in mean BMI per year among subjects with a middle educational level for both, women and men. The lowest increase in mean BMI per year was found among women with a low education and men with high education (table 14).

The prevalence of obesity increased mainly in women and men with the lowest educational level, with higher absolute change (AC) for low-educated men than women. The smallest AC was calculated for those subjects with a high educational level, with lower values in women than men. The aetiologic fraction (AF) was highest among women with a middle educational level and men with a low educational level (table 14).

Table 14: Linear regression estimates of BMI-change per year, absolute changes (AC) and aetiologic fractions (AF) of obesity prevalence during the period 1983 to 2006/07 by sex and educational levels (adjusted for age)

Predictor	**B BMI kg/m²** **(95% CI)**	**P value**	**AC obesity in %**	**AF obesity in %**
Women				
Low education	0.040 (0.035, 0.045)	< 0.001	2.1	41.2
Middle education	0.055 (0.044, 0.067)	< 0.001	1.1	61.2
High education	0.052 (0.032, 0.071)	< 0.05	0.7	52.2
Men				
Low education	0.042 (0.031, 0.039)	< 0.001	3.1	49.8
Middle education	0.048 (0.038, 0.057)	< 0.001	1.3	40.1
High education	0.036 (0.024, 0.049)	< 0.05	1.0	43.2

7.1.3. Interaction of age and educational level

In order to make even clearer statements among age and educational groups, low-educated and high-educated younger adults with low-educated and high-educated older adults were compared.

Two educational groups were built by allocating those subjects with a middle educational level to the high educateional group. The group of younger adults included subjects aged younger than 54 years, whereas individuals aged 55 years and older comprised the group of older adults.

Figure 11 represents the age-standardised prevalence of obesity between 1983 and 2006/07 for subjects categorized into two age goups and two educational levels. It illustrates that women and men aged 55 years and older with a low educational level had the highest obesity prevalence between 1983 and 2006/07. There was a constant increase in every survey for older adults with a low education, with higher prevalence proportions among women than men. Younger individuals with a high educational level on the contrary showed the lowest prevalence of obesity during the period of 1983 to 2006/07. The prevalence of obesity was still lower for women aged younger than 54 years with high educational level, compared to men in the same subgroup. In 2006/07 there was no great difference in the obesity prevalence for female and male adults in the groups `low education and younger adults´ and `high education and older adults´.

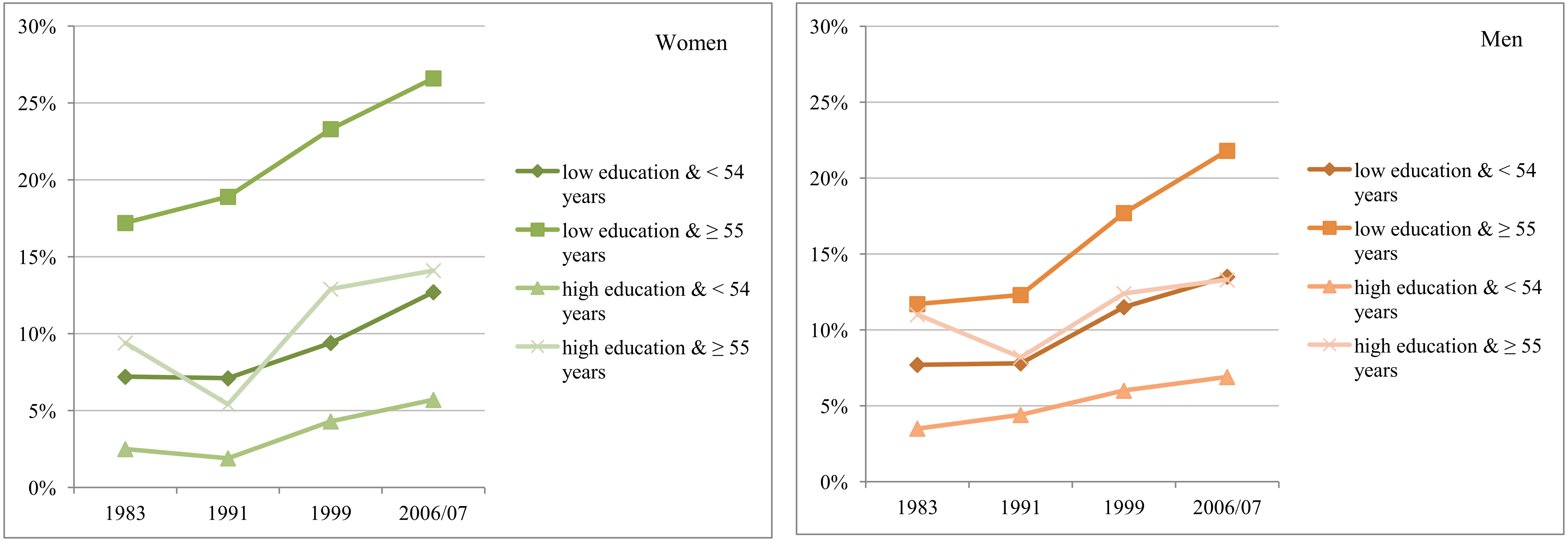


Figure 11: The age-standardised prevalence of obesity between 1983 and 2006/07 by two age groups and two educational levels in women and men

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The linear regression analyses showed that there was the highest increase in mean BMI per year among older subjects with a low education, for both sexes, with higher increases for men than women. The lowest increase in mean BMI per year was found for women aged 54 years and younger with a low educational level. The group men aged 55 years and older with a high educational level showed the slowest rise in the mean BMI per year between 1983 and 2006/07 (table 15).

In both sexes, the absolute change (AC) was highest among older adults with a low educational level. The increase in the prevalence of obesity was lowest among subjects aged 54 years and younger with a high educational level. Among men the ACs were lowest for younger and older men with high education,. In men with a high educational status the AC was 2.8% for both age groups. The greatest dynamic for obesity during the study period, represented by the aetiologic fraction (AF), was found for high-educated younger adults (table 15).

Table 15: Linear regression estimates of BMI-change per year, absolute changes (AC) and aetiologic fractions (AF) of obesity prevalence during the period 1983 to 2006/07 by sex and the interaction by 2 age groups and 2 educational groups

Predictor	**B BMI kg/m²** **(95% CI)**	**P value**	**AC obesity in %**	**AF obesity in %**
Women				
< 54 years and low education	0.031 (0.024, 0.037)	< 0.001	3.9	42.9
≥ 55 years and low education	0.050 (0.042, 0.058)	< 0.001	8.3	37.9
< 54 years and high education	0.044 (0.034, 0.053)	< 0.05	2.4	66.8
≥ 55 years and high education	0.047 (0.022, 0.071)	< 0.001	5.5	49.5
Men				
< 54 years and low education	0.027 (0.022, 0.032)	< 0.001	4.9	47.4
≥ 55 years and low education	0.062 (0.054, 0.070)	< 0.001	8.2	50.0
< 54 years and high education	0.047 (0.038, 0.055)	< 0.05	2.8	51.0
≥ 55 years and high education	0.025 (0.008, 0.042)	< 0.001	2.8	24.2

7.1.4. Region

Between 1973 and 2006/07 the crude and age-standardised mean BMI values for women and men living in three different Austrian regions are presented in table 16. The highest mean BMI values were observed among women and men residing in Eastern Austria with the highest values in the latest survey. Subjects living in Western Austria had the lowest mean BMI values for the whole study period.

Between 1973 and 2006/07 the highest obesity prevalence was observed in women and men in Eastern Austria, with higher prevalence among women. The lowest obesity prevalence was found among female and male subjects living in Western Austria (table 16).

In figure 12 the age-standardised obesity prevalence for women and men living in three different regions in Austria is presented. Between 1973 and 1983 a decline in the prevalence of obesity was observed for women and menamong all regions in Austria. However, the obesity prevalence clearly increased from 1983 upwards among both sexes and in all regions. From 1983 onwards the curves are very similar for women and men living in different geographic regions, with slightly higher proportions for women. There was a linear increase between 1983 and 2006/07 for men living in Eastern Austria.

Table 16: Mean BMI and the prevalence of obesity in five health surveys stratified by sex and region

	1973 (n = 55,841)		1983 (n = 38,835)		1991 (n = 35,093)		1999 (n = 34,731)		2006/07 (n = 14,318)	
Sex	BMI	Obesity	BMI	Obesity	BMI	Obesity	BMI	Obesity	BMI	Obesity
Region (n)	mean (SD)	% (95% CI)	mean (SD)	% (95% CI)	mean (SD)	% (95% CI)	mean (SD)	% (95% CI)	mean (SD)	% (95% CI)
Women										
Western Austria (18,339)	24.6 (4.0)	9.5 (8.9, 10.1)	23.8 (4.0)	6.5 (6.0, 7.0)	23.9 (4.1)	7.4 (6.9, 7.9)	24.3 (4.8)	10.0 (9.4, 10.6)	24.6 (4.6)	12.6 (12.0, 13.2)
Western Austria AS*	24.2 (5.2)	8.5 (7.9, 9.1)	23.8 (4.9)	6.7 (6.1, 7.2)	24.0 (4.9)	7.7 (7.1, 8.2)	24.2 (4.9)	10.0 (9.4, 10.6)	24.5 (4.9)	12.2 (11.6, 12.9)
Central Austria (35,910)	24.7 (4.3)	12.5 (11.9, 13.15)	24.6 (4.2)	9.5 (8.9, 10.1)	24.6 (4.1)	10.8 (10.2, 11.4)	25.2 (5.4)	13.7 (13.0, 14.4)	25.5 (4.7)	15.4 (14.6, 21.1)
Central Austria AS*	24.9 (5.2)	10.9 (10.3, 11.6)	24.5 (5.1)	9.3 (8.7, 9.9)	24.5 (5.0)	10.2 (9.6, 10.9)	25.0 (5.1)	13.0 (12.4, 13.8)	25.2 (5.0)	14.3 (13.7, 15.0)
Eastern Austria (41,768)	25.3 (4.2)	15.0 (14.3, 15.7)	25.1 (4.3)	12.7 (12.1, 13.3)	25.1 (4.5)	13.4 (12.7, 14.1)	25.1 (5.1)	14.6 (13.9, 15.3)	25.7 (4.8)	18.1 (17.3, 18.9)
Eastern Austria AS*	25.2 (5.2)	12.8 (12.2, 13.6)	24.8 (5.1)	11.6 (11.0, 12.3)	24.8 (5.1)	12.3 (11.8, 13.2)	24.8 (5.0)	13.7 (13.1, 14.5)	25.4 (5.0)	16.8 (16.3, 17.7)
Men										
Western Austria (16,891)	25.1 (3.3)	5.8 (5.3, 6.3)	24.9 (3.1)	5.1 (4.6, 5.5)	25.1 (3.3)	6.6 (6.1, 7.1)	25.4 (3.7)	8.5 (8.0, 9.0)	25.9 (3.6)	11.7 (11.1, 12.3)
Western Austria AS*	25.0 (5.5)	5.6 (5.0, 6.0)	24.9 (5.3)	5.3 (4.8, 5.7)	25.2 (5.4)	6.6 (6.0, 7.0)	25.3 (5.5)	8.5 (7.9, 9.0)	25.8 (5.5)	11.5 (11.0, 12.3)
Central Austria (31,713)	25.6 (3.4)	8.8 (8.2, 9.3)	25.4 (3.4)	8.0 (7.5, 8.5)	25.8 (3.7)	8.9 (8.3, 9.5)	26.2 (4.3)	12.4 (11.8, 13.0)	26.3 (3.6)	13.6 (12.9, 14.3)
Central Austria AS*	25.5 (5.7)	8.4 (7.8, 8.9)	25.5 (5.6)	8.2 (7.7, 8.8)	25.7 (5.6)	8.6 (8.0, 9.1)	26.1 (5.6)	12.2 (11.6, 12.9)	26.2 (5.6)	13.1 (12.5, 13.8)
Eastern Austria (34,197)	26.1 (3.6)	12.4 (11.8, 13.0)	25.7 (3.4)	9.7 (9.1, 10.3)	25.8 (3.7)	10.1 (9.5, 10.7)	26.2 (4.1)	14.0 (13.3, 14.7)	26.5 (4.0)	16.1 (15.3, 16.8)
Eastern Austria AS*	25.9 (5.7)	11.8 (11.2, 12.5)	25.7 (5.6)	9.7 (9.1, 10.4)	26.0 (5.6)	11.4 (10.8, 12.2)	26.1 (5.6)	13.4 (12.8, 14.2)	26.4 (5.6)	15.4 (14.8, 16.3)

*AS = age-standardised

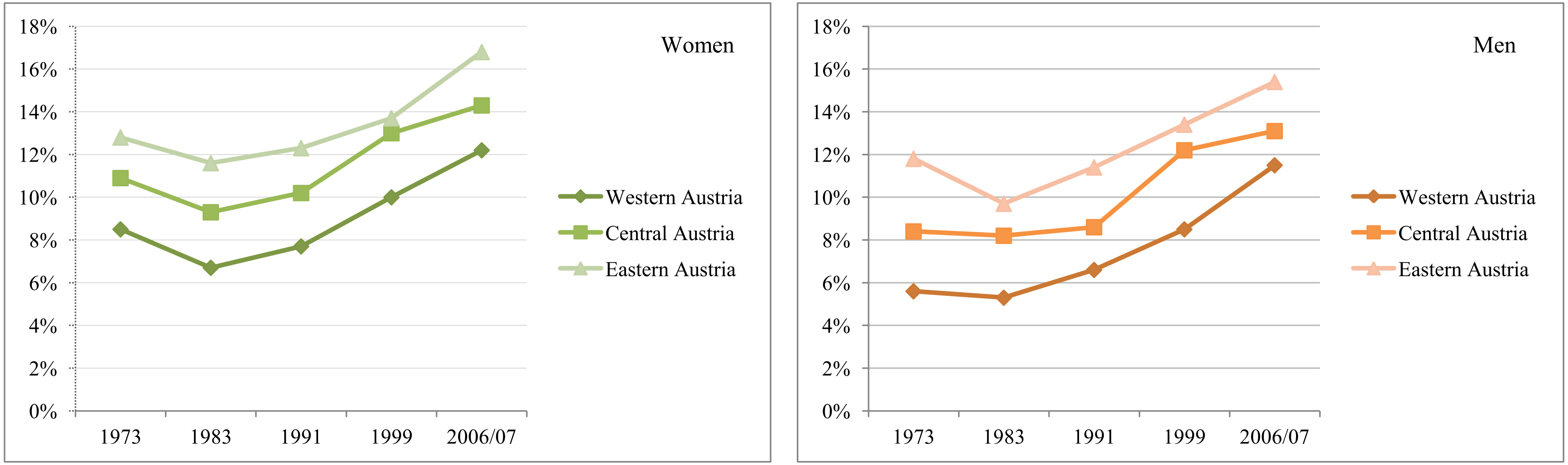

Figure 12: The age-standardised prevalence of obesity between 1973 and 2006/07 by region in women and men

Western Austria: Vorarlberg, Tyrol, Salzburg;

Central Austria: Carinthia, Upper Austria, Styria;

Eastern Austria: Lower Austria, Vienna, Burgenland;

Due to the increase in the prevalence of obesity in every region from 1983 upwards the trends are presented for the period 1983 to 2006/07. The linear regression analyses have shown that the highest increase in mean BMI values was among women and men in Central Austria. Among women, the lowest increase in mean BMI per year was found for those living in Eastern Austria. Among men the lowest increase was observed in subjects from Western and Eastern Austria (table 17).

Among women, the steepest increase in the prevalence of obesity was recorded between 1983 and 2006/07 for individuals in Central Austria. The highest absolute change (AC) among men was found for subjects residing in Western Austria. In general, the highest AC was found for male adults living in Western Austria. The increase in the prevalence of obesity was low for women and men in Eastern Austria. For both sexes, the greatest aetiologic fraction (AF) was found in Western Austria (table 17).

Table 17: Linear regression estimates of BMI-change per year, absolute changes (AC) and aetiologic fractions (AF) of obesity prevalence during the study period 1983 to 2006/07 by sex and regions (adjusted for age)

Predictor	B BMI kg/m² (95% CI)	P value	AC obesity in %	AF obesity in %
Women				
Western Austria	0.023 (0.014, 0.032)	< 0.001	2.02	29.67
Central Austria	0.032 (0.025, 0.039)	< 0.001	2.44	24.36
Eastern Austria	0.018 (0.012, 0.024)	< 0.001	1.52	19.87
Men				
Western Austria	0.030 (0.022, 0.038)	< 0.001	4.64	50.25
Central Austria	0.035 (0.029, 0.041)	< 0.001	3.81	39.39
Eastern Austria	0.030 (0.024, 0.036)	< 0.001	0.82	25.93

To give an overview about the presence of obesity in the different federal states of Austria, in figure 13 the age-standardised obesity prevalence for every federal state is presented separately for women and men. The results are illustrated for the entire study duration. The red dashed line represents the course of the obesity prevalence for the whole female and male study population.

Figure 13 shows that the highest obesity prevalence in the last survey was in the easternmost federal state Burgenland for both sexes. In 2006/07 the prevalence of obesity was 22.8% for women, and 19.8% for men living in Burgenland. For women, the prevalence of obesity was highest in Burgenland from 1983 onwards. Men living in Burgenland still had the highest obesity prevalence during the study period, compared to men from other Austrian federal states. In 2006/07 quite high obesity proportions were also found among women and men living in the federal states Lower Austria and Upper Austria.

In 2006/07 the prevalence of obesity was lowest for women in Tyrol (9.7%) and for men in Carinthia (8.8%). Furthermore, figure 13 shows, that women in Vorarlberg had very low obesity prevalence in the past, with the lowest prevalence in 1991. However, after 1991 there was a strong increase in the prevalence of obesity for women in that federal state (+11.6%).

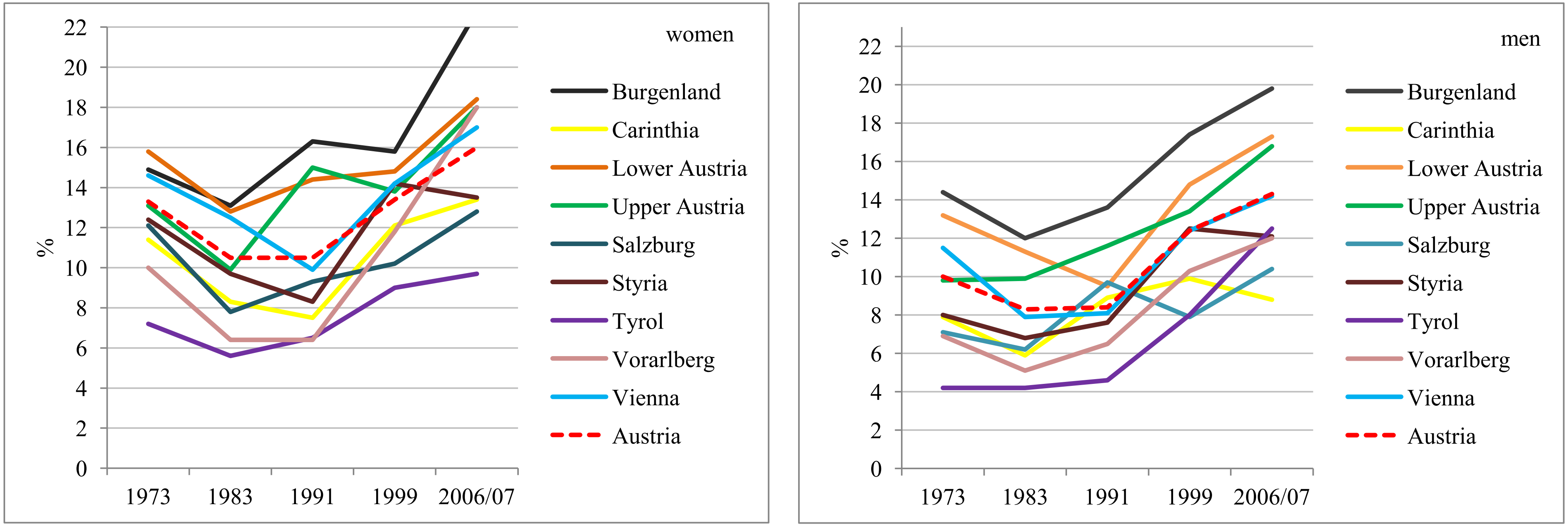

Figure 13: The age-standardised prevalence of obesity between 1973 and 2006/07 by the nine Austrian federal states in women and men.

7.2. Long-term trends in education-related inequalities for obesity

Table 18 shows the relative index of inequality (RII) for obesity, which was calculated to present education-related inequalities; it went up for the whole study population between 1983 and 2006/07.

Comparing the RII among women and men, the values of the RII were still higher for women than men. However, among men the RII for obesity showed a rising trend in the prevalence of obesitybetween 1983 and 2006/07. In women, the RII for obesity was quite instable during the study period (table 18).

When comparing the surveys 1983 and 2006/07 the RII´s for obesity calculated for three age groups showed that there was an increase in education-related inequality among the youngest subjects and among those between 55 and 74 years of age. However, during the investigation period there was no increase of the RIIs identifiable from survey to survey for those two age groups. Among subjects aged 75 years and older the RII decreased between 1983 and 2006/07. This indicates that the education-related inequalities for obesity diminished within this period. In 2006/07, the highest RII was found for subjects aged 55- to 74-years, and the lowest RII among those aged 75 years and older (table 18).

Furthermore, the outcomes in table 18 show that between 1983 and 2006/07 the RII apparently increased in Western Austria. In Eastern Austria the RII in 2006/07 was higher than in 1983. However, the percentages were unstable for subjects living in Eastern Austria during the study period. In 2006/07 most education-related inequalities for obesity were found for subjects in Eastern Austria. The RII was lowest for those living in Central Austria in 2006/07.

However, in general the results regarding the magnitude of inequalities for obesity are quite unstable.

Table 18: Relative index of inequality for the prevalence of obesity between 1983 and 2006/07 per period, by sex, age group and region

	1983	**1991**	**1999**	**2006/07**
	RII (95% CI)	RII (95% CI)	RII (95% CI)	RII (95% CI)
Total	222.5 (146.6, 329.1)	367.5 (251.5, 521.9)	265.2 (200.3, 344.3)	330.5 (328.9, 463.6)
Sex				
Women	387.9 (208.6, 671.5)	1,048.5 (785.0, 1825.7)	323.1 (219.5, 460.3)	393.0 (230.0, 636.5)
Men	139.3 (68.6, 239.7)	161.1 (84.7, 269.3)	217.0 (141.6, 318.1)	271.0 (157.5, 343.7)
Age group				
20 - 49 years	568.2 (332.2, 930.0)	372.6 (224.2, 588.9)	357.1 (231.9, 529.5)	369.1 (225.8, 575.4)
50 - 74 years	104.9 (42.9, 193.9)	492.0 (278.9, 825.0)	255.4 (170.0, 367.9)	499.3 (284.4, 834.4)
≥ 75 years	961.1 (124.9, 4,905.1)	660.5 (106.4, 2,701.6)	148.4 (41.4, 335.8)	57.6 (-34.8, 279.2)
Region				
Western Austria	93.0 (83.0, 348.9)	186.2 (74.2, 370.2)	343.2 (153.1, 676.2)	352.9 (111.5, 869.8)
Central Austria	457.3 (208.1, 908.0)	737.4 (455.8, 1143.9)	210.5 (128.7, 321.6)	260.7 (120.9, 488.9)
Eastern Austria	229.6 (234.4, 463.5)	433.6 (247.1, 820.4)	301.7 (201.3, 434.4)	461.2 (291.4, 704.5)

7.3. Long-term trends in the prevalence of obesity-associated diseases and disorders

The outcomes for the long-term trends in the prevalence of the following selected obesity-associated diseases and disorders are illustrated and described subsequently: diabetes mellitus, hypertension, back pain, sleep disorder, depression and headache. The outcomes for diabetes mellitus, hypertension and back pain were calculated for the whole study period (1973 - 2006/07), while the outcomes for sleep disorder, depression and headache are only presented for the Microcensus surveys (1973 – 1999), due to the non-comparable data with the AT-HIS 2006/07. The outcomes for obesity-associated diseases and disorders were stratified by sex, obesity and age.

7.3.1. Diabetes mellitus

Table 19 shows that in 2006/07 the age-standardised prevalence of diabetes mellitus was 5.3%. Between 1973 and 2006/07 the prevalence of diabetes mellitus increased in all obese and non-obese adults. The highest proportions of diabetic subjects were still found among obese women and men. Subjects aged 75 years and older were significantly the most concerned group. Considering both sexes during the study period, the prevalence of diabetes mellitus was still higher for women than men in all age groups. The higher prevalence in women is more obvious among obese individuals, compared to men.

Figure 14 represents the prevalence of diabetes mellitus for women and men, as well as obese and non-obese individuals. Among women a steady increase in diabetes mellitus can be observed from 1983 onwards, whereas the prevalence among men has been rising from the year 1991 onwards. Considering subjects suffering from obesity, the diabetes prevalence rose between 1983 and 2006/07, with the highest increase within the last two surveys (+8.3%). Among non-obese subjects the prevalence was relatively constant between 1973 and 1991. Afterwards the proportion of diabetic non-obese individuals also showed an upward trend.

The prevalence of diabetes mellitus for the period 1973 to 2006/07 for obese and non-obese women and men is illustrated in figure 15. The curves show similar courses for non-obese women and men. A considerable increase was found for non-obese subjects from 1991 onwards. Among obese women and men the prevalence of diabetes mellitus, with higher rates in women, has continually been rising since 1983. There was a significant increase within the two latest surveys observable for obese women and men suffering from obesity.

Table 19: The prevalence of diabetes mellitus in five health surveys stratified by sex, obesity and age

Sex (n) Age group (n)	P value[a] Total	P value[a] Obese	P value[a] Non-obese	1973 (n = 55,841) % Total	1973 % Obese	1973 % Non-obese	1983 (n = 38,835) % Total	1983 % Obese	1983 % Non-obese	1991 (n = 35,093) % Total	1991 % Obese	1991 % Non-obese	1999 (n = 34,731) % Total	1999 % Obese	1999 % Non-obese	2006/07 (n = 14,318) % Total	2006/07 % Obese	2006/07 % Non-obese
Total (178,818)	p<0.001	p<0.001	p<0.001	1.0 (0.8*)	1.9	0.9	0.8 (0.7*)	1.6	0.7	0.9 (0.9*)	2.6	0.7	2.4 (2.3*)	5.9	1.9	6.0 (5.3*)	14.2	4.5
20-34 (50,509)	p<0.001	p<0.001	p<0.001	0.1	0.3	0.1	0.1	0	0.1	0.1	0	0.1	0.3	1.0	0.2	0.6	5.5	0.3
35-54 (64,666)	p<0.001	p<0.001	p<0.001	0.5	1.3	0.4	0.3	0.6	0.3	0.4	1.5	0.3	1.3	3.4	1.0	2.1	5.6	1.6
55-74 (49,112)	p<0.001	p<0.001	p<0.001	1.9	2.7	1.7	1.6	2.6	1.4	2.0	3.9	1.5	4.7	8.3	3.7	11.2	20.4	8.1
≥ 75 (14,531)	p<0.001	p<0.001	p<0.001	2.5	3.4	2.4	2.5	2.2	2.5	2.9	4.1	2.8	7.1	10.5	6.6	20.9	24.8	20.0
Women (30,142)	p<0.001	p<0.001	p<0.001	1.1	2.3	1.0	0.9	1.8	0.8	1.1	3.6	0.8	2.4	6.7	1.8	6.4	15.6	4.6
20 – 34 (25,140)	p<0.001	p<0.001	0.083	0.1	0.8	0.1	0.1	0.0	0.1	0.1	0.0	0.1	0.3	1.1	0.2	0.8	7.2	0.3
35 – 54 (33,168)	p<0.001	p<0.001	p<0.001	0.4	1.1	0.3	0.3	0.5	0.2	0.4	1.6	0.3	0.9	3.2	0.7	2.2	7.1	1.5
55 – 74 (27,967)	p<0.001	p<0.001	p<0.001	2.1	3.1	1.9	1.6	2.9	1.4	2.2	4.9	1.6	4.4	8.8	3.0	9.7	18.9	6.4
≥ 75 (9,742)	p<0.001	p<0.001	p<0.001	2.9	3.9	2.7	2.9	1.7	3.1	3.4	5.0	3.2	7.6	11.3	6.9	22.1	26.6	20.9
Men (25,699)	p<0.001	p<0.001	p<0.001	0.8	1.3	0.8	0.6	1.2	0.6	0.6	1.4	0.6	2.3	4.9	2.0	5.6	12.5	4.4
20 – 34 (25,368)	p<0.001	p<0.001	0.078	0.1	0.0	0.1	0.1	0.0	0.1	0.1	0.0	0.1	0.3	0.9	0.2	0.5	3.7	0.3
35 – 54 (31,498)	p<0.001	p<0.001	p<0.001	0.6	1.5	0.5	0.4	0.6	0.4	0.4	1.4	0.2	1.6	3.5	1.3	2.0	4.3	1.6
55 – 74 (21,146)	p<0.001	p<0.001	p<0.001	1.6	1.7	1.6	1.5	2.1	1.4	1.6	1.9	1.5	5.0	7.6	4.4	12.8	22.7	9.9
≥ 75 (4,789)	p<0.001	p<0.001	p<0.001	1.9	1.6	1.9	1.6	4.5	1.5	2.0	1.0	2.1	6.1	8.0	5.9	18.5	18.0	18.6

[a]according to the chi-square test of period effect

*age-standardised prevalence

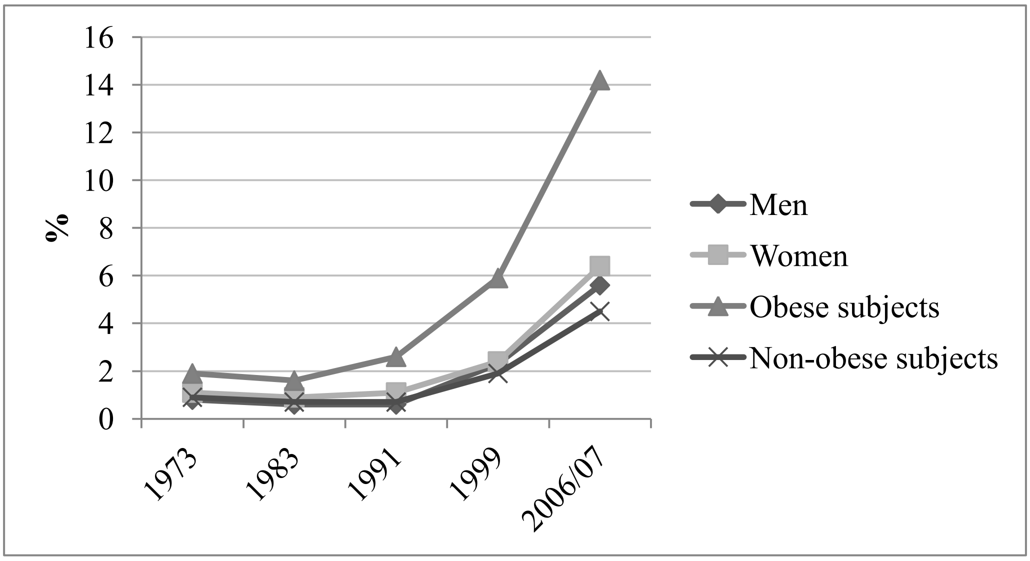

Figure 14: The prevalence of diabetes mellitus by sex and obesity

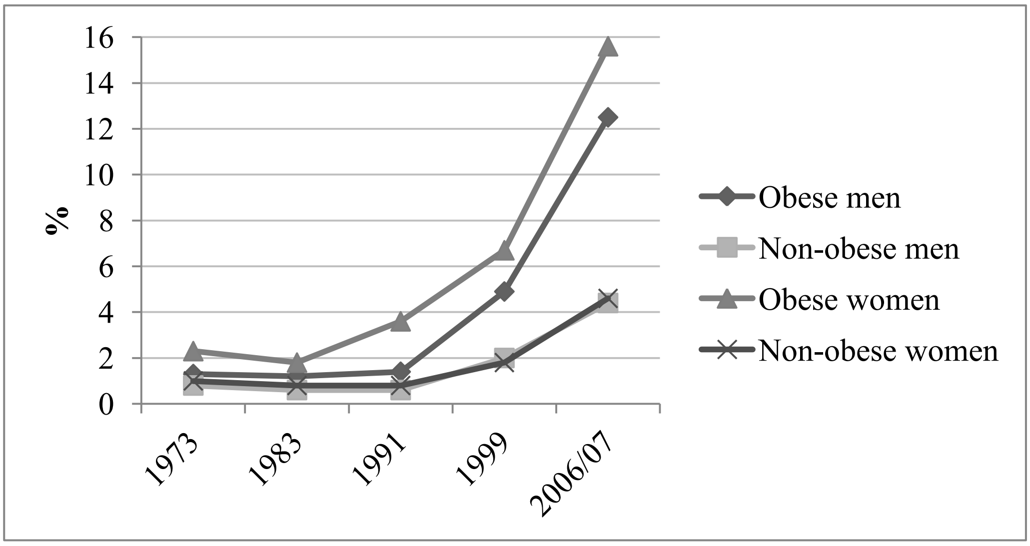

Figure 15: The prevalence of diabetes mellitus of obese and non-obese women and men

The absolute change (AC) for diabetes mellitus was 9.5% for the whole study population. The highest increase in the prevalence of diabetes mellitus was found t in obese subjects and in women. The AC for female adults with obesity was more than twice as high as for obese men. Hence the AC between 1973 and 2006/07 was highest for obese women. The aetiologic fractions (AFs) for diabetes mellitus were high for the study population and among the different subgroups. The risk for diabetes mellitus was highest for men suffering from obesity. The lowest AF was found in non-obese women (table 20).

Table 20: Absolute changes (AC) and aetiologic fractions (AF) of the prevalence of diabetes mellitus during the period 1973 to 2006/07 by sex and obesity (adjusted for age)

Predictor	**AC diabetes mellitus in %**	**AF diabetes mellitus in %**	**P value***
Total	9.5	86.5	< 0.001
Obese	14.1	89.6	< 0.001
Non-obese	8.5	83.1	< 0.001
Women	10.6	83.3	< 0.001
Obese	14.7	87.5	< 0.001
Non-obese	9.3	79.1	< 0.001
Men	5.0	89.6	< 0.001
Obese	6.6	92.9	< 0.001
Non-obese	4.6	87.3	< 0.001

* p value for period effect (from logistic regression analyses)

7.3.2. Hypertension

In 2006/07 the age-standardised prevalence of hypertension was 18.3% among the adult population in Austria. From 1973 to 2006/07 a continuous increase in the prevalence of hypertension was observed. The highest increase was among subjects suffering from obesity, with a very high proportion in 2006/07 (42.6%). In total, hypertension prevalence was higher for women than men. Especially in obese subjects, the prevalence was higher for female than male individuals. Considering the different age groups, hypertension was most prevalent among older subjects above the age of 75 years. However, this was not true for obese men stratified in age groups in the latest survey. In 2006/07 the highest values for hypertension were found in the group of the 55- to 74-year old obese men (table 21).

According to the chi-square test the comparisons of the hypertension prevalence during the study period was statistically significant in total and for all subgroups presented in table 21.

Figure 16 shows that there was continuous increase in the prevalence of hypertension between 1973 and 2006/07 for women and men, as well for obese and non-obese subjects. A strong upward trend was monitored for obese subjects. Within the two latest surveys the prevalence of hypertension increased from 15.8% in 1999 to 42.6% in 2006/07 among obese individuals.

Considering the study population divided in obese and non-obese subjects, similar curves in the development of hypertension were observed for non-obese women and non-obese men. Between 1973 and 1991 hypertension increased only slightly among non-obese subjects. Since 1991 a stronger increase among subjects not suffering from obesity has been observed. The greatest increase in the prevalence of hypertension was found in the early 1990s for obese women and men (figure 17).

Table 21: The prevalence of hypertension in five health surveys stratified by sex, obesity and age

	P value[a]			1973 (n = 55,841)			1983 (n = 38,835)			1991 (n = 35,093)			1999 (n = 34,731)			2006/07 (n = 14,318)		
Sex (n) Age group (n)	Total	Obese	Non-obese	% Total	% Obese	% Non-obese	% Total	% Obese	% Non-obese	% Total	% Obese	% Non-obese	% Total	% Obese	% Non-obese	% Total	% Obese	% Non-obese
Total (178,818)	p<0.001	p<0.001	p<0.001	1.2 (1.0*)	1.9	1.1	1.4 (1.4*)	3.9	1.2	2.0 (2.0*)	6.4	1.5	6.4 (6.1*)	15.8	5.0	20.3 (18.8*)	42.6	16.2
20-34 (50,509)	p<0.001	p<0.001	p<0.001	0.2	0	0.2	0.3	0.1	0.3	0.3	1.0	0.2	0.5	2.1	0.5	3.1	11.5	2.5
35-54 (64,666)	p<0.001	p<0.001	p<0.001	0.7	1.3	0.7	0.8	2.9	0.6	1.4	4.7	1.0	3.7	11.2	2.6	11.7	28.8	9.1
55-74 (49,112)	p<0.001	p<0.001	p<0.001	2.0	2.7	1.9	3.0	4.7	2.7	3.9	8.4	3.0	13.0	21.4	10.7	38.8	57.0	32.8
≥ 75 (14,531)	p<0.001	p<0.001	p<0.001	3.0	3.1	3.0	3.3	7.4	2.9	5.7	9.5	5.3	16.7	23.7	0.9	48.6	61.1	45.8
Women	p<0.001	p<0.001	p<0.001	1.5	2.6	1.4	1.9	5.0	1.5	2.3	7.2	1.8	7.1	18.1	5.4	21.5	46.9	16.6
20 – 34 (25,140)	p<0.001	p<0.001	p<0.001	0.2	0.0	0.3	0.4	0.2	0.4	0.2	0.0	0.2	0.4	2.5	0.3	3.0	12.0	2.3
35 – 54 (33,168)	p<0.001	p<0.001	p<0.001	0.9	1.8	0.8	1.0	3.6	0.7	1.2	4.3	0.9	3.7	12.1	2.6	11.0	34.1	7.7
55 – 74 (27,967)	p<0.001	p<0.001	p<0.001	2.6	3.3	2.4	3.6	6.0	3.0	4.8	9.8	3.5	13.7	22.7	10.9	39.0	56.4	32.7
≥ 75 (9,742)	p<0.001	p<0.001	p<0.001	3.6	3.5	3.6	3.9	7.6	3.5	6.0	7.5	5.8	17.9	26.5	16.3	51.4	65.6	47.3
Men	p<0.001	p<0.001	p<0.001	0.7	0.8	0.7	1.0	2.2	0.9	1.6	5.3	1.3	5.6	12.9	4.6	18.9	37.3	15.8
20 – 34 (25,368)	p<0.001	p<0.001	p<0.001	0.1	0.0	0.1	0.2	1.5	0.2	0.3	1.7	0.3	0.7	1.7	0.6	3.2	11.0	2.6
35 – 54 (31,498)	p<0.001	p<0.001	p<0.001	0.5	0.7	0.5	0.7	2.2	0.6	1.5	5.1	1.1	3.7	10.5	2.6	12.5	24.2	10.5
55 – 74 (21,146)	p<0.001	p<0.001	p<0.001	1.3	1.3	1.3	2.2	1.9	2.2	2.8	5.5	2.4	12.1	19.4	10.5	38.6	57.8	32.9
≥ 75 (4,789)	p<0.001	p<0.001	p<0.001	2.0	1.7	2.1	2.0	6.9	1.8	5.1	16.2	4.3	14.0	14.0	14.0	43.2	43.8	43.2

[a]according to the chi-square test of period effect

*age-standardised prevalence

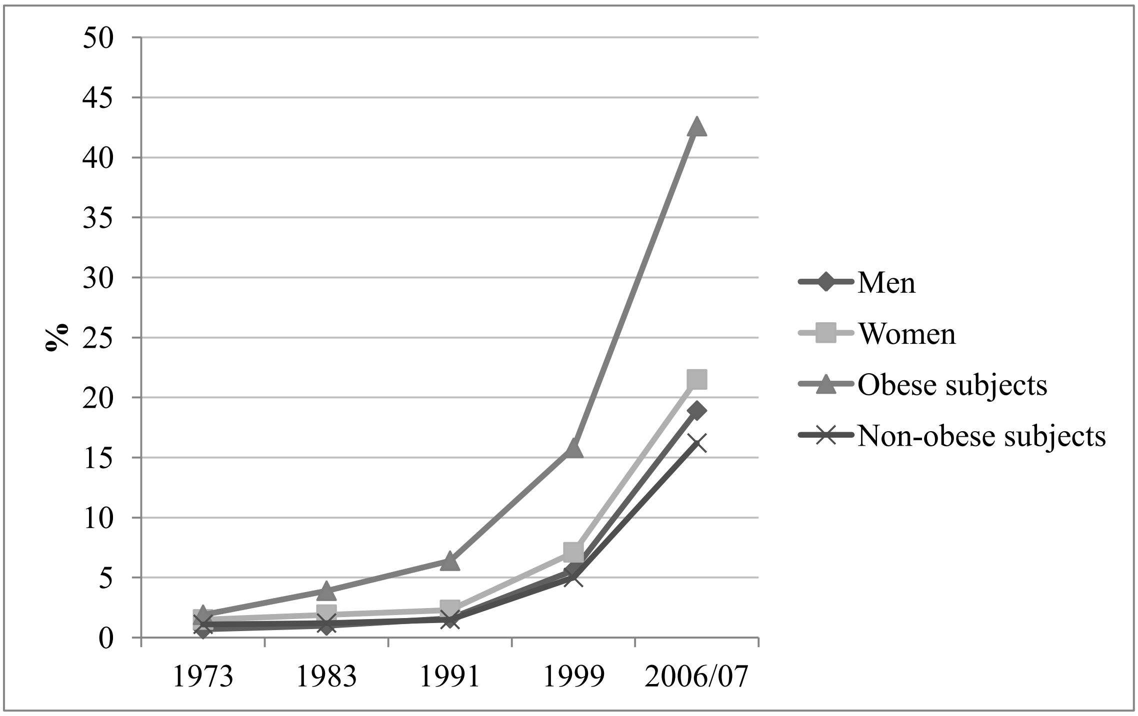

Figure 16: The prevalence of hypertension by sex and obesity

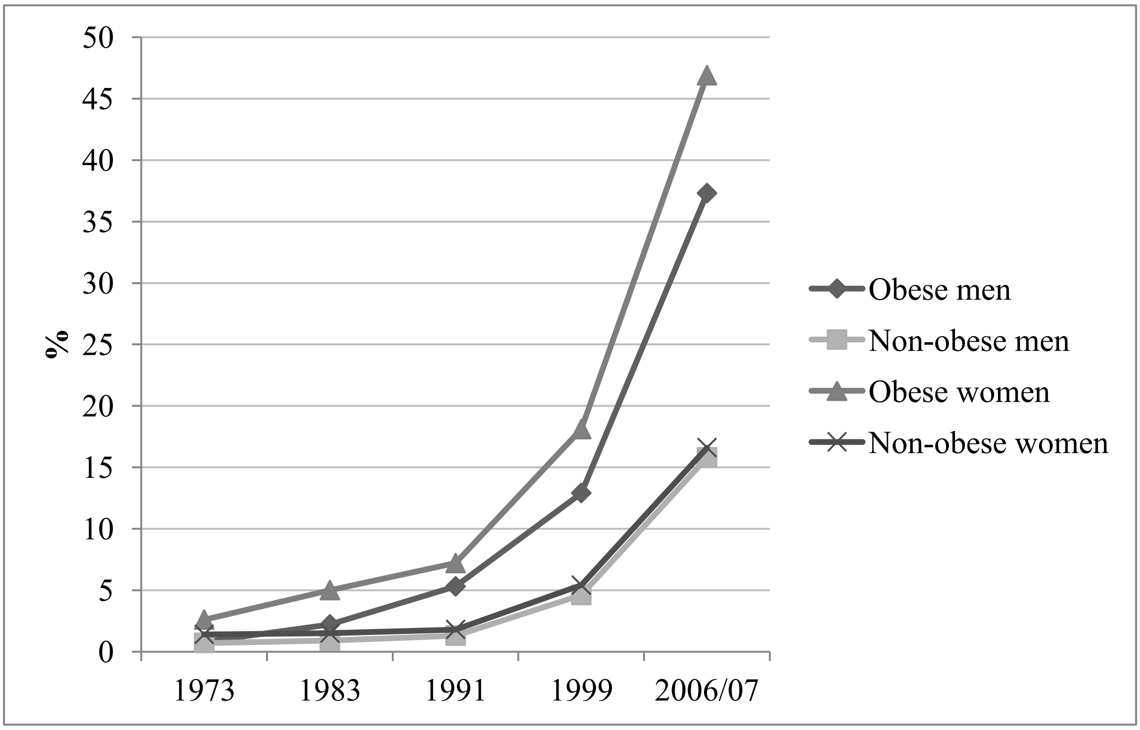

Figure 17: The prevalence of hypertension of obese and non-obese women and men

Among the whole study population the absolute change (AC) for the prevalence of hypertension was 34.1% for the whole study duration. AC was higher for obese subjects and for women. The maximum values were found for obese women. Therefore, the highest increase in the prevalence of hypertension occurred in women with obesity. The highest percentages for aetiologic fractions (AFs) were calculated for obese men, while the lowest AF was found for non-obese women (table 22).

Table 22: Absolute changes (AC) and aetiologic fractions (AF) of the prevalence of hypertension during the period 1973 to 2006/07 by sex and obesity (adjusted for age)

Predictor	**AC hypertension in %**	**AF hypertension in %**	**P value***
Total	34.1	96.3	< 0.001
Obese	44.0	97.0	< 0.001
Non-obese	31.6	95,7	< 0.001
Women	35.0	94.8	< 0.001
Obese	47.4	95.8	< 0.001
Non-obese	32.8	93.4	< 0.001
Men	24.8	98.2	< 0.001
Obese	16.9	98.9	< 0.001
Non-obese	24.9	97.8	< 0.001

*p value for period effect (from logistic regression analyses)

7.3.3. Back pain

The age-standardised prevalence of back pain showed that 32.9% of the adult population had back pain in 2006/07. Between 1973 and 2006/07 the prevalence of back pain steadily increased among obese and non-obese subjects. Highest prevalence was found in 2006/07 among obese subjects. The prevalence was slightly higher among women than men. Considering obese subjects in different age groups, the highest prevalence of back pain was in subjects aged 55 to 74 years; this was true for both sexes. Among non-obese subjects the prevalence was highest for women aged 75 years and older, and for men aged 55 to 74 years (table 23).

Figure 18 shows that the prevalence of back pain increased from survey to survey among women and men as well as obese and non-obese subjects. In 2006/07 the prevalence was similar for non-obese subjects and men.

The continuous increase in the prevalence of back pain among obese and non-obese women and men is illustrated in figure 19. The outcomes for obese women showed the highest prevalence. Between 1999 and 2006/07 the prevalence of back pain strongly increased among women not suffering from obesity.

Table 23: The prevalence of back pain in five health surveys stratified by sex, obesity and age

	P value[a]			1973 (n = 55,814)			1983 (n = 38,835)			1991 (n = 35,093)			1999 (n = 34,731)			2006/07 (n = 14,318)		
Sex (n) Age group (n)	Total	Obese	Non-obese	% Total	% Obese	% Non-obese	% Total	% Obese	% Non-obese	% Total	% Obese	% Non-obese	% Total	% Obese	% Non-obese	% Total	% Obese	% Non-obese
Total (178,818)	p<0.001	p<0.001	p<0.001	14.8 (13.9*)	19.1	14.2	16.7 (16.5*)	21.2	16.2	19.2 (19.0*)	24.4	18.7	25.0 (24.3*)	33.7	23.7	34.3 (32.9*)	42.8	32.8
20-34 (50,509)	p<0.001	p<0.001	p<0.001	7.0	10.9	6.9	7.6	11.2	7.5	9.8	18.3	9.5	14.6	19.6	14.3	18.6	23.9	18.2
35-54 (64,666)	p<0.001	p<0.001	p<0.001	15.5	17.3	15.2	19.3	22.4	19.0	22.3	23.5	22.2	26.0	30.7	25.4	33.6	38.0	32.9
55-74 (49,112)	p<0.001	p<0.001	p<0.001	19.3	22.0	18.7	22.1	21.1	22.3	25.6	25.2	25.7	33.0	38.8	31.4	45.8	50.4	44.4
≥ 75 (14,531)	p<0.001	p<0.001	p<0.001	19.8	22.0	19.5	21.7	27.9	21.0	23.9	31.9	23.0	29.6	39.1	28.1	46.4	48.4	46.0
Women	p<0.001	p<0.001	p<0.001	15.7	21.3	14.9	17.0	22.7	16.4	19.0	25.7	18.2	24.6	35.2	23.0	36.3	44.5	34.7
20 – 34 (25,140)	p<0.001	0.444	p<0.001	7.1	14.2	6.9	7.3	11.8	7.2	9.4	15.5	9.2	13.6	18.0	13.6	19.7	17.4	19.9
35 – 54 (33,168)	p<0.001	p<0.001	p<0.001	15.3	18.8	14.3	18.8	23.8	18.2	20.7	25.0	20.3	24.7	30.9	23.9	34.9	39.4	34.3
55 – 74 (27,967)	p<0.001	p<0.001	p<0.001	20.4	23.3	19.7	22.5	22.2	22.6	25.4	25.6	25.3	32.6	40.1	30.2	47.0	51.8	45.2
≥ 75 (9,742)	p<0.001	p<0.001	p<0.001	22.1	25.0	21.7	22.7	28.9	21.9	25.4	34.5	24.2	30.5	39.9	28.7	49.3	51.2	48.7
Men	p<0.001	p<0.001	p<0.001	13.7	15.5	13.5	16.3	18.9	16.0	19.5	22.6	19.2	25.5	31.8	24.6	32.2	40.9	30.7
20 – 34 (25,368)	p<0.001	p<0.001	p<0.001	6.9	8.7	6.8	8.0	10.7	7.9	10.2	20.3	9.8	15.3	21.1	15.0	17.5	30.4	16.5
35 – 54 (31,498)	p<0.001	p<0.001	p<0.001	15.6	15.5	15.6	19.8	21.0	19.7	24.0	22.1	24.2	27.4	30.5	26.9	32.3	36.8	31.5
55 – 74 (21,146)	p<0.001	p<0.001	p<0.001	17.7	18.9	17.5	21.6	18.9	22.0	25.9	24.2	26.1	33.4	36.7	32.7	44.6	48.6	43.4
≥ 75 (4,789)	p<0.001	p<0.001	p<0.001	15.1	11.8	15.3	19.5	23.1	19.4	20.8	23.1	20.7	27.7	36.2	26.7	41.0	38.0	41.2

[a]according to the chi-square test of period effect

*age-standardised prevalence

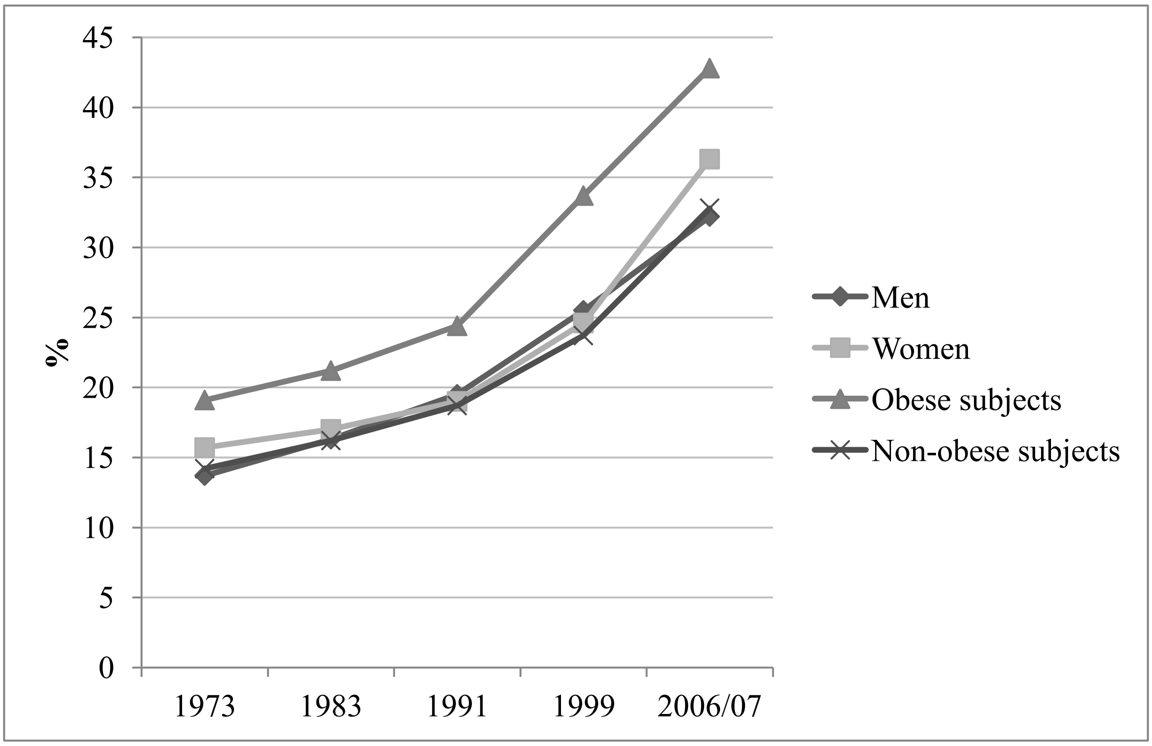

Figure 18: The prevalence of back pain by sex and obesity

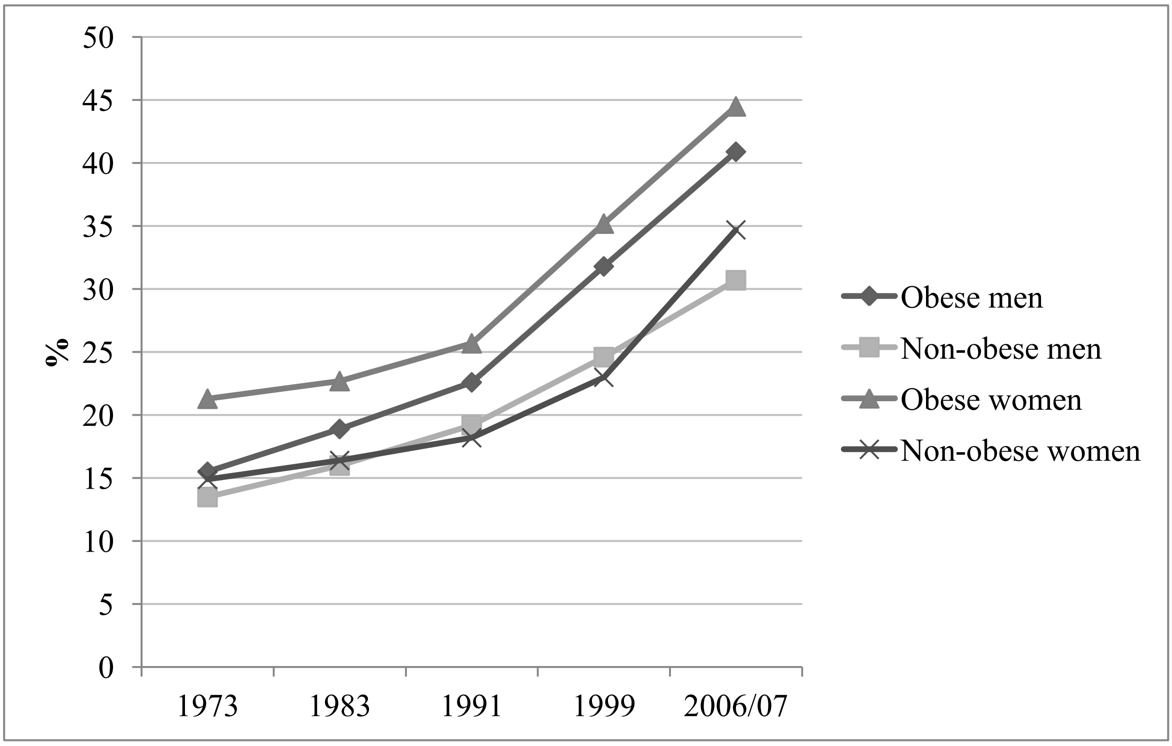

Figure 19: The prevalence of back pain of obese and non-obese women and men

For the whole study population the absolute change (AC) for the prevalence of back pain was 19.4% for the study period 1973 to 2006/07. The highest AC was calculated for obese men. The lowest increase in the prevalence of back pain was found among non-obese subjects. The highest aetiologic fraction (AF) for back pain was found for men suffering from obesity, while obese women showed the lowest AF rate (table 24).

Table 24: Absolute changes (AC) and aetiologic fractions (AF) of the prevalence of back pain during the period 1973 to 2006/07 by sex and obesity (adjusted for age)

Predictor	**AC back pain in %**	**AF back pain in %**	**P value***
Total	19.4	54.55	< 0.001
Obese	25.0	53.70	< 0.001
Non-obese	18.4	53.92	< 0.001
Women	19.7	52.61	< 0.001
Obese	23.3	50.00	< 0.001
Non-obese	19.5	52.38	< 0.001
Men	17.3	57.98	< 0.001
Obese	25.6	61.83	< 0.001
Non-obese	16.0	57.08	< 0.001

*p value for period effect (from logistic regression analyses)

7.3.4. Sleep disorder

In 1999 the age-standardised prevalence of sleep disorder was 11.8% among the Austrian adult population. Comparing the prevalence of sleep disorder between 1973 and 1999 there was a decrease for adults, with highest proportions in 1973. Sleep disorder was most often observed in older subjects. The highest prevalence was reported by those aged 75 years and older. The prevalence of sleep disorder was higher for women than men, regardless whether obese or non-obese (table 25).

Figure 20 shows that there was a decrease in the prevalence of sleep disorder between 1973 and 1991 among women, men and non-obese subjects. Among obese individuals the proportion of subjects with sleep disorder rose within the both first surveys and removed until 1991. From 1991 upwards the prevalence of sleep disorder increased among women and men as well as obese and non-obese subjects, with the highest increase among obese subjects.

In figure 21 the trends in the prevalence of sleep disorder are shown for obese and non-obese women and men. Among non-obese men the prevalence of sleep disorder was quite stable between 1973 and 1999. During the investigation period the lowest prevalence was found among men who were not obese. Until 1991 sleep disorder was more prevalent among non-obese women than obese men. Thereafter, the proportion of sleep disorder has risen among obese men. In 1999 the prevalence was somewhat higher for obese men than non-obese women. The highest prevalence was found for obese women. Between 1973 and 1999 a decrease in the prevalence of sleep disorder could be observed in non-obese female subjects.

Table 25: The prevalence (%) of sleep disorder in four health surveys stratified by sex, obesity and age

	P value[a]			1973 (n = 55,841)			1983 (n = 38,835)			1991 (n = 35,093)			1999 (n = 34,731)		
Sex (n) Age group (n)	Total	Obese	Non-obese	% Total	% Obese	% Non-obese	% Total	% Obese	% Non-obese	% Total	% Obese	% Non-obese	% Total	% Obese	% Non-obese
Total (164,500)	p<0.001	p<0.001	p<0.001	12.5 (12.2*)	16.1	12.0	11.8 (11.5*)	17.8	11.2	10.3 (10.2*)	15.0	9.8	12.3 (11.8*)	19.3	11.2
20-34 (46,951)	p<0.001	0.058	p<0.001	3.0	4.2	2.9	2.4	2.8	2.3	2.3	4.6	2.3	4.5	6.6	4.2
35-54 (59,029)	p<0.001	p<0.05	p<0.001	9.4	10.8	9.2	9.1	12.5	8.8	7.7	9.8	7.5	9.0	12.9	8.5
55-74 (45,421)	p<0.05	p<0.05	p<0.001	20.4	22.3	20.0	20.6	22.3	20.3	18.7	19.92	18.4	19.9	25.4	18.5
≥ 75 (13,098)	p<0.05	p<0.05	p<0.001	27.0	23.8	27.3	30.6	34.3	30.2	27.6	24.6	27.9	28.3	32.4	27.6
Women	p<0.001	p<0.001	p<0.001	15.5	19.8	14.8	15.0	21.9	14.2	12.9	19.9	12.1	14.9	24.1	13.4
20 – 34 (23,371)	p<0.001	0.096	p<0.001	3.8	6.2	3.7	2.8	2.4	2.8	2.7	5.0	2.6	5.0	8.3	4.8
35 – 54 (30,366)	p<0.001	0.242	p<0.001	11.3	13.2	11.0	10.8	14.9	10.4	8.7	13.2	8.3	9.9	16.2	9.1
55 – 74 (26,027)	0.113	0.064	0.100	24.1	25.3	23.8	24.4	25.2	24.2	22.6	23.9	22.2	24.1	28.6	22.8
≥ 75 (8,798)	p<0.05	p<0.05	0.016	30.4	25.9	31.1	35.4	38.1	35.0	31.8	29.0	32.2	31.6	37.0	30.6
Men	p<0.001	p<0.001	p<0.001	8.8	10.0	8.6	8.2	11.7	7.8	7.3	8.2	7.3	9.3	13.5	8.8
20 – 34 (23,580)	p<0.001	0.460	p<0.001	2.,2	2.8	2.1	1.9	3.2	1.8	2.0	4.3	1.9	3.7	5.0	3.6
35 – 54 (28,664)	p<0.05	p<0.05	0.169	7.1	7.8	7.0	7.5	10.2	7.2	6.8	6.6	6.8	8.2	10.3	7.8
55 – 74 (19,394)	0.061	p<0.001	0.081	15.3	15.3	15.3	15.2	16.2	15.0	13.4	11.6	13.7	14.9	19.9	13.8
≥ 75 (4,300)	0.789	0.545	0.885	20.0	16.3	20.3	20.5	16.3	20.8	19.2	9.7	19.9	21.0	16.3	21.5

[a]according to the chi-square test of period effect

*age-standardised prevalence

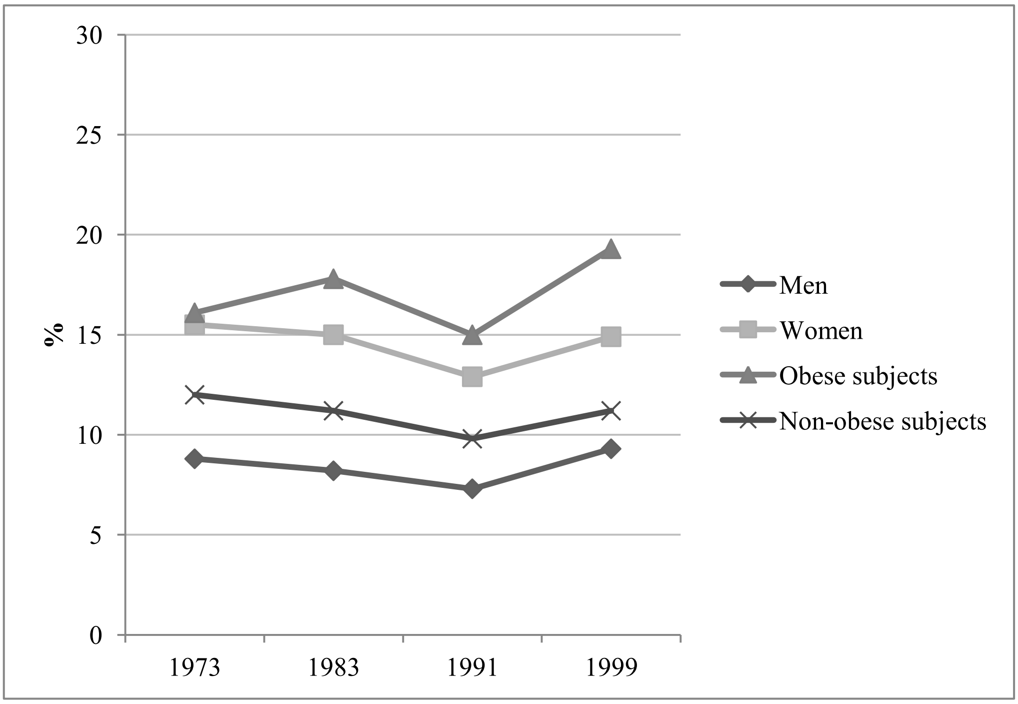

Figure 20: The prevalence of sleep disorder by sex and obesity

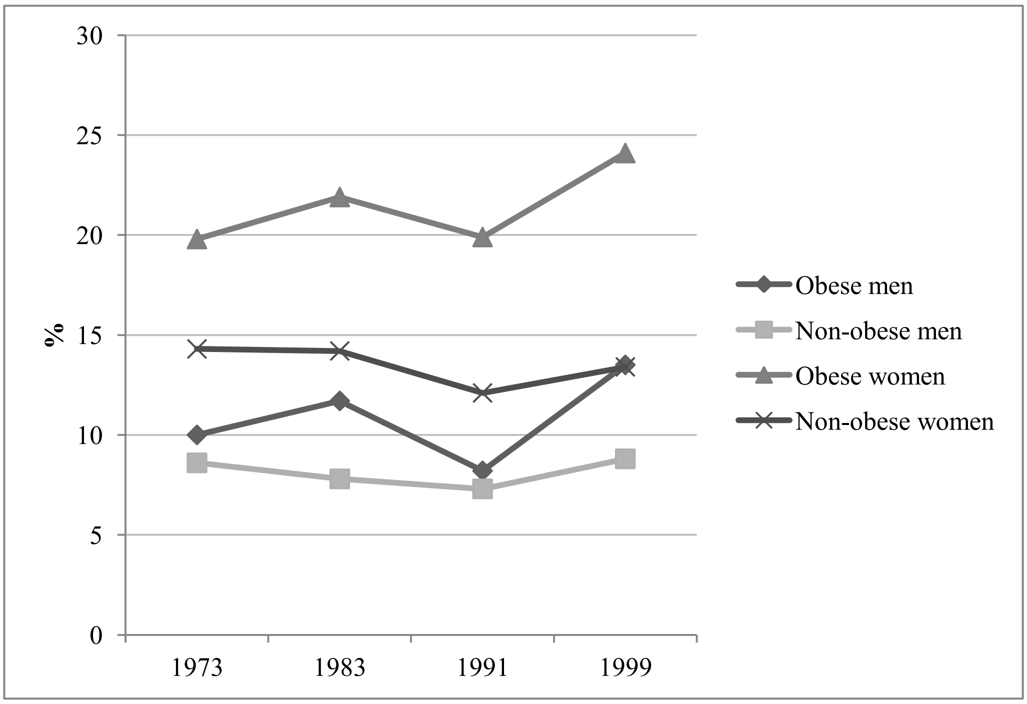

Figure 21: The prevalence of sleep disorder of obese and non-obese women and men

The absolute change (AC) for the prevalence of sleep disorder showed that there was no increase for the Austrian adult population between 1973 and 1999. However, this result is not statistically significant. Considering subgroups the AC for the prevalence of sleep disorder was highest for obese subjects and generally higher for women than men. Between 1973 and 1999 a statistically significant decrease was found in non-obese women. The greatest risk for sleep disorder presented by the aetiologic fraction (AF) was found for obese men. The lowest AF was observed among non-obese women (table 26).

Table 26: Absolute changes (AC) and aetiologic fractions (AF) of the prevalence of sleep disorder during the period 1973 to 1999 by sex and obesity (adjusted for age)

Predictor	AC sleep disorder in %	AF sleep disorder in %	P value*
Total	0.0	44.83	0.919
Obese	3.0	43.18	< 0.05
Non-obese	-0.1	41.18	0.088
Women	0.0	39.02	0.431
Obese	4.0	41.86	< 0.05
Non-obese	-2.0	37.89	< 0.05
Men	1.0	45.36	< 0.05
Obese	3.0	51.70	< 0.05
Non-obese	1.0	44.13	0.305

*p value for period effect (from logistic regression analyses)

7.3.5. Depression

The age-standardised prevalence of depression was 3.8% among the Austrian adult population in 1999. The prevalence of depression slightly increased during the investigation period, with a decrease between 1973 and 1991. Among obese and non-obese subjects depression was most prevalent in the oldest age group. Women, especially obese women, most often suffered from depression (table 27).

Analysing depression stratified by sex and obesity, the prevalence decreased between 1973 and 1991 among women and men, as well as obese and non-obese individuals. In 1991 women were most frequently concerned to be depressive, followed closely by obese subjects. After 1991 the prevalence of depression among obese subjects strongly increased and showed the highest prevalence among the four illustrated subgroups in figure 20 for the survey in 1999. In total, the prevalence of depression increased between 1991 and 1999 among women and men as well as obese and non-obese subjects (figure 22).

In figure 23 the prevalence of depression is separately presented for obese and non-obese women and men. From 1991 onwards the prevalence increased in all subgroups illustrated in that figure. The illustration clearly shows that depression among obese women and men strongly increased from 1991 onwards

Table 27: The prevalence of depression in four health surveys stratified by sex, obesity and age

	P value[a]			1973 (n = 55,841)			1983 (n = 38,835)			1991 (n = 35,093)			1999 (n = 34,731)		
Sex (n) Age group (n)	Total	Obese	Non-obese	% Total	% Obese	% Non-obese	% Total	% Obese	% Non-obese	% Total	% Obese	% Non-obese	% Total	% Obese	% Non-obese
Total (164,500)	p<0.001	p<0.001	p<0.001	3.6 (3.3*)	4.3	3.5	3.4 (3.3*)	4.3	3.3	2.8 (2.8*)	3.5	2.7	3.7 (3.8*)	5.8	3.6
20-34 (46,951)	p<0.001	0.412	p<0.001	1.3	1.5	1.3	0.9	2.6	0.9	1.2	1.3	1.2	1.6	2.2	1.6
35-54 (59,029)	p<0.05	0.372	0.120	2.8	3.2	2.7	2.8	3.8	2.7	2.6	3.5	2.5	3.2	4.2	3.0
55-74 (45,421)	p<0.001	p<0.001	p<0.001	5.6	5.6	5.6	5.5	4.6	5.6	4.0	3.7	4.0	5.6	7.2	5.2
≥ 75 (13,098)	p<0.001	0.188	p<0.001	7.1	7.1	7.1	8.7	6.3	9.0	6.4	5.7	6.5	8.4	9.6	8.2
Women	p<0.001	p<0.001	p<0.001	4.7	5.5	4.6	4.7	5.5	4.6	3.8	5.2	3.6	5.0	8.0	4.5
20 – 34 (23,371)	p<0.001	0.365	p<0.001	1.9	3.2	1.8	1.3	1.2	1.3	1.8	3.2	1.7	2.4	4.3	2.3
35 – 54 (30,366)	0.467	0.101	p<0.001	3.8	4.5	3.7	4.1	5.6	3.9	3.6	5.3	3.4	4.1	7.0	3.7
55 – 74 (26,027)	p<0.001	p<0.05	p<0.001	6.8	6.3	7.0	6.7	5.7	6.9	5.1	4.9	5.1	6.9	8.4	6.4
≥ 75 (8,798)	p<0.001	0.135	p<0.001	8.1	7.2	8.3	10.1	6.9	10.5	6.8	7.3	6.7	9.2	11.3	8.8
Men	p<0.001	p<0.001	p<0.05	2.2	2.4	2.1	2.0	2.5	1.9	1.7	1.3	1.8	2.6	3.0	2.6
20 – 34 (23,580)	0.364	0.749	0.100	0.8	0.5	0.8	0.6	3.8	0.5	0.7	0.0	0.7	0.9	0.2	0.9
35 – 54 (28,664)	p<0.001	p<0.001	p<0.001	1.5	1.5	1.5	1.5	2.0	1.5	1.6	1.9	1.6	2.3	2.0	2.3
55 – 74 (19,394)	p<0.001	p<0.001	0.023	3.9	4.0	3.8	3.6	2.4	3.8	2.5	1.2	2.7	4.1	5.2	3.9
≥ 75 (4,300)	0.277	0.148	0.138	4.9	6.8	4.8	5.9	3.7	6.0	5.8	0.0	6.3	6.8	3.5	7.2

[a]according to the chi-square test of period effect

*age-standardised prevalence

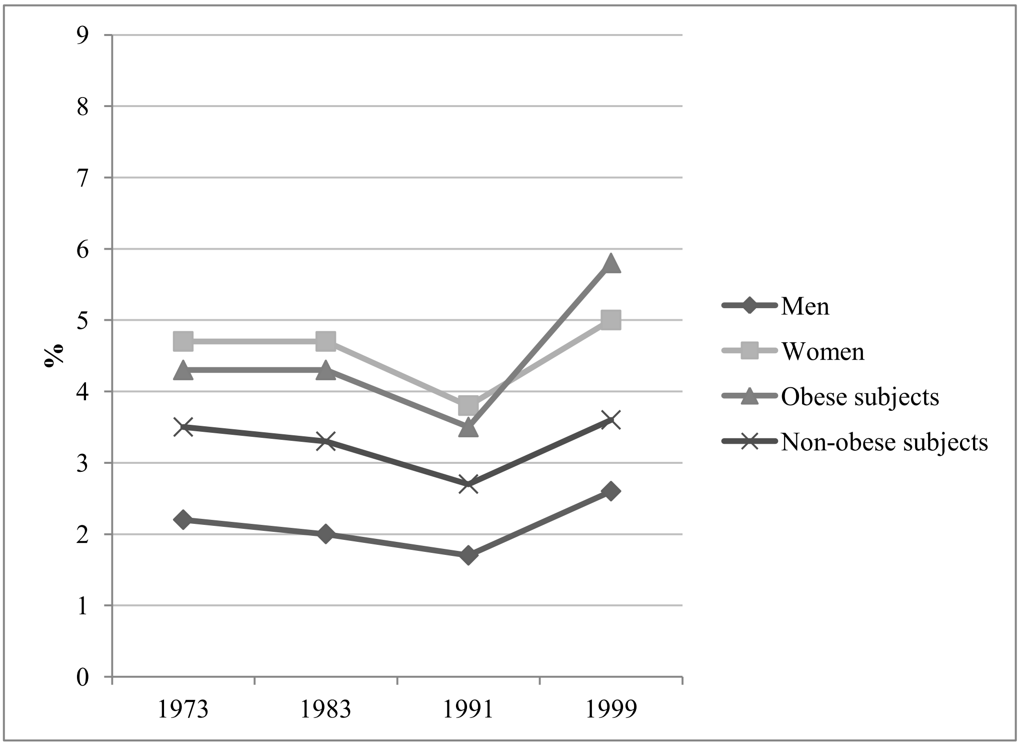

Figure 22: The prevalence of depression by sex and obesity

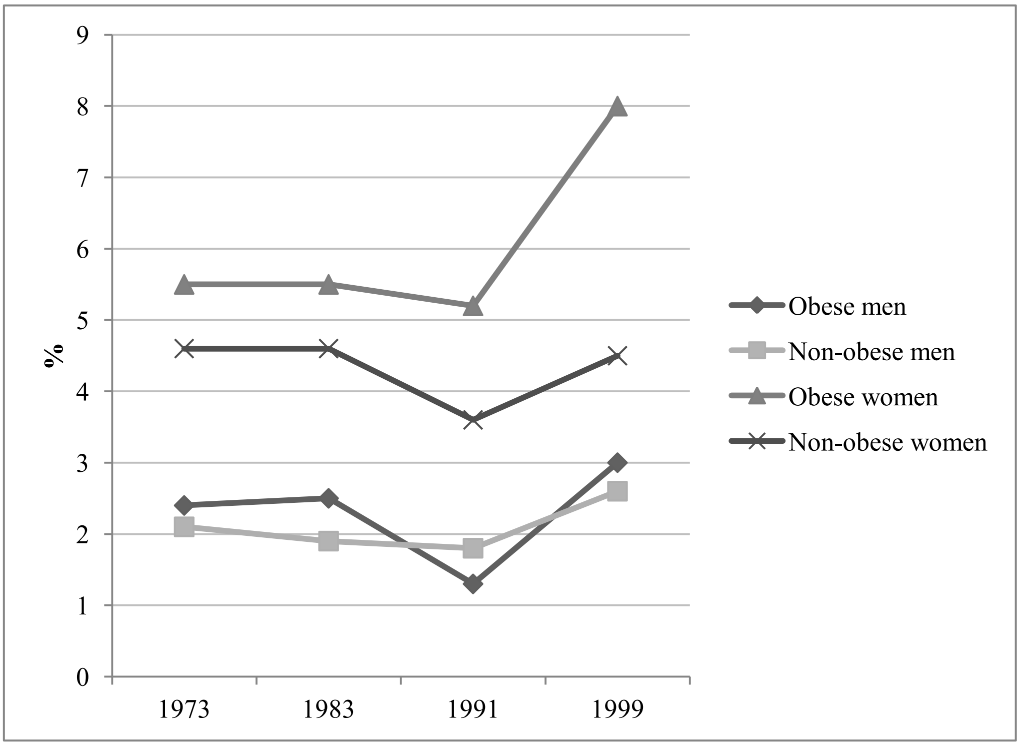

Figure 23: The prevalence of depression of obese and non-obese women and men

Between 1973 and 1999 the absolute change (AC) for the prevalence of depression was 0.4% among the whole study population. However, this outcome is not statistically significant. Obese women showed the highest increase in the prevalence of depression. The aetiologic fraction (AF) for the prevalence of depression was highest for obese women (table 28).

Table 28: Absolute changes (AC) and aetiologic fractions (AF) of the prevalence of depression during the period 1973 to 1999 by sex and obesity (adjusted for age)

Predictor	**AC depression in %**	**AF depression in %**	**P value***
Total	0.4	49.23	0.152
Obese	1.4	53.05	< 0.05
Non-obese	0.1	48.45	0.622
Women	0.2	48.44	0.546
Obese	3.0	55.55	< 0.001
Non-obese	-0.2	47.37	0.445
Men	1.0	52.60	< 0.05
Obese	0.0	51.92	0.656
Non-obese	1.0	52.38	< 0.05

*p value for period effect (from logistic regression analyses)

7.3.6. Headache

The age-standardised prevalence of headache was 12.6% in 2006/07 among the Austrian adult population. The prevalence decreased during the investigation period. The highest age-standardised prevalence was found in 1973. Considering the prevalence in 1999 non-obese women most often suffered from headache. However, the outcomes for obese individuals were not statistically significant. Considering the age groups, the highest prevalence was observed for those aged 35 to 54 years. In 1999 the prevalence of headache was high among the youngest women, while the prevalence among men aged 20 to 34 years was much lower. Compared to men, women more often self-reported to suffer from headache (table 29).

Among women, men and non-obese subjects a decrease in the prevalence of headache could be observed between 1973 and 1991. Afterwards, the proportion of subjects suffering from headache rose. The outcomes for obese subjects illustrated in figure 22 are not statistically significant (figure 24).

The curves in figure 25 show the course of the prevalence of headache for obese and non-obese women and men. The results will only be described for non-obese women and men, because no statistically significant differences could be observed in women and men suffering from obesity. There was a strong increase in the prevalence of headache during the study period among non-obese women. Among non-obese men the prevalence of headache hardly changed between 1973 and 1999, with the lowest prevalence in 1991.

Table 29: The prevalence of headache in four health surveys stratified by sex, obesity and age

	P value[a]			1973 (n = 55,814)			1983 (n = 38,835)			1991 (n = 35,093)			1999 (n = 34,731)		
Sex (n) Age group (n)	Total	Obese	Non-obese	% Total	% Obese	% Non-obese	% Total	% Obese	% Non-obese	% Total	% Obese	% Non-obese	% Total	% Obese	% Non-obese
Total (164,500)	p<0.001	0.032	p<0.001	13.8 (13.4*)	14.7	13.7	12.8 (12.8*)	14.6	12.6	11.0 (11.0*)	12.7	10.8	12.7 (12.6*)	14.8	12.4
20-34 (46,951)	p<0.001	p<0.005	p<0.001	10.5	9.9	10.5	8.8	13.0	8.7	8.8	13.1	8.6	12.1	16.1	11.9
35-54 (59,029)	p<0.001	0.059	p<0.001	15.5	15.0	15.6	14.6	15.7	14.4	13.0	13.0	13.0	14.3	16.7	14.0
55-74 (45,421)	p<0.001	p<0.05	p<0.001	15.1	15.7	15.0	14.6	13.9	14.7	11.3	12.5	11.1	11.8	13.2	11.4
≥ 75 (13,098)	p<0.001	0.565	p<0.001	11.8	11.9	11.8	13.9	15.4	13.7	10.4	12.2	10.2	10.4	13.8	9.8
Women	p<0.001	0.134	p<0.001	17.8	18.0	14.9	16.7	18.2	16.4	14.2	16.4	18.2	16.4	19.1	23.0
20 – 34 (23,371)	p<0.001	0.943	p<0.001	14.5	16.3	14.4	12.3	18.0	12.1	11.5	18.3	11.3	16.1	17.7	16.0
35 – 54 (30,366)	p<0.001	p<0.05	p<0.001	20.3	19.9	20.4	19.1	21.4	18.8	17.7	18.7	17.6	19.2	24.9	18.5
55 – 74 (26,027)	p<0.001	0.392	p<0.001	18.4	17.5	18.6	18.2	16.6	18.6	13.9	15.0	13.6	15.0	16.8	14.5
≥ 75 (8,798)	p<0.001	0.661	p<0.001	14.2	13.8	14.3	16.7	17.2	16.6	12.0	15.6	11.6	11.9	16.2	11.0
Men	p<0.001	0.175	p<0.001	9.0	9.3	9.0	8.2	9.2	8.1	7.4	7.5	7.4	8.6	9.6	8.4
20 – 34 (23,580)	p<0.001	p<0.05	p<0.001	6.6	5.7	6.6	5.4	8.8	5.3	6.1	9.3	6.0	8.1	14.6	7.7
35 – 54 (28,664)	p<0.05	0.326	p<0.05	9.9	8.9	10.1	10.0	10.1	10.0	8.4	7.8	8.4	9.5	10.3	9.4
55 – 74 (19,394)	p<0.001	0.010	p<0.001	10.6	11.7	10.4	9.3	8.4	9.4	7.9	7.2	8.0	8.0	7.7	8.1
≥ 75 (4,300)	0.797	0.465	0.874	7.0	5.4	7.1	8.0	6.9	8.1	7.1	0.9	7.5	7.1	5.3	7.3

[a]according to the chi-square test of period effect

*age-standardised prevalence

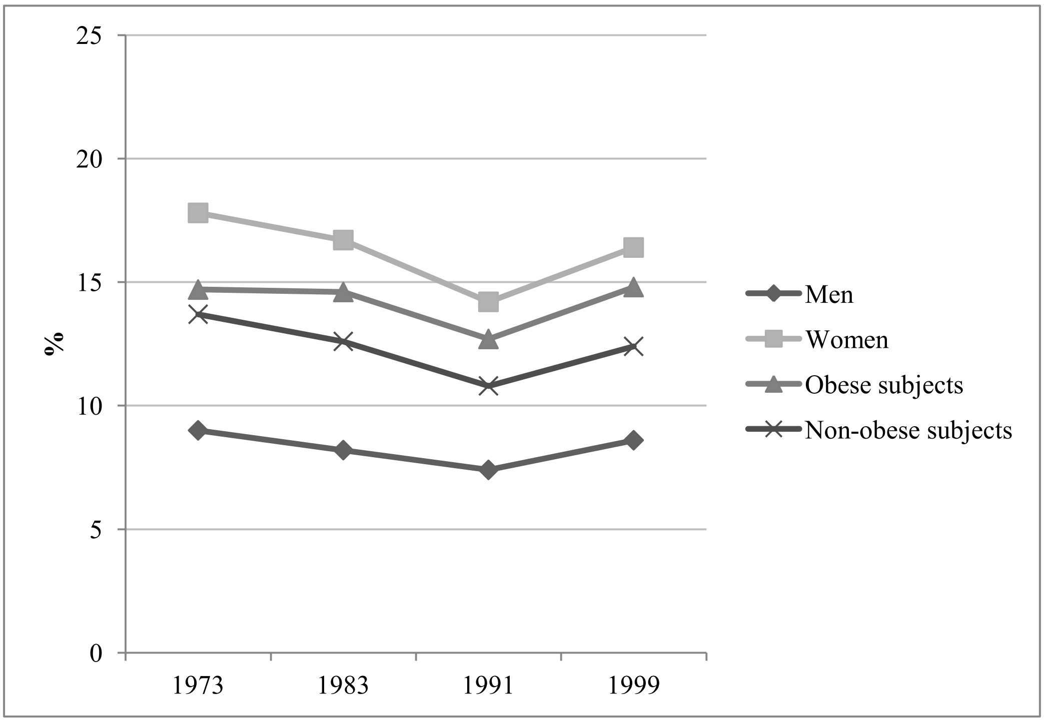

Figure 24: The prevalence of headache by sex and obesity

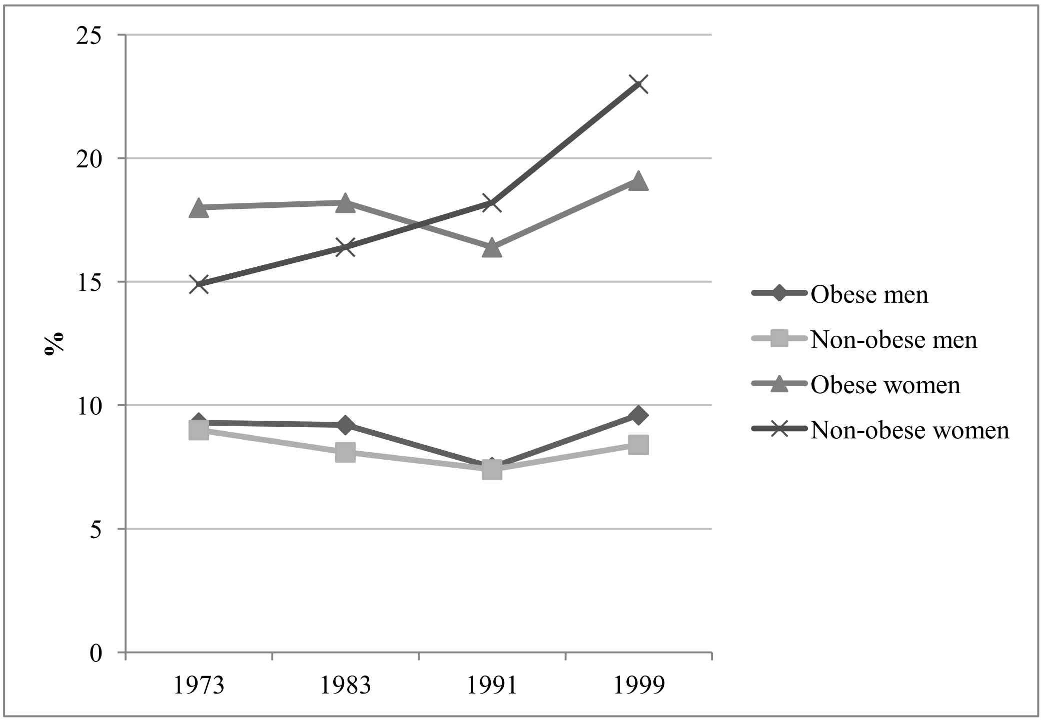

Figure 25: The prevalence of headache of obese and non-obese women and men

Between 1973 and 1999 there was a decrease in the prevalence of headache when investigating the total adult study population. The absolute change (AC) was highest among men, compared to women. The outcomes for the ACs and aetiologic fractions (AFs) were not statistically significant among obese subjects. According to the AF higher values were found among men than women (table 30).

Table 30: Absolute changes (AC) and aetiologic fractions (AF) of the prevalence of headache during the period 1973 to 1999 by sex and obesity (adjusted for age)

Predictor	**AC headache in %**	**AF headache in %**	**P value***
Total	-2.0	43.18	< 0.001
Obese	0.0	46.24	0.609
Non-obese	-2.0	42.86	< 0.001
Women	-0.1	43.50	< 0.001
Obese	0.1	47.64	0.398
Non-obese	-0.2	42.53	< 0.001
Men	-4.0	45.65	< 0.001
Obese	0.0	49.24	0.812
Non-obese	-4.0	45.05	< 0.001

*p value for period effect (from logistic regression analyses)

8. Discussion

8.1. Summary of main findings

In this large population-based study an upward trend in mean BMI and the prevalence of obesity was observed in Austrian adults within the study period. A rise in overall obesity prevalence has occurred between 1973 and 2006/07 among women (age-standardised prevalence: from 11.5% to 15.0%) and men (age-standardised prevalence: from 9.5% to 13.8%). Between 1973 and 1983 a significant decline in the prevalence of obesity could be observed. But after 1983 obesity increased steadily, with a peak between 1991 and 2006/07. This was true for both sexes, with higher prevalence in women than men during the whole study period. The absolute change (AC) was higher for men than women between 1983 and 2006/07. The aetiologic fraction (AF), showing the dynamic for obesity, was also higher for male compared to female adults.

The outcomes of this study provided evidence that the obesity prevalence varied across the sociodemographic subpopulations among Austrian adults. Considering the investigated age groups, the highest proportions of obesity were observed in older subject, with the highest prevalence in individuals aged 55 to 74 years. The most prominent AC in obesity prevalence between 1983 and 2006/07 was found for women 75 years and older and for men aged 55 to 74 years. The smallest increase in obesity prevalence took place among women aged 35 to 54 years, and men aged 20 to 34 years. The highest AF was found in women aged 20 to 34 years and men 75 years and older.

Examining the different educational groups, the highest obesity proportions were observed in individuals with the lowest educational level, whereas the lowest obesity prevalence was found among subjects with the highest education. Between 1983 and 2006/07 the strongest increase in obesity prevalence turned out to be in persons with low educational status. However, the prevalence of obesity increased in all educational groups during the whole study period. The highest AF for obesity was found among women with middle educational level und men with low educational level.

By analysing the interaction between age and educational level, it was observed that older subjects with low education most often suffered from obesity and showed the highest AC during the study period, compared with all other investigated subgroups in this study.

Furthermore, the results of this study showed a clear regional difference in obesity prevalence during the 34-year period, with the highest prevalence in Eastern Austria, and the lowest in Western Austria. The prevalence of obesity increased in every region in Austria, with the highest AC among women in Central Austria and men in Western Austria. The highest AF was found among subjects living in Western Austria.

The magnitude of education-related inequalities for obesity was higher among women than men. For men a considerable tendency was observed; education-related inequalities for obesity increased between 1983 and 2006/07. In 2006/07 relative inequalities for obesity were lowest among subjects aged 75 years and older and diminished during the investigation period for this age group. Comparing Austrian regions the education-related inequalities for obesity were highest in Eastern Austria.

Considering the investigated obesity-associated diseases and disorders the prevalence was highest for back pain. According to the age-standardised prevalence about one third of the Austrian adult population suffered from back pain in 2006/07. Between 1973 and 1999 or rather 2006/07 there was a rise in the investigated obesity-associated diseases and disorders diabetes mellitus, hypertension and backache. A slight decrease in the prevalence of headache was observed between 1973 and 1999. During the investigation period 1973 to 1999 there was no statistically significant increase observed for sleep disorder and depression among the general adults population. In the general study population the highest increase was found for the prevalence of hypertension, followed by back pain, while the lowest AC was observed for headache. The highest increase in the prevalence of the analysed diseases and disorders was found for obese subjects. By analysing data stratified by sex and obesity, the highest ACs for diabetes mellitus, hypertension, sleep disorder, depression and headache (no statistically significant results for headache, $p > 0.05$) were found among obese women. For back pain obese men indicated the highest AC between 1983 and 2006/07. Obesity in men was associated with the highest AFs for diabetes mellitus, hypertension, back pain, sleep disorder and headache (no statistically significant results for headache, $p > 0.05$), while obese women showed the highest AF for depression.

8.2. Comparison with literature

Long-term trends in BMI and obesity

The results of this study showed that between 1973 and 2006/07 the mean BMI was higher among men than women. This result was also confirmed by other European studies (Gallues et al., 2012; Marques-Vidal, Paccaud & Ravasco, 2011; Howel, 2010; Ng et al., 2010; Schneider, Dietrich & Venetz, 2010). It can be assumed that especially the higher prevalence of overweight in male compared to female adults in Austria (Großschädl & Stronegger, 2012b) causes higher mean BMI values among men.

The observed increase in the overall prevalence of obesity over the last decades in Austrian adults is consistent with many studies across the world (Ljungvall & Zimmerman, 2012; Ford et al., 2011; Pigeyre et al., 2011; Cámara & Spijker, 2010; Diouf et al., 2010; Flegal et al., 2010; Marques-Vidal et al., 2010; Lahti-Koski et al., 2009; Singh-Manoux et al., 2009; Faeh et al., 2008). In comparison with European studies carried out in Belgium (Charafeddine, Van Oyen & Demarest, 2009), France (Charles, Eschwége & Basdevant, 2008), Italy (Gallus et al., 2006) and the Netherlands (Schokker et al., 2006), the age-standardised prevalence of obesity in Austrian adults is high.

Faeh et al. (2004) reported quite similar obesity prevalence for female adults living in Switzerland compared to this study results. In 2004 the age-standardised prevalence based on measured and self-reported BMI data was 14.5% among Swiss women and thus lower than among Swiss men (17.1%). However, Faeh et al. (2004) did not investigate the whole adult population and the analysis was restricted to subjects aged 34 to 74 years, which limits the comparison with this study. Schneider, Dietrich and Venetz (2010) also reported higher obesity prevalence in men compared to women in Switzerland. Slightly higher prevalence of obesity was found in the study from Pigeyre et al. (2011), in which measured BMI data from French adults aged 35 to 64 years for the study period 1986 to 2006 were analysed. Pigeyre et al. (2011) also reported that more men (18.4%) than women (17.2%) were obese in 2006. This outcome reported for Switzerland and France is unusual, because in most studies - and also in this study - it was found that the obesity prevalence is higher in women than men (Gallus et al., 2012; Ljungvall & Zimmerman, 2012; von Ruesten et al., 2011; Howel, 2010; Ng et al., 2010; Lahti-Koski et al., 2009; Singh-Manoux et al., 2009; Zaninotto et al., 2009; Gallus et al., 2006). For Austria only one study which indicated that prevalence of obesity measured through WC was higher among male than female participants was found. However, a specific subgroup (patients of primary care physicians) was investigated. Therefore these results can only apply to this Austrian subpopulation and not to the general adult population (Schwarz, 2007).

Considering further obesity long-term trend analyses in Europe the obesity prevalence of Finnish adults showed much higher obesity proportions than this study (Lahti-Koski et al., 2009; Pietinen et al., 1996). According to that study more than 20% of the Finnish adult population, over the age of 30 years, were obese in 2001 (Lahti-Koski et al., 2009). A possible reason for such a high prevalence in the Finnish study could be that young adults, who most often show the lowest obesity proportions (Gallus et al., 2012; Doak et al., 2011; Low, Chin & Deurenberg-Yap, 2009), were not investigated in that study. A German study examined trends in obesity prevalence between 1985 and 2002 in adults aged 25 to 69 years. It revealed an increase in the prevalence of obesity for women from 20.7 to 31.0% and men from 17.7 to 27.7% (Helmert & Strube, 2004), and thus show much higher proportions than in our study. Across Europe the obesity prevalence among Austrian adults found in this study, is average.

Very high obesity prevalence has also been reported in the United States (Grabner, 2012; Ljungvall & Zimmerman, 2012; Ford et al., 2011; Flegal et al., 2010; Low, Chin & Deurenberg-Yap, 2009). In 2008 the prevalence of obesity obtained from measurements of body weight and height was high in most adult age groups in the United States. About 30% were obese (Flegal et al., 2010). These results are more than twice as high than in this study. In 1991 no state in America had prevalences over 20%; only ten years later the obesity prevalence had exceeded the 20% barrier in 37 states (Ahluwalia et al., 2003). However, it must be noted that obesity in the United States showed a significant upward trend among men only between 1999 and 2008. Afterwards the prevalence stabilised among white men (Flegal et al., 2010).

Although in this study the prevalence of obesity was higher in women than men, the AC as well as the AF was more pronounced in men. This outcome was also found in several European countries (Cámara & Spijker, 2010; Lahti-Koski et al., 2009; Gutíerrez-Fisac et al., 2000), and the United States (Odgen et al., 2006). Reasons could be that women excercised more and paid more attention to a healthy diet in the last decades, because social norms make women more cautious about their body.

In a Swiss study from Faeh et al. (2004) the development of obesity was similar to trends in Austria. This is also in coincides with the study results of Singh-Manoux et al. (2009). Singh-Manoux et al. (2009) investigated the trend in self-reported obesity prevalence between 1970 and 2003 in France. Their outcomes also showed relative stability of obesity between 1970 and the early 1990ies and a strong increase afterwards. In the United States a similar striking increase in the prevalence of obesity took place ten years earlier. Until 1980 obesity prevalence was relatively stable, but rose considerably from then on (Grabner, 2012; Ljungvall & Zimmerman, 2012; Flegal, 1999; Costa & Steckel, 1997).

The increase in obesity prevalence is attributed to the reduction in physical activity and to changes in eating patterns due the increased production of low cost and energy dense foods as well as sweetened beverages (Lagerros & Rössner, 2013; Garcia, Sunil & Hinojosa, 2012; Lean et al., 2006; Flegal, 1999). Ludwig and Pollack (2009) reported that an increase in energy intake and a decline in physical activity are almost universal consequences of industrial development and improved living conditions. Lakdawalla, Philipson and Bhattacharya (2005) also explained that the technological change has a major impact on the growth of obesity. Technological changes in agriculture made it possible to produce cheaper food, which is more often unhealthy and leads to weight gain among subjects. In the meantime exercise has become more expensive and therefore there was a decrease in physical activity. Across the different countries more sedentary and productive technologies were employed, also leading to higher weight gain in the population.

Especially the lower prices of energy-dense food seem to lead to much higher obesity prevalence. Chou, Grossman & Saffer (2004) investigated various price effects on weight gain. They found that weight rises with lower relative costs of food for the household, lower relative costs of food in fast-food restaurants and full-service restaurants, as well as greater availability of these restaurants. Further influences are lower costs of alcohol and higher costs of cigarettes. Therefore, the strong increase in obesity prevalence in Austria might be due to a better standard of living in the early 1990s, brought on by the above mentioned factors at that time.

However, overall population trends in the prevalence of obesity seem hardly reliable, since opposing trends in subgroups would be masked and a distorted overall picture would arise. To avoid this, this public health issue was investigated among various subpopulations in Austria based on age, educational level and region.

Age

The highest obesity proportions in Austria were found among older subjects, which is in accordance with similar studies (Gallus et al., 2012; Doak et al., 2011; Diouf et al., 2010; Esteghamati et al., 2009; Tian, Bárdos & Adany, 2006). Another study from Austria, which investigated self-reported weight and height in participants older than 55 years in 2003 (n = 645), found the highest obesity prevalence among the 55- to 65-year-olds whereas the proportion of malnourished individuals increased among those aged over 65 years (Fritz & Elmadfa, 2008). Similarly, a study from Lithuania which examined obesity prevalence in adults between 2000 and 2004 (n = 2,049), also reported the highest proportions in subjects 50 to 64 years of age (Klumbiene et al., 2006).

In this study the highest BMI values and the highest obesity prevalence were found in subjects aged 55 to 74 years. The highest ACs were also reported among older adults with highest increase in the prevalence of obesity among women aged 75 years and older and men aged 55 to 74 years. The same result was also reported for the Finnish population (Lahti-Koski et al., 2009). A study which investigated measured BMI data of 3,793 people 65 years and older in Great Britain has revealed that higher BMI values in older persons are associated with a greater risk of reduced physical functions. The higher the BMI of the elderly was, the higher the risk of problems with mobility and the capacity to carryout of their daily tasks. They also reported that persons with a higher BMI do not necessarily die earlier. Higher BMI values in the elderly lead to a lower quality of life in the affected group and to higher health care costs for society (Lang et al., 2008). Thus the increase in BMI among the oldest generation in Austria represents a major problem. Not only is the number of older people increasing in general. The proportion of care-dependent persons is set to increase enormously and health-care costs will probably rise accordingly.

The life expectancy has risen in most countries. In Europe the rate of individuals aged 65 years and older will probably increase from 17.1% in 2008 to 25.4% in 2035 and to 30% in 2060 (European Union, 2008). For Austria the proportion of subjects 65 years and older was 14.9% in 1990. By 2011 the rate had risen to 17.7%. It is assumed that in 2030 24% of the Austrian population will be older than 65 years (Statistik Austria, 2013). Especially due to the high obesity prevalence in elderly people, obesity is an issue of serious concern in the future.

However, when considering the outcomes of the AFs it must be taken into account that the risk for obesity within the study period was high in the youngest age group of Austrian adults. While the prevalence is lowest yet this threatens to grow more rapidly in that subgroup. Despite the high obesity prevalence and the strong increase in the oldest study population it was observed that the prevalence of obesity increased in all age groups which is in accordance with other European studies (Lahti-Koski et al., 2009; Bendixen et al., 2004; Flegal et al., 2002).

Educational level

The outcome of higher obesity prevalence and mean BMI in subjects with lower educational status is in line with similar studies conducted in Europe (Fleischer et al., 2012; Gallus et al., 2012; Grabner 2012; Charafeddine, Van Oyen & Demarest, 2009; Sassi et al., 2009; Sulander & Uutela, 2007; Deutch, Pedersen & Hansen, 2005; Helmert & Strube, 2004). Several authors reported that low educational status associated with obesity is more common in women than in men (Yoo, Cho & Khang, 2010; Singh-Manoux et al., 2009; Helmert & Strube, 2004; Wardle & Griffith, 2001), which is also true for Austrian women. Interestingly, women with a high educational status constituted the only sub-population in this study for which the prevalence of obesity decreased in the last survey, from 6.9% in 1999 to 5.5% in 2006/07. A decline in obesity was also reported in Finnish

(Flegal, 1999; Pietinen, Vartiainen & Männistö, 1996) and Lithuanian (Grabauskas et al., 2003) women. The obesity prevalence was lowest among women with the highest educational level in these two countries as well.

Studies in different countries have demonstrated the increase in obesity prevalence to be stronger in low than in high education strata of the population (Marques-Vidal et al., 2010; Gutiérrez-Fisac et al., 2000; Pietinen, Vartainen & Männistö, 1996). The same result could be observed in this study, with the highest AC of obesity prevalence among men with low educational status. Low-educated men in Austria also showed the highest AF during the study period. The Copenhagen Male Study observed a trend toward higher obesity in lower-educated men as well (Suadicani, OleHein & Gyntelberg, 2005), while in Finland the observed increase was most striking among men with high educational level (Lahti-Koski et al., 2010). In the United States there is a trend towards a strong increase in obesity among adults with middle education, in both men and women (Mokdad et al., 1999). In this study the AF among women was also highest for middle-educated women. The population group with the highest AF should be considered in more detail, because it seems that the obesity prevalence will strongly increase among middle-educated women and low-educated men in Austria in the future.

To make even clearer statements for the prevalence of obesity among age and education, younger and older subjects with low and high educational level were compared in this study. It was not unexpected that the highest obesity prevalence between 1983 and 2006/07 and the highest AC during that period was found among older subjects with low educational level. This group showed the highest increase in the prevalence of obesity in the whole study population.

In Austria, persons at retirement age with low educational status comprise the group with the most obese subjects. Reasons could be that retired subjects with low educational level had professions in the past where they had to work hard and were more physically active. In retirement these people are prone gaining weight, because physical activity decreases while the energy flow remains the same.

Interestingly that the AFs were highest among those subgroups with the lowest prevalence: younger subjects with high education. It can be supposed that the obesity prevalence will increase for this group in the future. However, in total the prevalence of obesity is very low among younger adults with high educational level compared to older adults with low educational level in Austria.

Region

A systematic review of obesity prevalence in Europe based on measured data has found that proportions vary widely from country to country, with lowest prevalence in Western Europe (Berghöfer et al., 2008). However, Finucane et al. (2011) found that the highest increase in mean BMI since 1980 could be observed in Western Europe. The results presented in this study showed also lowest prevalence in the Western geographic parts of Austria. It was found that there was a clear east-west gradient for Austria among subjects suffering from obesity. There were much higher proportions in Eastern Austria than in the rest of the country. Schwarz (2007) also found an east-west decrease in the prevalence of obesity for Austria, but only for men. However, for women they did not find significant differences in the obesity prevalence in Austrian regions. In the present study an east-west gradient was found among both sexes. Studies about regional obesity trends in Austria, based on measured data of cohorts of male conscripts (1985 to 2005), found the highest obesity prevalence among 18-year-old men in Eastern Austria (Schober et al., 2007; Kirchengast et al., 2004). For the study period 2001 to 2005 (n = 209.168) they reported lowest obesity rates for Western Austria and highest for Eastern Austria. The prevalence doubled in all regions during the study period (Schober et al., 2007). Another study examined the obesity prevalence among female and male Austrian farmers (n = 11.144). The highest obesity prevalence was also reported in the Eastern region and the lowest in Western Austria (Dorner et al., 2004).

However, these studies conducted in Austria are not indeed comparable to this study, because their results are only valid for small Austrian subgroups. Nevertheless, all studies showed that in Western regions of Austria, in the more rural areas, fewer individuals are obese. One explanation might be that the population in Western Austria is ethnically more homogeneous than in Central and Eastern region. The majority of migrants lives in Eastern Austria (Schober et al., 2007). For hundreds of years immigrants have settled in Vienna and the surrounding of Austria’s capital. Several studies already reported higher obesity prevalence among migrants (Gualdi-Russo et al., 2009; Powell et al., 2009; Delva, Johnston & O´Malley, 2007; Ahluwalia et al., 2003). Kirchengast & Schober (2007) also found highest obesity prevalence in migrants living in Austria, especially in those from Ex-Yugoslavia. Migrants often have a lower socio-economic status, which presents a high risk factor for becoming obese (Sulander & Uutela, 2007; Seidell, 2005). The high rates of migrants in Eastern and Central Austria could be the reason for higher obesity in that area.

For Germany it was also reported that the obesity prevalence was much higher for adults living in East- than West-Germany. The authors described that this can be attributed due to differences in lifestyle (Mensink, Lampert & Bergmann, 2005). Changes in physical activity and diet seem to be responsible for the increased prevalence of obesity (Lagerros & Rössner, 2013; Eckert, 2012; Garcia, Sunil & Hinojosa, 2012; Stuckler et al., 2012). Health survey data conducted in Austria showed, that adults living in Western Austria exercise on a regular basis compared to those in Central and Eastern Austria. Adults from Eastern Austria self-reported the lowest prevalence of physical activity. Furthermore, it was observed that subjects in Western Austria more often have a healthier diet, followed by subjects living in Central and Eastern Austria (Großschädl & Stronegger, 2012a). It seems that these two factors - poor nutrition and physical activity - are linked stronger to the Eastern parts of Austria. However, these outcomes are based on self-reported data and may be biased. More accurate data regarding lifestyle factors and their association with obesity in the Austrian population would be useful. However, differences in lifestyle may be a further reason for the clear east-west difference in obesity prevalence in Austria.

Whereas the obesity prevalence was highest in Eastern Austria between 1973 and 2006/07, the highest increase and the highest AFs during this period were found in Western and Central Austria. There is a risk that the obesity prevalence will strongly increase in those regions. In Europe a similar trend could be observed. The highest increase took place in countries which had the lowest obesity prevalence in the past (Finucane et al., 2011).

Former studies reported higher obesity rates in urban than rural regions (Chin & Deurenberg-Yap, 2009; Yadav & Krishnan, 2008; Chhabra & Chhabra, 2007; Sabbah et al., 2007; Jackson et al., 2005; Andersen et al., 2004; Grabauskas et al., 2003). Thus, it seems that urbanization is not longer a risk factor for obesity (Stuckler et al., 2012; Jackson et al., 2005). Analysis of data from the Behavioural Risk Factor Surveillance System (BRFSS) among adults in the United States found the highest prevalence of obesity among residents in rural counties. The contribution for higher prevalence was a lower compliance with dietary recommendations, higher television and video games consumption and fewer pavements and sports facilities in rural areas (Jackson et al., 2005). The largest cities in Austria are located in Eastern (Vienna) and Central (Graz, Linz) regions, in which the highest obesity prevalence was found. However, it is delicate conclude to urban and rural differences on basis of these results. An investigation of obesity which analyses obesity in urban and rural areas in Austria separately would be necessary to get more information.

Long-term trends in education-related inequalities for obesity

In this study the magnitude of social inequalities for obesity was measured based on data regarding the educational level. It was not surprising that the calculated relative index of inequality (RII) showed that education-related inequalities were higher for women than men. This finding is consistent with outcomes from several other studies (Devaux & Sassi, 2012; Tchicaya & Lorentz, 2012; Singh-Manoux et al., 2009; Wilkinson & Pickett, 2009; Mackenbach et al. 2008; Wilkinson, 2005). Devaux and Sassi (2012) investigated social inequality for obesity in European countries (including Austria), Australia, Canada, Korea and the United States. The greatest education-related inequality for obesity was found in France, Sweden, Austria, Spain and Italy. In comparison with other countries the rate of inequality was quite high among men living in Austria. However, they also reported much higher education-related inequality for female than male adults in Austria. Devaux and Sassi (2012) also calculated trends for education-related inequalities for Australia, Canada, Great Britain, France, Italy, Spain and the United States, showing that they remained quite stable with a few minor variations. This was also true for Sweden (Lissner et al., 2000). A small narrowing of inequality for obesity by educational status was observed for Great Britain, France and Korea (Devaux & Sassi, 2012).

In this study there was a tendency that the education-related inequality for obesity increased during 1983 and 2006/07 with a considerable increase in men. The increase in the prevalence of obesity among Austrian adults has led to an increase in relative inequalities in men. In a French study, education-related inequalities for obesity did not increase between 1970 and 2003 among French men, whereas the RII decreased among French women (Singh-Manoux et al., 2009). In this study a considerable decrease in relative inequalities between 1983 and 2006/07 was only found among subjects 75 years and older. A disproportionate rise in obesity among subjects with high educational level leads to a decrease in relative inequality (Singh-Manoux et al., 2009). Highest obesity rates among older subjects in Austria are also a reason for lower inequalities in that age group.

In general, the results of the RII were quite unstable for the whole study population and for different subgroups. That can be attributed to the fact that the proportion of subjects with high educational level was low, especially among women. Therefore, the educational groups were quite unbalanced regarding the number of allocated subjects.

Long-term trends in the prevalence of obesity-associated diseases and disorders

A progression of the selected diseases and disorders during the study period could be observed for diabetes mellitus, hypertension and back pain for which the prevalence raised in every survey between 1973 and 2006/07. Due to methodological issues, the prevalence for sleep disorder, depression and headache could only be presented for the study period between 1973 and 1999. There was a decrease among these disorders between 1973 and 1991. After 1991 the prevalence of obese subjects suffering from sleep disorder, depression and headache increased.

Results of this study showed that obesity is a significant factor which contributes to the rise in increasing prevalence of diabetes mellitus, hypertension, back pain, sleep disorder and depression, particularly in women. No significant differences were found in the prevalence of headache between obese versus non non-obese subjects. This result is not in accordance with other studies, which indicated an association between headache and obesity (Bigal & Rapoport, 2012; Yu et al., 2012).

Considering all investigated obesity-associated diseases and disorders, the prevalence of suffering from a condition was higher for women than men, regardless of whether they were obese or not. A possible reason could be that the visceral fat, which is mainly located in the abdominal area and creates an increased risk for the development of fatal diseases, grows with age. This is more common among women than men (Chau et al., 2008; Hunter et al., 2005). Crawford et al. (2010) also reported a higher risk for obese subjects compared to non-obese subjects for diabetes and hypertension. But they found greater prevalence among adult men than women for the diseases mentioned.

In this study the crude prevalence of diabetes mellitus is estimated to be 6% in 2006/07 which is in accordance with Statistik Austria (2007). The age-standardised prevalence was 5.3% among Austrian adults. Compared to the results of this study Timper and Donath (2012) reported that the prevalence of diabetes mellitus is lower when considering subjects living in industrial countries. They estimated that about 3% of subjects living in industry nations are diabetics. When comparing the curves of the prevalence in obesity and diabetes mellitus in this study for the period of 1983 to 2006/07 the prevalence is indeed lower for diabetes but the regressions are very similar for Austrian women and men. This is a hint that there was a contemporaneous increase in the prevalence of obesity and diabetes mellitus from 1983 onwards in Austria. A parallel increase in the prevalence of obesity and diabetes was also observed in other studies (Barnes, 2011; Kortelainen & Porvari, 2011; Ng et al., 2010).

A 50% lower prevalence could be observed in this study compared to the prevalence of hypertension among adults in the United States. In the United States 40% among the adult population suffer from hypertension (Ervin, 2009). Pakesch et al. (1992) investigated hypertension among individuals in Vienna. They also found that subjects with hypertension are more likely to be obese. This was especially true for those aged 40 years and younger. The results of this study showed a much higher prevalence among obese compared to non-obese individuals in all age groups. A strong relationship between obesity and cardiovascular diseases was also reported from Dudina et al. (2011) and Berrington de Gonzales et al. (2010). Among all investigated obesity-associated diseases and disorders in this study, the highest AC was found for hypertension. Maybe subjects in the earlier surveys were less often aware of their blood pressure values, while nowadays many individuals have already sphygmomanometers at home to regularly monitor their blood pressure.

The prevalence of back pain was quite high in this study. The AC for the prevalence of this disorder was slightly higher among obese men than women. A Finnish study reported that abdominal obesity increases the incidence of low back pain in young female and male adults (Shiri et al., 2012). However, back pain represents a common disorder in Austria, especially in elderly adults. This study results also showed that obese subjects, notably in younger adults, more often suffer from back pain compared to non-obese subjects. Shiri et al. (2012; 2010) recommend a moderate level of physical activity to prevent back pain, among obese as well as non-obese subjects. Obese subjects should maintain physical activity to prevent this disorder, even if they do not lose weight.

The prevalence of sleep disorder was quite stable between the investigation period 1973 to 1999. A significant small increase was only found for obese subjects, with highest proportions among women. It was reported that sleep problems are strongly associated to weight gain and vice versa (Lyytikäinen et al., 2011; Pillar & Shedadeh, 2008; Dixon, Schachter & O´Brian, 2001). When considering the different age groups, obese subjects aged 75 years and older had the highest prevalence of sleep disorder in the Austrian adult population. One third of obese women and men in that age category self-reported to suffer from sleep disturbances. Weight loss could improve the sleep status of those subjects.

In 1999, the self-reported prevalence of depression was higher in women (5.0%) than men (2.6%) in Austria. A representative survey in Germany showing more recent results of prevalence, investigated subjects 18 years and older (n = 21,262) and found a diagnostic depression prevalence of 6.3% with also much higher rates for women (8%) than men (4.5%) (Busch et al., 2010). In accordance with the study of Busch et al. (2010), depression was more often found among obese than non-obese subjects. This is not in accordance with the study result of Pakesch et al. (1992). They reported lower prevalence of psychiatric illnesses among obese than non-obese individuals living in Vienna. However, Pakesch et al. (1992) have not only studied the prevalence of depression alone. It was striking, that depression strongly increased among obese women from 1991 onwards in Austria. They also showed highest AF for depression during the study period. Obese women in Austria represent a risk group for becoming depressive in any case.

Ulmer et al. (2001) investigated the prevalence of self-reported headache among Austrian women living in Innsbruck in 1999. They reported a more than twice as high prevalence of the disorder than the self-reported data among female adults in this study. 42% of the women in Innsbruck suffered from headache (Ulmer et al., 2011). However, to make more accurate statements, the results for headache in this study should be measured at a federal state level. Within the investigation period between 1973 and 1999 a slight decrease in the prevalence of headache was found in this study. No statistically significant relationship between obesity and headache could be observed among Austrian adults.

8.3. Strengths and Limitations

Research work unavoidably has limitations that need to be taken into account when considering a study and its results.

One limitation in this study was that there were only self-reported data available to process. As discussed in the literature section of this study, self-reported data on body weight and height may lead do a misclassification of BMI values and might induce a bias in prevalence studies investigating obesity (Shiely et al., 2010; Faeh et al., 2008). The disadvantage of self-reported BMI data was compensated. A preliminary validation study about self-reported weight and height data was conducted (Großschädl, Haditsch & Stronegger, 2012) and thereupon the self-reported BMI for women and man in this study was corrected. When studying the prevalence of obesity over such a long period, there is also the question if the validity of self-reported weight and height data changed over time. No study was found reporting about changes in the underestimation of weight and overestimation of height over time. Assuming that the tendency to underestimate weight and overestimate height remainded constant during the study period, the observed increase in the prevalence of obesity would still be unbiased.

Self-reported data concerning obesity-associated diseases and disorders may also be biased due to subjects' unawareness of their medical conditions. Studies reported that the prevalence of diseases or disorders, as diabetes mellitus (Machón et al., 2013; Margolis et al., 2008), cardiac infarction (Espelt et al., 2012) or depression (Sanchez-Villegas et al, 2008) are underestimated only little and showed adequate validity, when based on self-reported data. The validity of self-reported information for back pain and hypertension was lower (Carragee, 2008; Vargase et al., 1997). Self-reported information about the presence of subjects' diseases or disorders is more valid for chronic illnesses. Health surveys based on self-reported data have been considered as a good instrument for measuring the prevalence of above mentioned chronic diseases (Espelt et al., 2012), with highest validity among subjects who consult their general practitionerregularly (Vargas et al., 1997). Nevertheless, the prevalence of the selected diseases and disorders in this study, based on medical diagnostic data, would have been more accurate.

When investingating obesity-associated diseases among adults it is recommended to measure the abdominal or rather central obesity (Mathus-Vliegen et al., 2012), as described in section 3.1.2. The results of the selected diseases and disorders for obese subjects investigated in this study apply to obesity measured by BMI. For getting more robust indices of obesity-associated diseases and disorders the measurement of WC and WHR would have been more suitable (Mathus-Vliegen et al., 2012). Unfortunately anthropometric measurements were not available for Austrian adults during the investigation period.

A further limitation of this study is that self reported data did not distinguish between diabetes type 1 and type 2. In most health data no distinction is made between the two diabetes types (Wild et al., 2004). This concerned also the health surveys analysed for this study. However, both types are rising globally and it is estimated that about 90% of all diabetes mellitus cases concern type 2 (Timper & Donath, 2012; WHO, 2012b). Insulin resistance, the cause of type 2 diabetes, is enhanced by obesity (Diabetes Austria 2013). Hence, diabetes type 2 and obesity are strongly linked (WHO, 2012b; Wild et al., 2004). Therefore a detailed examination of type 2 diabetes would have been interesting in this study.

Literature showed that obesity is often associated with low back pain (Shiri et al., 2012; Shiri et al., 2010). For this study only data concerning general back pain was available to analyse. Furthermore, the data from the AT-HIS 2006/07 could not be used for comparing the prevalence of sleep disorder, depression and headache with the data from the Microcensus surveys, due to differences in the method of data collection. Therefore, trends for the obesity-associated conditions sleep disorder, depression and headache were only presented for the investigation period 1973 to 1999.

Another limitation was that the socioeconomic status of subjects was only represented by the variable educational level in this study, as other variables eligible to measure socioeconomic status, eg. income, were not available for most surveys. The disadvantage of calculating the relative index of inequality (RII) on basis of education is that it is not possible to distinguish between good and poor quality of education. This aspect likely influences the knowledge as well as cognitive and analytical skills in health domains (Galobardes et al., 2006). In order to calculate the RII the income would have been a better variable to present the magnitude of inequality for obesity. By calculating the education-related inequality for obesity the values for RII were quite unstable. Investigating subjects in different income groups would have probably resulted in more stable values for RII. Furthermore, study analyses which include the variable educational level refer only to the period of 1983 to 2007, because data on education was not collected in the first health survey in 1973. Therefore, the investigation of long-term trends in education-related inequalities for obesity was only possible from 1983 onwards.

Furthermore, the investigation of other sociodemographic determinants of obesity would have been interesting. Regrettably lifestyle factors, such as physical activity and nutrition habits, which are the most direct factors associated with obesity (Lagerros & Rössner, 2013; Eckert, 2012; Garcia, Sunil & Hinojosa, 2012; Stuckler et al., 2012; Mozaffarian et al., 2011; Wadden, Brownell & Foster, 2002) were not collected in all health surveys (especially not in the earlier ones). Respectively, available data for those determinants were collected very dissimilar which would have restricted comparability.

When interpreting the prevalence of diseases, it is recommended to standardise crude rates due populations may differ in their age composition. The benefit is that age-standardisation allows a valid comparison of disease rates. However, it must be taken into account that age-adjusted rates are partially deduced from a reference population, so they do not precisely describe the study population (Doak et al., 2011; Jekel et al., 2007). Thus it is a positive aspect and strength that crude as well age-standardised obesity prevalence was mentioned in this study. To facilitate the comparison of the prevalence in this study with other studies, the international valid BMI cut-off points according to the WHO (2006) were used.

The participation rates were quite large for the Microcensus surveys, especially in 1973, and relatively low in the AT-HIS 2006/07. This is probably due to the fewer number of questions asked in the first surveys. The questionnaire applied in the AT-HIS was much more extensive in comparison with the questionnaires of the earlier surveys. However, each survey sample was weighted according to sex, age and region to ensure respresentativeness of the Austrian population distribution.

The strength of this study also comprises the unique database with a large number of subjects included in the study sample. The investigation of the prevalence of obesity as well obesity-associated diseases and disorders over a 34-year period of time, allowed an accurate assessment of the development of the obesity epidemic which represents a major advantage of this study. Thereby it was possible to analyse long-term trends in various subgroups for the Austrian population aged 20 years and older. By the large sample size, statistically reliable data in subgroups were achieved.

8.4. Implications for further research and health promotion

The results of this study emphasis the need for appropriate health-policy strategies to prevent obesity and improve health among the Austrian population. To achieve this aim continuous analyses of time trends are required. Regular monitoring of obesity among adults is important to control vulnerable groups with increased risk for weight gain. Monitoring the obesity problem is also important to study effectiveness of health promoting policies at national and local levels. Ongoing evaluations are needed to establish effective prevention strategies for Austria. More recent data for the Austrian adult population will be available in 2014/15, when the next AT-HIS will be carried out, with a comparable method as before. The results of this study provide a good basis of quantitative findings for further investigations in obesity. When comparing the last surveys with upcoming data of the AT-HIS, correction for self-reported BMI should also be made, in order to calculate the most accurate obesity prevalence.

Nevertheless, to achieve more precise outcomes in the future, it may be beneficial to collect additional anthropometric measures regularly, such as BMI, WC or WHR. This would be especially important for getting more robust indices of obesity-associated diseases and disorders (Mathus-Vliegen et al., 2012). Thereby obesity-associated diseases and disorders could be analysed more accurate.

When investigating diabetes mellitus it would be important to distinguish between type 1 and 2, due only diabetes mellitus type 2 is strongly asscociated with obesity (WHO, 2012b; Wild et al., 2004). For adequate treatment of obesity-associated diseases and disorders an early detection of a chronic condition is very important. Therefore, it would be worthwile that physicians examine obese subjects regarding frequent obesity-associated diseases and disorders. Barnes (2011) recommend that obese subjects should be screened regularly for pre-diabetes and diabetes mellitus, because diabetic subjects are often diagnosed very late, which complicates the treatment for counteracting this disease.

There is need for prospective population-based studies designed to investigate cultural determinants and lifestyle factors as physical activity, and nutrition behaviour related to weight change. This would improve the understanding of the development of obesity and could be beneficial to construct effective prevention strategies for Austria. Thus, the causality of lifestyle factors in the course of obesity could be assessed adequately.

An upward trend in the obesity prevalence and its consequences was already noticed 30 years ago in developed countries. However, prevention programs from public health professionals and the governments were implemented at a very late stage which led to a worldwide epidemic.

It can be expected that the burden of obesity as well obesity-associated diseases and disorders will increase further in the future. It is a great challenge to get the prevalence of obesity under control. Therefore, treatment of obesity must become a higher priority and more effort should be invested in effective prevention programs. Preventive strategies need to target those subpopulations which are most affected by obesity. In this study, analyses were only undertaken for the adult population in Austria showing that there was the highest prevalence and strongest increase in obesity prevalence among older subjects with a low educational level. However, obesity prevention should already start in early life. The European charta on counteracting obesity pointed out, that the trend in the prevalence of obesity is also very alarming in children and adolescents (WHO Europe, 2006).

Tsigos et al (2008) recommended that it is also the responsibility of physicians to recognise obesity as a disease and to help the affected subjects with adequate treatment based on evidence-based interventions. The treatment needs life-long management with realistic aims in weight loss. Accurate interventions would have an important impact on the incidence of obesity and obesity-associated diseases among risk groups (Webber et al., 2012). A significant method for weight loss represents the bariatric surgery, which is mainly done in severely obese subjects (Lagerros & Rössner, 2013). However, effective obesity prevention strategies should help to avoid that subjects are getting morbidly obese so they need a surgical intervention for weight loss. Prevention is important because high obesity prevalence threatens to overload the resources of the health systems. The therapy is getting more difficult for severely obese subjects and health consequences by weight loss is not always reversible (Kiefer et al., 2006).

Cornerstones of obesity prevention in the future will be modification of lifestyle factors, especially diet and exercise behaviour (Lagerros & Rössner, 2013; Samaranayake et al., 2012). Healthy weight control promotion programs should target vulnerable groups helping them to keep or reduce their weight. Due to the greater prevalence of obesity among women, public health strategies should be developed from a gender perspective (Díaz et al., 2009). A promising example of obesity prevention is a current project in Vienna. The project is organised by the Institute for Women- and Men Health in cooperation with the Medical University Vienna. It is designed for women aged 18 to 80 years. The aim of this program is to induce a permanent change of the nutrition and exercise behaviour. The prevention program is composed as a combination of nutrition information, physical activity and psychological treatment. An interdisciplinary team of psychologists, physicians, psychotherapists, dieticians and sport scientists support the participants during the program which lasts one year. An aftercare is also offered. The advantage of this prevention program is that it aims at supporting especially affected groups (women with lower socioeconomic status and migrants). The evaluation of this program will be published soon (Institut für Frauen- und Männergesundheit, 2010).

Time should also be spent on specific forms on information and communication about the obesity problem in the general population and how to avoid getting obese. The significance of a healthy diet and regular physical activity should be the main focus. Strasser (2012) recommends spending 60 minutes per day of moderate-intensity physical activity to prevent unhealthy weight gain.

The tasks of the government to decrease the prevalence of obesity could be by supporting the change of subjects' lifestyles. They should make new healthy environmental options available and make them more attractive, through health education and better facilities for physical activity (e. g. extensions of cycle and walk paths, adequate and enough playgrounds). Useful initiatives for affected individuals are needed. Coordinated national programs were conducted for example in Great Britain (Change4Life) and Switzerland (Actionsanté). Partnerships with food and beverage industry took place in the design and the implementation of these prevention programs. Recent studies showed that there was a stabilisation of obesity in both countries (OECD, 2012). These programs were successful and could serve as a model for a national program in Austria.

The initiatives in Great Britain and Switzerland showed that a multi-factor strategy is needed to develop comprehensive food policy programs aimed at stopping the ongoing trend in the prevalence of obesity (Díaz et al., 2009). Public health professionals should engage in big food and beverage companies regarding nutritional issues to make positive changes. In the past there were a few actions and programs but measures have been taken too late. It would be a first step to improve the quality of products by making them healthier and market them responsibly. Public health advocates should place more priority on nutrition and should lobby for better nutritional standards for meal cosumption in various settings, before obesity becomes even more acute (Stuckler & Nestle, 2012).

Since 2011 several countries (Denmark, Hungary, Finland and France) introduced taxes on unhealthy food and beverages with the aim to change eating habits of the population. Romania and Great Britain consider introducing taxes on unhealthy food and beverages. Until now it is difficult to predict how subjects will react to higher prices by taxation. The OECD (2012) assumes that if the tax is appropriate, i. e. if the tax is on products which are immediate substitute, the consumers will likely buy less of those foods and beverages. Probably it will be seen only in a few years if taxation on unhealthy products can contribute to a reduction in the prevalence of obesity.

Public policy should also guarantee that all subjects have equal access to achieve a non-obesogenic diet (Giskes et al., 2009; WHO Europe, 2007). Therefore, the reduction in the material inequality would be an important contribution in the fight against obesity (Wilkinson & Pickett, 2009) and in general to narrow social class inequalities in health.

The results of this study showed that older subjects with low educational level had the highest prevalence of obesity and showed the highest increase during the study period. This subgroup represents the greatest risk group for obesity among the Austrian adult population. Possible reasons were discussed above. In summary it can be assumed that the physical activity of low-educated subjects in retirement age decreases while the ingestion remains the same. Planing prevention strategies are urgent for this subgroup in Austria. Particular emphasis should be placed on lower educated, middle-aged individuals before they become obese. Targeting those subjects might reducing the prevalence of being obese in later life as well as reduce the length of time the health burden of excess weight is carried.

For Austria long-term prevention strategies to counteract obesity should be planned to achieve satisfactory results in the future. It is important to develop effective programs according to evidence-based criteria that are easily accessible for affected individuals. To get this complex problem under control an interdisciplinary collaboration, consisting of experts from research, politics and practice, will be necessary.

9. Conclusions

The prevalence of obesity has increased between 1973 and 2006/07 in Austrian adults. The obesity prevalence varied according to sociodemographic characteristics of Austrian adults. In 2006/07 obesity was still more common among women than men, and most common in the elderly, in subjects with low educational status and in the Eastern region of Austria. Considering the different subgroups, the strongest increase of obesity in the last few decades was found in women and men aged 55 years and over with low educational status. However, overall the obesity prevalence increased in all investigated sociodemographic subpopulations among Austrian adults.

Regarding the geographical variation the reduction and prevention of obesity is especially challenging in Eastern Austria, where cultural and lifestyle factors may contribute to the higher prevalence. However, despite the highest prevalence in Eastern Austria, the prevalence of obesity grew fastest in Western Austria during the study period.

Relative inequalities in obesity were higher for women than men in all data waves, whereas they rised only among men during the study period. It seems that the increase in the obesity prevalence among Austrian adults has led to an increase in relative inequalities in men. The reduction of education-related inequalities in the prevalence of obesity would be important to reverse the obesity epidemic in Austria. Due to the high obesity prevalence in low-educated subjects it will be a challenge to reduce social differences in the future. In this context, public health strategies should be developed from a gender perspective.

Obesity is a significant factor, contributing to the increasing comorbidities diabetes mellitus, hypertension, sleep disorder, depression and back pain, particularly in women. The increases in the above mentioned obesity-associated disease and disorders are probably attributed to the rise of obesity prevalence during the study period. Obese women showed the highest increase in the prevalence of obesity-associated diseases and disorders. Overall the greatest risk was found for depression.

The results of this study showed that it is important to examine trends in various subpopulations in order to determine groups with a high risk of becoming obese in the future. The outcomes indicate that this worrying trend has to be monitored in the Austrian population and that preventive measures should be implemented for specific target groups. These results should be used to plan controlled promotion programs among adults suffering from obesity

In the last decades, the most undesirable trends occurred in elderly women and men with low educational level. This group should be given special observance when planning prevention programs. However, in the future the investigation of cultural as well as and lifestyle factors are recommended for Austria, because it seems that they have an impact on the prevalence of obesity among subgroups (for example: regional differences).

Finally, obesity is a public health problem of high importance in Austria. The presented data suggests that the development of strategies for weight maintenance and reduction must become a higher priority in Austria, especially in certain sub-groups. Public health strategies to decrease the prevalence of obesity have been insufficient until now. Much greater efforts with interdisciplinary collaborations are needed to influence the obesity development in the near future in Austria. These strategies have to be assisted by ongoing monitoring of the prevalence of obesity.

10. References

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Acknowledgements

I am greatly indebted to so many people who have supported me during this time.

Professor Willibald Stronegger deserves special mention. I was lucky to have this great supervisor whose wide knowledge in the field of epidemiology is admirable. While writing this thesis I was very thankful for his kind understanding and for being an example of a careful and thorough researcher. His invaluable support throughout my career as a researcher will always be gratefully remembered.

I thank Professor Sylvia Titze, who patiently supported me in my intensions and allowed me to catch a glimpse of the research of physical activity. Thank you for your encouragement by publishing our paper. I am also grateful to Professor Andrea Berghold, for the support and pleasant cooperation during this time. Thank you for always providing well-grounded and prompt answers.

My superior Professor Wolfgang Freidl deserves thanks for allowing me to participate in various meetings based on this thesis. This was very important for me to move forward. I am also thankful to Professor Éva Rásky for the constantly supplying me with relevant literature.

Special thanks to my dear colleague Johanna and Nathalie for their truly valuable comments that improved the quality of this thesis. I appreciate the time you spent on reading the different parts of this work. Thank you very much.

Travel grants for scientific meetings were provided by the European Association for Obesity Studies and the Medical University of Graz. The participation at different congresses and meetings enabled me to expanding my scientific horizon. This assistance is gratefully acknowledged.

Challenging work needs a good stress outlet. I would like to thank my study colleagues for the nice time during the study, especially Barbara and Maria for the mutual support and our great spontaneous short trip to Croatia. Thanks to all my friends for the warm friendship. I am grateful for sharing all the ups and downs of the last three years with you all.

I owe my heartfelt thanks to my dear family. My brother Markus, my sister-in-law Maria and my beloved nieces Sarah and Julia, for bringing joy, action, colour and thrill into my life. I would especially like to thank my dear parents Josefine und Franz, for constant love and endless support. Thank you so much for always let me try my own wings!

Finally I would like to thank Martin, my darling partner and best travelling companion, for giving me the necessary push in the last months. It was really encouraging to experience the final phase of our theses together.

Appendix

Questionnaire of the validation study

Medizinische Universität Graz

Sehr geehrte Damen und Herren,

das *Institut für Sozialmedizin der Medizinischen Universität Graz* führt im Rahmen der Vorsorgeuntersuchung eine Studie zum Bewegungsverhalten durch. Wir bitten Sie uns dabei zu unterstützen, indem Sie die unten angeführten Fragen ausfüllen. Sämtliche Antworten sind freiwillig und werden anonym behandelt und nicht an Dritte weitergegeben.

Dieses Formular ist der Ärztin bzw. dem Arzt auszuhändigen, bei welcher bzw. welchem Sie heute Ihr Abschlussgespräch zur Vorsorgeuntersuchung haben.

Mit freundlichen Grüßen

Univ. Prof. Dr. Willibald Stronegger

Franziska Großschädl, BSc., MSc.

1. Es geht um körperliche Aktivitäten, bei denen Sie ein bisschen außer Atem kommen, zum Beispiel zügiges Gehen, Wandern, Tanzen, oder vieles Gartenarbeiten.		
Machen Sie zurzeit körperliche Aktivitäten, bei denen Sie ein bisschen außer Atem kommen?	□ Ja	□ Nein
Haben Sie vor, sich in nächster Zeit körperlich so zu betätigen, dass Sie ein bisschen außer Atem kommen?	□ Ja	□ Nein
Betätigen Sie sich zurzeit täglich oder fast täglich mindestens eine halbe Stunde lang körperlich so, dass Sie dabei ein bisschen außer Atem kommen? Sie können alle Aktivitäten von mindestens 10 Minuten zusammenzählen	□ Ja	□ Nein
Betätigen Sie sich seit mehr als einem halben Jahr regelmäßig täglich oder fast täglich mindestens eine halbe Stunde lang körperlich so, dass Sie dabei zumindest ein bisschen außer Atem kommen?	□ Ja	□ Nein
2. Jetzt geht es um sportliche oder andere Aktivitäten, bei denen Sie ziemlich ins Schwitzen kommen.		
Kommen Sie in Ihrer Freizeit mindestens einmal pro Woche durch körperliche Betätigung zum Schwitzen? Zum Beispiel durch schnelles Laufen, Radfahren usw.?	□ Ja	□ Nein
Haben Sie vor, in nächster Zeit mit körperlichen Aktivitäten anzufangen, bei denen Sie ziemlich ins Schwitzen kommen?	□ Ja	□ Nein
Sind Sie zurzeit regelmäßig dreimal pro Woche 20 Minuten lang sportliche aktiv?	□ Ja	□ Nein
Machen Sie seit mehr als 6 Monaten regelmäßig drei Mal pro Woche mindestens 20 Minuten lang sportliche Aktivitäten, bei denen Sie ziemlich ins Schwitzen kommen?	□ Ja	□ Nein

Bitte setzen Sie mit den Fragen auf der Rückseite fort.

3. Geben Sie bitte Ihr Geschlecht an:	□ Weiblich □ Männlich
4. Wie groß sind Sie ohne Schuhe?	____________ cm
5. Wie viel wiegen Sie ohne Kleidung und ohne Schuhe?	____________ kg
6. Wie alt sind Sie?	____________ Jahre
7. Rauchen Sie Zigaretten?	□ Gelegentlich □ Täglich bis 10 Zigaretten □ Täglich 11 bis 20 Zigaretten □ Täglich mehr als 20 Zigaretten □ Aufgehört □ Nie geraucht
8. Was ist Ihre höchste abgeschlossene Schulbildung?	□ Pflichtschule □ Lehre mit Berufsschule □ Fach- oder Handelsschule ohne Matura □ Höhere Schule mit Matura □ Studium an Universität, Fachhochschule □ Andere Ausbildung nach Matura
9. Wo wohnen Sie?	□ Graz □ Anderer Wohnort
10. Welche Staatsbürgerschaft besitzen Sie?	□ Österreich □ Deutschland □ (ehem.) Jugoslawien □ Türkei □ Andere
11. Bitte tragen Sie zum Abschluss das heutige Datum in die rechte Spalte ein:	_______ /_______ 2010 (TT/MM/JJ)

Herzlichen Dank für Ihre Teilnahme an dieser Befragung!

Arztfeld (wird in der Ordination vom zuständigen Arzt ausgefüllt):

_____________ cm _____________ kg