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# Obesity, Smoking and Dieting

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ACADEMIC DISSERTATION

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# 1 Abstract

Overweight and obesity have become more prevalent during the last decades; more than half of the western population is now overweight and a fifth obese. Especially among adolescents the increase in overweight prevalence has been rapid. Overweight combined with a large waist circumference (i.e. abdominal obesity) and smoking increase the morbidity of cardiovascular disease, metabolic diseases, like diabetes, and many cancers. Obesity and smoking are two leading causes of preventable death in developed countries.

Paralleling the escalating trends in obesity, dieting and especially health compromising dieting methods, including smoking motivated by weight control reasons, are becoming more prevalent. Dieting for rapid weight loss usually leads to weight regain with possible extra pounds and detrimental effects in fat distribution or other health measures. Three quarters of those with intentional weight loss more than 5 kg reports regaining it all. Smoking and dieting seem to be intertwined with the way that they affect the development of overweight and obesity.

In this study the effects of recurrent dieting and smoking on body weight were examined. In addition the effect of smoking on the development of abdominal obesity was studied. A further aim was to clarify how strongly smoking and recurrent dieting are associated among Finnish men and women at different ages.

Three different data sets were used in this study. FinnTwin16 consists of virtually all twins born between 1975 and 1979 (N=5563), surveyed at ages 16, 17, 18.5 and 24 years. The Finnish Twin Cohort includes 12 793 same-sex twins born between 1930 and 1957 surveyed in 1990. The Cohort of male elite athletes consists of 1838 athletes and 834 matched referents surveyed at 1985, 1995 and 2001. Self-reported height, weight and smoking are included in all questionnaires. Dieting behaviour was self-reported in twin data and based on sport among athletes. It is known that recurrent dieting with regains is common among sportsmen in sports with weight classes like boxing and wrestling.

Smoking in adolescence predicted later abdominal obesity in both sexes and overweight among women. Recurrent dieting among men was found to predispose for later weight gain and obesity. Smoking was associated with recurrent dieting among young men and women, but among older men the association was the opposite.

Smoking prevention and discouragement of unnecessary dieting might be more effective tools against later morbidity associated with obesity and abdominal obesity than previously thought.

## 2 Tiivistelmä

Lihavuus ja ylipaino ovat viime vuosikymmeninä yleistyneet; jo yli puolet länsimaiden väestöstä on ylipainoisia ja viidennes lihavia. Varsinkin nuorilla ylipainon lisääntyminen on ollut nopeaa. Ylipaino, erityisesti yhdistettynä vyötärölihavuuteen, sekä tupakointi lisäävät sairastavuutta sydän- ja verisuonisairauksiin, metabolisiin sairauksiin, kuten diabetekseen, sekä moniin syöpiin. Lihavuus ja tupakointi ovatkin kehittyneiden maiden tärkeimpiä ehkäistävissä olevia kuolinsyitä. Samanaikaisesti ylipainon kanssa laihduttaminen ja jopa terveydelle haitalliset laihdutusmenetelmät, kuten tupakointi painonhallintakeinona on tullut yhä yleisemmäksi. Nopeaan painonpudotukseen tähtäävällä laihduttamisella on usein terveydelle haitallisia seurauksia kuten painon nousu yli alkuperäisen painon ja kehon rasvajakauman muuttuminen epäterveellisemmäksi. Kolme neljänestä merkittävästi laihduttaneista kertoo painon nousseen takaisin. Tupakoinnin ja toistuvan laihduttamisen vaikutukset ylipainon ja lihavuuden kehittymiselle kytkeytyvät toisiinsa.

Tässä väitöskirjatyössä tutkittiin toistuvan laihduttamisen ja tupakoinnin vaikutusta kehon painoon ja lisäksi tupakoinnin vaikutusta vyötärölihavuuden kehittymiseen. Työn toisena tavoitteena oli tutkia, kuinka voimakkaasti tupakointi ja toistuva laihduttaminen liittyvät toisiinsa suomalaisilla ja onko tämä yhteys erilainen eri ikäryhmissä ja sukupuolilla.

Työ perustuu kolmeen laajaan kyselyaineistoon: Nuorten Kaksosten Terveystutkimuksen (englanniksi FinnTwin16) aineistossa on seurattu 1975-79 syntyneitä kaksosia 16, 17, 18 ja 24 vuoden ikäisinä (N=5563). Suomen kaksoskohortin aineisto (N= 12 793) on kerätty vuonna 1990 samaa sukupuolta olevilta, vuosina 1930–57 syntyneiltä kaksosilta. Entisten huippu-urheilijoiden (N=1838) ja heille kaltaistettujen verrokkien (N=834) seurantatutkimuksessa tiedot on kerätty vuosina 1985, 1995 ja 2001. Pituus, paino ja tupakointi on kysytty kaikissa kyselyissä. Kaksoset vastasivat laihdutusikäytymistä koskeviin kysymyksiin. Urheilijoiden laihdutusikäytyminen pääteltiin lajin perusteella, sillä toistuvan laihduttamisen tiedetään olevan yleistä painoluokissa urheilevilla urheilijoilla (esim.painijat, nyrkkeilijät).

Nuoruusiän tupakointi ennusti vyötärölihavuutta molemmilla sukupuolilla ja lisäksi ylipainoisuutta naisilla. Toistuva laihduttaminen oli yhteydessä myöhempään painonnousuun ja lihavuuteen miehillä. Lisäksi toistuvan laihduttamisen ja tupakoinnin todettiin liittyvän toisiinsa nuorilla aikuisilla. Vanhemmissa ikäluokissa miehet, jotka tupakoivat, laihduttivat harvemmin kuin tupakoimattomat. Lihavuuteen ja vyötärölihavuuteen liittyvän oheissairastavuuden ennaltaehkäisyssä tupakoinnin ja toistuvan laihduttamisen vähentäminen saattavat olla aiemmin luultua tehokkaampia keinoja.

### 3 List of original publications

This thesis is based on the following original publications, referred to in the text by their Roman numerals (I–IV).

- I. Saarni SE, Pietiläinen KH, Kantonen S, Rissanen A, Kaprio J: “Smoking in adolescence predicts abdominal obesity in adulthood; A follow-up study of five birth cohorts of Finnish twins”. Submitted
- II. Saarni SE, Silventoinen K, Rissanen A, Sarlio-Lähteenkorva S, Kaprio J. “Intentional weight loss and smoking in young adults”. *Int J Obes* 2004;28:796–802.
- III. Saarni SE, Silventoinen K, Rissanen A, Sarlio-Lähteenkorva S, Kaprio J. “Recurrent dieting and smoking among Finnish men and women”. *Obesity* 2007;15: 1851–9.
- IV. Saarni SE, Rissanen A, Sarna S, Koskenvuo M, Kaprio J. “Weight cycling of athletes and subsequent weight gain in middle age”. *Int J Obes* 2006;30:1639–1644.

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## 4 Abbreviations

BMI	Body mass index
CI	Confidence interval
CVD	Cardiovascular disease
DZ	Dizygotic
IWL	Intentional weight loss
MZ	Monozygotic
OR	Odds ratio
OSDZ	Opposite sex dizygotic
SSDZ	Same sex dizygotic



## 5 Introduction

With more than half of the western population being overweight, one fifth obese and one fourth current smokers, the public health importance of these problems is undisputable (WHO, 2000; Vartiainen *et al.*, 2002; West *et al.*, 2007). Excess body weight is now the sixth most important risk factor contributing to the overall burden of disease worldwide (Ezzati *et al.*, 2002), and both smoking and obesity are the leading preventable causes of death in western countries (WHO, 2002; Mokdad *et al.*, 2004). Abdominal obesity and smoking are major risk factors for metabolic dysfunction, cardiovascular disease (CVD), cancer, osteoarthritis and sleep apnoea (Manson *et al.*, 2000; Visscher and Seidell, 2001). The joint health effects of smoking and obesity on premature deaths are stunning: A combination of smoking and obesity reduced the life expectancy more than 13 years among forty year old subjects in the Framingham Heart Study; for obesity or smoking alone the corresponding reductions were 6–7 years (Peeters *et al.*, 2003). Obesity prevalence has increased at an alarming rate during the last decades all over the world (WHO, 2000). In the USA and Great Britain the prevalence of obesity has doubled since the 1980's. At the same time the proportion of normal weight subjects has decreased suggesting a shift to the right in the population BMI (Canoy *et al.*, 2005). The rapid increases in overweight and obesity prevalence also are seen among children (Lobstein *et al.*, 2004). A significant proportion of them will remain overweight for the rest of their lives; society can be expected to face a growing number of adverse health consequences, such as the metabolic syndrome.

Adolescence and young adulthood are critical periods for lifelong health habits. Once established, smoking, overweight, as well as healthy or unhealthy eating and exercising routines have a tendency to persist throughout life. With the alarmingly increasing trend of obesity, dieting has also in recent years become more prevalent even among normal weight men and women. During the last few decades the proportion of adults reporting dieting to lose weight has internationally tripled: every second Finnish woman and every third man recently reported making serious attempts to lose weight (Laatikainen *et al.*, 2003; Kruger *et al.*, 2007). Very often the weight lost is regained with some extra kilos added. This kind of “yo-yo” dieting may counteract the health benefits attained by weight loss (Montani *et al.*, 2006). Furthermore, health compromising dieting methods like skipping meals, intense compulsive training, use of laxatives, diuretics or other “diet pills” or tobacco as a weight control method, have become more prevalent. This especially concerns young women, but also men and adult women (Neumark-Sztainer *et al.*, 1996; Gerend *et al.*, 1998).

Despite the scanty evidence (Cooper *et al.*, 2003), there is a widespread and popular belief that tobacco may prevent weight gain. While smoking prevalence is decreasing overall in developed countries, a worrisome trend has been observed among young women. Keeping in mind the reasonably high prevalence of dieting and especially the health compromising dieting methods among young women, there might be a cause for concern. In the light of the scientific literature, smoking and dieting seem to be intertwined in the way they affect body weight and shape.

## 6 Review of the literature

### 6.1 Obesity

Obesity is excess body fat leading to ill health. However, the definition of excess fat is not clear-cut but more like a continuum from normal to abnormal. Being easy to assess and calculate, well known by general public and professionals and the most widely used measure to assess obesity in both population studies and in clinical settings, body mass index (BMI  $\text{kg}/\text{m}^2$ ) is the cornerstone of the current classification system for obesity (Prentice and Jebb, 2001). BMI is calculated by dividing body mass (kg) by squared height (m) and the concept of it dates as far back as Quetelet's "average man" in the late nineteenth century (Quetelet 1869 in Willett 1990). In addition to Quetelet's index are Benn index; weight/height<sup>P</sup> (Benn, 1971), and Khosla-Lowe index; weight/height<sup>3</sup> (Khosla and Lowe, 1967), a reformulation of ponderal index that are traditionally used as adiposity measures in epidemiology. For a given BMI adiposity varies by age, sex and ethnicity (Gallagher *et al.*, 1996; Prentice and Jebb, 2001). However, it correlates reasonably well with body fat (WHO, 2000; Haslam and James, 2005) and the risk of obesity-related diseases (Manson *et al.*, 1995; Calle *et al.*, 1999; WHO, 2000; Haslam and James, 2005).

Adults with a BMI  $\geq 30 \text{kg}/\text{m}^2$  are classified as obese, those with a BMI 25–29.9 as overweight, BMI within 18.5–24.9 is considered normal and BMI  $< 18.5$  as underweight (WHO, 2000) (Table 1). Among adolescents and children, defining normal weight is somewhat more complicated due to the variation in weight, height and adiposity by age as children grow. The use of specific international standards for children and adolescents is a way to avoid this problem (Cole *et al.*, 2000).

During the last decades the prevalence of obesity and overweight has increased among adults as well as adolescents. From 1982 to 2002 the proportion of obese subjects among adult Finns has increased from 15% to 21% among men and from 17% to 21% among women. The rise has been steepest among young adults aged 25–34 years (Lahti-Koski *et al.*, 2002; Vartiainen *et al.*, 2003). Among Finnish adolescents the trend has also been alarming. From the late 1970's the prevalence of overweight has more than doubled, and the prevalence of obesity has more than tripled by 2000 (Kautiainen *et al.*, 2002; Laitinen *et al.*, 2005). Increasing trends have also been observed among the US population. The proportion of obese subjects among the population has raised the 1960's value from 13% to 31% in 2001–2002 (Flegal *et al.*, 1998; Hedley *et al.*, 2004).

Despite the indisputable value of BMI as an obesity measure in epidemiological and clinical work, it has some limitations. Therefore a need for a more accurate measure of body fat has arisen. In epidemiological settings, waist-to-hip ratio and waist circumference alone have proven to be a reasonable accurate measure of health risks associated with abdominal fat (Lean *et al.*, 1998). In a classification of US National Institutes of Health overweight combined with a large waist circumference is associated with additional health hazards (NIH, 1998), and a 10% larger waist circumference has been found to correspond to 50% higher mortality over the whole range of waist circumference in men and women (Bigaard *et al.*, 2005).

**Table 1.** Obesity and overweight classification (Han *et al.*, 1995; WHO, 2000; NCEP, 2001)

Classification	BMI	Waist circumference
Underweight	<18.5	–
Normal weight	18.5–25	–
Overweight	25–30	Women $\geq$ 80, Men $\geq$ 94 cm
Obesity	>30	Women $\geq$ 88, Men $\geq$ 102 cm

## 6.2 Dieting, intentional weight loss and weight cycling

Dieting is a lay term with multiple meanings. In this thesis “dieting” is used to cover intentional behaviour heading for weight loss. Therefore dieting is a more ample term than weight cycling, recurrent intentional weight losses and recurrent dieting. Covering all these three terms with the demand of repetitiveness, dieting also includes all other behaviour heading for weight loss.

Paralleling the escalating rates of obesity the prevalence of dieting has increased rapidly during the last decades. Due to the detrimental social and health consequences of overweight, efforts to lose and control weight have become very common. For example, among young adult Finns dieting has more than doubled during the last decades (Vartiainen *et al.*, 1998; Lahti-Koski *et al.*, 2000) and similar trends are found in the US (Williamson *et al.*, 1992; Serdula *et al.*, 1999). Currently about 50% of the adult population is trying to lose weight (Laatikainen *et al.*, 2003; Kruger *et al.*, 2007). Dieting is more prevalent among women than men, so that approximately four men and six women out of ten report having tried to lose weight (Laatikainen *et al.*, 2003). Even if dieting is most prevalent among overweight and obese persons, it is not absent among normal weight or even un-

derweight subjects (Korkeila *et al.*, 1999; Bendixen *et al.*, 2002; Keski-Rahkonen *et al.*, 2005; Montani *et al.*, 2006). Simultaneously with an increasing prevalence of dieting, health compromising dieting methods (i.e. fasting, excessive compulsive exercise, use of diuretics, laxatives or diet pills and using tobacco as a weight control method) have become more prevalent (Neumark-Sztainer *et al.*, 1996; Neumark-Sztainer *et al.*, 1999). People trying to lose weight by dieting tend to have repeated periods of weight loss followed by regain, a phenomenon called “yo-yo” dieting or weight cycling (National Task Force on the Prevention of obesity, 1994). At population level approximately 75% of subjects having intentionally lost at least 5kg, report regaining it all (Laatikainen *et al.*, 2003).

There is a lack of a single accepted definition of weight cycling and a wide variety of definitions can be found in the literature (National Task Force on the Prevention of obesity, 1994; Montani *et al.*, 2006). Weight cycling can constitute losses and gains of different lengths or amplitudes (with absolute cut-offs or percentage weight changes). It is also measured with variable numbers of cycles ranging from a single gain-loss or loss-gain to multiple repeats seen in unsuccessful dieters or athletes, who undergo repeated cycles in order to make a weight category (Oppliger *et al.*, 2003). Furthermore, it is very difficult or even impossible to fully distinguish between intentional and unintentional weight loss. Weight loss after an intention might take place due to the intentional efforts or/and despite of them and intention might arise after some “unintentional success” (Coffey *et al.*, 2005). Most typically weight cycling is classified based on questions of intention, duration, frequency and amount of weight losses (Neumark-Sztainer *et al.*, 1997), and defined comprising at least two episodes of minimum 5kg weight loss with regain (Kroke *et al.*, 2002; Field *et al.*, 2004b; Lahti-Koski *et al.*, 2005).

The health effects of weight cycling have been subject to vivid discussion in both scientific and public media. Weight cycling has been thought to result in greater weight gain and unhealthier body fat distribution (Field *et al.*, 2004b; Wallner *et al.*, 2004). It has also been found to be associated with binge eating (Venditti *et al.*, 1996; Field *et al.*, 2004a; Field *et al.*, 2004b; Marchesini *et al.*, 2004; Wallner *et al.*, 2004), psychological stress and lower general well-being (Foreyt *et al.*, 1995). Although this is still controversial whether weight cycling promotes body fat accumulation and obesity, there is mounting evidence from large population studies of increased risk for cardiovascular morbidity in response to weight cycling (Lissner *et al.*, 1991; Montani *et al.*, 2006). Despite plentiful studies on the issue, long-term health consequences of intentional weight loss and weight cycling still remain controversial (Steen *et al.*, 1988; Prentice *et al.*, 1992; Wannamethee *et al.*, 2002; Sørensen, 2003; Yang *et al.*, 2003; Field *et al.*, 2004a; Sørensen *et al.*, 2005; Berentzen and Sørensen, 2006; Rzehak *et al.*, 2007).

### 6.3 Smoking, dieting, body mass index and abdominal obesity

Among men the smoking prevalence has fallen from the early seventies from 36% to 24% in 2006. Among women smoking became more prevalent from the seventies to the eighties stabilizing thereafter at the level of approximately 20% (Helakorpi *et al.*, 2007). The association between BMI and smoking is complex. Many large population-based epidemiological studies with cross-sectional and longitudinal designs have shown that smokers have lower body weight than non-smokers (Molarius *et al.*, 1997; Yarnell *et al.*, 2000; Mokdad *et al.*, 2003). This is widely considered to be due to the effect of smoking on the metabolic rate or differences in dietary habits between smokers and non-smokers (Hofstetter *et al.*, 1986; Palaniappan *et al.*, 2001). However, in some cross-sectional studies, female or young male smokers have been found to be heavier than non-smokers (Marti *et al.*, 1989; Lahti-Koski *et al.*, 2002). In addition, many studies have shown middle aged and older smokers to have a larger waist circumference, even if they are leaner than non-smokers (Barrett-Connor and Khaw, 1989; Marti *et al.*, 1989; Bamia *et al.*, 2004; Akbartabartoori *et al.*, 2005; Canoy *et al.*, 2005). Also among smokers the number of cigarettes smoked during a day appears to be positively associated with the waist circumference and BMI (Bamia *et al.*, 2004). In a longitudinal study conducted on a large Australian population-based sample (N=8726) of young women, smokers were more prone to gain weight than never-smokers (Ball *et al.*, 2002). Molarius *et al.* (Molarius and Seidell, 1997) and Laaksonen *et al.* (Laaksonen *et al.*, 2005) have found the association between smoking and BMI to depend on the level of education, so that heavy smokers with a high education tended to be heavier than never-smokers whereas the opposite was observed among less educated subjects. In addition to the educational level, age and the socioeconomic status also modify the effect smoking has on body weight (Marti *et al.*, 1989; Molarius and Seidell, 1997; Molarius *et al.*, 1997; Akbartabartoori *et al.*, 2005). Furthermore, genetic and common environmental factors have been shown to be important in tobacco use (Avenevoli and Merikangas, 2003; Ho and Tyndale, 2007) and in weight loss attempts (Korkeila *et al.*, 1999).

Short-term weight gain following smoking cessation is well documented (Williamson *et al.*, 1991; Flegal *et al.*, 1995; Filozof *et al.*, 2004; Janzon *et al.*, 2004; Pisinger and Jorgensen, 2007), but in longer follow-ups the effect is more controversial (Kaprio and Koskenvuo, 1988; Klesges *et al.*, 1997b; Mizoue *et al.*, 1998), and at the population level the effect of smoking cessation on obesity prevalence may be minimal (Flegal, 2007). Furthermore, quitting has been shown to have an increasing impact on waist circumference (Lissner *et al.*, 1992; Grinker *et al.*, 1995; Koh-Banerjee *et al.*, 2003; Pisinger and Jorgensen, 2007). However, some

studies (Lissner *et al.*, 1992; Pisinger and Jorgensen, 2007) found the increase in waist per gained kilogram to be smaller in quitters than continuous smokers. Also the health benefits following smoking reduction are still controversial and at most modest (Pisinger and Godtfredsen, 2007).

Adolescence is a critical age for the development of obesity (Gordon-Larsen *et al.*, 2004) and the establishment of health habits such as smoking, eating behaviour and physical activity. Reviewed by Potter, previous results on the relationships between smoking and body weight in adolescents have been inconsistent (Potter *et al.*, 2004). There are only few studies spanning from adolescence to adulthood focusing on the association between smoking and later abdominal obesity. A rather crude measure of smoking (weekly vs. never) at a very young age (12–14 years) was in use in all previous studies, and no association between adolescent smoking and later abdominal obesity has been found (Twisk *et al.*, 1998; van Lenthe *et al.*, 1998; Laitinen *et al.*, 2004). Similarly, the few longitudinal studies limited to adolescence have not found a positive association between smoking and body weight or waist circumference (Cooper *et al.*, 2003; Stice and Martinez, 2005; Fidler *et al.*, 2007). It is also of interest that early maturation has been shown to have an impact on smoking initiation and other health habits in adolescence. Smoking and sedentary behaviour have been reported to be more prevalent among girls with early menarche, but later maturing girls tend to catch up during late adolescence (Dick *et al.*, 2000; Van Jaarsveld *et al.*, 2007).

Adolescents often believe that smoking aids weight control (Neumark-Sztainer *et al.*, 1996). In longitudinal studies examining the role of weight control intentions in smoking initiation among adolescents, dieting has been found to predict smoking initiation (French *et al.*, 1994; Ryan *et al.*, 1996; Austin and Gortmaker, 2001; Maldonado-Molina *et al.*, 2007). Austin and Gortmaker found in a study of 15 year old US schoolgirls, during a two year follow-up, a doubled likelihood for smoking initiation in frequent dieters as compared to that in non-dieters (Austin and Gortmaker, 2001). In a one year follow-up of 12–15 year old adolescents in Minnesota, French *et al.* found that girls who reported two or more eating disorder symptoms were about twice as likely to become smokers as other girls (French *et al.*, 1994). In a later analysis of the same sample in a three year follow-up using different classification of dieting behaviours, French *et al.* (French *et al.*, 1995) found no significant difference in increases in smoking rates by dieting status. Ryan *et al.* reported that 13% of 15 year old female smokers gave weight control as a reason for smoking initiation or continuation (Ryan *et al.*, 1996). During the latter years the prevalence of adolescent smokers who cite weight control as a reason for starting to smoke increased considerably. In 1993 among 12<sup>th</sup> grade smokers in the USA, 39% of girls and 12% of boys began their smoking for reasons of weight

control (Camp *et al.*, 1993). In 1998, the corresponding figures were 49% in girls and 28% in boys (Fulkerson and French, 2003).

The results of the few studies concerning the association between tobacco use and dieting in adults are somewhat contradictory, probably due to methodological differences (French *et al.*, 1995; Serdula *et al.*, 1999; von Ranson *et al.*, 2002). French *et al.* found that dieting and weight concerns were unrelated to smoking cessation or relapse in a population-based sample of working adults (French *et al.*, 1995). In a large population-based survey (N=107 804) carried out in the late 1990's in the USA, Serdula *et al.* found current smokers to be less likely to try to lose their weight than never-smokers (Serdula *et al.*, 1999). On the other hand, heightened levels of weight concerns (Feldman *et al.*, 1985) and body dissatisfaction have been observed more frequently among female smokers than in non-smokers (Meyers *et al.*, 1997; Wiseman *et al.*, 1998; King *et al.*, 2000). Weight concerns are also considered an important factor in smoking initiation and inhibiting smoking cessation, not only among adolescents but also among young adults, particularly women (French *et al.*, 1994; Klesges *et al.*, 1997a; Neumark-Sztainer *et al.*, 1998; Pomerleau *et al.*, 2001; Cavallo *et al.*, 2006; Weiss *et al.*, 2007).

## 6.4 Summary of open questions

Smoking is known to affect body weight through many different mechanisms. There is also evidence that in addition to body weight, smoking seems to be associated with different patterns of body fat distribution. The direction of the effect on weight is still under discussion and there is some evidence that the association of smoking and body weight differs between younger and older generations. Differences between men and women also remain to be investigated. Comparative research across age cohorts should be conducted to explore possible cohort effects and to evaluate the change. Also longitudinal studies spanning adolescence to adulthood are scarce and methodologically limited. Special emphasis should be put on the use of accurate measurement of smoking and of body shape, including not only weight and height, but also waist circumference.

The association between tobacco use and weight cycling, found in many studies, may be due to the effects of smoking on weight cycling or alternatively weight cycling may precede smoking. There is also a third possible explanation: the association could be explained by familial factors associated with both smoking and weight cycling. Thus, it is reasonable to examine the association between weight cycling and tobacco use in a twin sample, to investigate the role of familial effects.



There is also some evidence of differences in smoking and dieting cultures in different cohorts, and between genders.

Despite the wealth of literature, there is still controversy and confusion of how weight cycling affects later weight gain. There are only few studies with sufficiently long follow-ups and well controlled confounding factors investigating this issue.

## 7 Aims of the study

This study was undertaken to investigate the interplay between body size, smoking and dieting from an epidemiological point of view.

Specific questions to be addressed in this study were as follows:

1. Does smoking in adolescence predict later general or abdominal obesity? (I)
2. Is the association of smoking and body size different across genders and age cohorts? (I, II, III)
3. How strongly are smoking and dieting linked among Finns? Does this association differ between men and women or in different age groups? (II, III)
4. Is the association of smoking and dieting due to familial or environmental factors? (II, III)
5. Does weight cycling predispose to later weight gain and following obesity? (IV)
6. Does smoking modify the effect weight cycling possibly has on future weight gain? (IV)

## 8 Subjects and methods

### 8.1 Subjects

#### 8.1.1 FinnTwin16 cohort

FinnTwin16 is a population-based study of five consecutive and complete birth cohorts of Finnish twins born between 1975 and 1979 and identified from the Central Population Registry of Finland (Kaprio *et al.*, 2002). Baseline data was collected through mailed questionnaires within 60 days of the twins' 16th birthday. Follow-ups were at ages 17 and 18.5 years and in young adulthood (mean age 24.4, range 22–27 years). All four questionnaires included items on anthropometrics (weight, height) and health-related behaviours such as physical activity, common psychological and physical symptoms, alcohol, drug and tobacco use, interpersonal relationships and educational and occupational level. The baseline questionnaire yielded 5563 responses. The response rates for the baseline questionnaire were 90%, and 95%, 94% and 85% for the ages 17, 18.5 and young adulthood, respectively.

In all analyses participants who were pregnant (N=112) or had a known illnesses (diabetes mellitus, systemic lupus erythematosus (SLE), inflammatory bowel disease, celiac disease, hyper- or hypothyroidism, malignancies, mobility disorders or eating disorder) or with medication affecting weight such as insulin, thyroxin and antipsychotic medication (N=302) were excluded.

Thus, the final follow-up data used in cross-sectional analyses of twins in young adulthood included 2123 male and 2398 female participants (II). Participants included 1367 monozygotic (MZ), 1419 same sex dizygotic (SSDZ), 1476 opposite sex dizygotic (OSDZ) and 259 unknown zygosity twins. Pair-wise analyses were conducted when both twins had responded and no data was missing. Among these pairs were found 250 pairs discordant for adolescent smoking, i.e. one twin smoked at least 10 cigarettes a day and the other was included in any other smoking category (<10 cigarettes daily, occasional, former or never-smoker; “heavy – other” pairs). In 70 of these pairs one twin was smoking at least 10 cigarettes a day whereas the other twin had never smoked (“heavy – never” pairs).

From the data used in longitudinal analyses (I) participants were also excluded with missing data on weight, height, waist circumference or smoking (N=158). The final data thus included 2278 females and 2018 males, including 1326 monozy-

gotic (MZ), 1353 same-sex dizygotic (SSDZ), 1478 opposite sex (OSDZ) and 139 unknown zygosity twins. Pair-wise analyses were conducted when both twins had responded and no data was missing.

At the time of the first mailing, parents were sent a questionnaire including questions about body size, education and occupation. The response rate of parents' was 85% (n=5055).

### **8.1.2 The Finnish Twin Cohort**

The Finnish Twin Cohort (III) was established to examine genetic, environmental, and psychosocial determinants of chronic diseases. It includes virtually all Finnish same-sex twin pairs born before 1958 in which both co-twins were alive in 1975 (Kaprio and Koskenvuo, 2002). In 1990 only twin pairs born in the period 1930-1957 were contacted. Twin individuals who replied to the questionnaire first mailed in the autumn of 1990 were included in this study. The study population thereby consisted of 12 793 twin individuals (response rate 77%); the youngest subject was aged 33 and the oldest 61 years at the time of response, as reminder letters prompted responses well into 1991. Excluded from the analyses were individuals with missing or ambiguous data on height (N=341), weight (N=368), dieting (N=345) or smoking status (N=445) (numbers not mutually exclusive). Also were excluded those with a history of malignant disease (N=168), a diagnosis of diabetes (N=251) or use of antihypertensive medication for at least two months during the past year (N=887). People with these diseases were excluded because they might have changed their eating patterns, smoking habits or dieting behaviours as a result of knowing they had such a condition. The final data included 5046 male and 6009 female twin individuals. In the final data 1010 twin pairs were found discordant for daily smoking. Of these "daily-other" smoking discordant pairs, 270 adult pairs and 109 adolescent pairs were also discordant for recurrent dieting, i.e. one twin had never dieted and the co-twin reported recurrent dieting.

### **8.1.3 Cohort of male elite athletes**

The study subjects were male athletes who had represented Finland in the Olympic Games or in other major international sport competitions between 1920 and 1965 in track and field athletics, cross-country skiing, football, ice hockey, basketball, shooting, boxing, wrestling, or weight lifting (IV). Athletes were identified from sports yearbooks and registers and traced through the records of local parishes, so 97.7% of them were traced. The control group consisted of conscripts

from the same age cohort and area of residence as the athletes, and were selected from the service register of the Finnish Defence Forces; because of universal conscription, all Finnish men are assessed for eligibility to serve. The completely healthy conscript listed in the service register living the closest geographically to each athlete was chosen as his matched control. The referents were selected in 1978–1979, and no referents for athletes traced later were obtained.

The surviving former athletes and referents were sent in 1985, 1995 and 2001 an extensive questionnaire on personal characteristics, including height, current weight, weight at the time of their military service (at age 20 years), sociodemographic factors, psychological traits, smoking and the use of alcohol, physical activity, the discontinuation of their sporting career, dietary habits, symptoms and diseases.

The overall response rates were 84%, 76% and 76% in 1985, 1995 and 2001 respectively. In 1985, the response rates for the referents, other athletes and the weight cyclers were respectively 92%, 79% and 91%. In 1995, the corresponding figures were 82%, 71% and 81%, and in 2001, 71%, 82% and 79%. The total number of subjects aged less than 65 years in at least one questionnaire and with data on BMI at age 20 was 2033, of which 273 (13.5%) were classified as weight cyclers, 1093 (53.7%) as other athletes, and 667 (32.8%) as referents.

## 8.2 Measures

**Anthropometric measures.** Height and weight were self-reported at every survey and body mass index (BMI) ( $\text{kg}/\text{m}^2$ ) was calculated based on these values. The BMI categories for adults were defined as BMI  $<25 \text{ kg}/\text{m}^2$  for normal weight, BMI  $25\text{--}29.99 \text{ kg}/\text{m}^2$  for overweight and BMI  $\geq 30 \text{ kg}/\text{m}^2$  for obese (WHO, 2000). At adolescence the categorization was made using the International Obesity Task Force reference for adolescent obesity, with the cut-off points based on UK data (Cole *et al.*, 2000; Vidmar *et al.*, 2004). In the latest follow-up of the FinnTwin16 (mean age 24), waist circumference was self-measured using a tape measure supplied by mail. The WHO cut-off points of 80cm for women and 94cm for men were used to measure abdominal obesity (Han *et al.*, 1995).

**Dieting.** In this study the term dieting is used as an overall term covering all intentional behaviour heading for weight loss. Three more specific terms are used in sub studies:

- 1) Recurrent intentional weight loss (IWL): If young adult twins from the FinnTwin16-cohort reported having intentionally lost 5kg or more at least twice in their lifetime, they were classified as having recurrent intentional weight loss episodes. This kind of dieting behaviour will later on in the text be referred as IWL. Furthermore, among the FinnTwin16-cohort the subjects were asked to compare their own behaviours with their co-twins behaviours during the last 12 months: which twin is or has been dieting more often (me, my co-twin, there is no difference between us, do not know).
- 2) Recurrent dieting: Twins from the adult cohort were asked how many times in their entire lifetime they had intentionally lost weight or tried to lose weight (never, 1–2, 3–5, and 6–10 times or more often). This will further on be referred as dieting. Overall, 12% reported having dieted 3-5 times, 4.6% 6-10 times and 6.3% more often. Because the smoking proportion of those who reported dieting more than 6 times did not differ from those who had dieted 3-5 times and the number of those who had dieted more than 6 times was relatively small, these two dieting categories were combined. Those who had dieted at least 3 times in their entire lifetime were classified as recurrent dieters. These subjects will be referred as having recurrent dieting.
- 3) Among athletes, men who had been engaged in sports with mandatory weight classes (boxing, weightlifting and wrestling) in which weight reduction before a competition is common will be referred to as weight cyclers in the text. This assumption is made on previous results where athletes competing in weight classes have often shown to be engaged with weight cycling (Tipton and Tcheng, 1970; Lakin *et al.*, 1990; Fogelholm and Hiilloskorpi, 1999; Kiningham and Gorenflo, 2001; Oppliger *et al.*, 2003; Alderman *et al.*, 2004).

**Smoking.** A detailed smoking history was used to define smoking status as a categorical variable divided into never, former, occasional and current regular smokers. In the athlete and adult twin samples the group of occasional smokers was small and similar to former smokers in respect of age and BMI, and thus combined with them. In the FinnTwin16-sample daily smokers were further divided to daily smokers smoking <10 cigarettes per day, and daily smokers, ≥10 cigarettes per day.

**Confounding factors.** A set of selected confounding factors known to be associated with BMI, smoking and weight loss behaviour were included in the analyses. Models were adjusted for age (as a continuous variable, also in analyses by age group), socioeconomic status (categorized variable) or educational level (categorized variable), physical activity (categorized variable), having children (dichoto-

mous variable) and among young adults also parental BMI (continuous variable), socioeconomic status (categorical variable) and alcohol consumption (continuous variable, used only in the athlete sample). Type of milk and spread on bread, use of cola drinks and alcohol, and breakfast skipping were used as indicators of dietary behaviour.

### 8.3 Validity assessment

**Twin zygosity.** Twin zygosity was determined by a validated questionnaire method (Sarna *et al.*, 1978). The validity of the questionnaire was assessed by 11 polymorphic genetic blood markers and responses to two questionnaire items in a sample of 104 twin pairs classified as monozygotic (MZ) or dizygotic (DZ) (Sarna *et al.*, 1978). Agreement between the blood test and the questionnaire was 100%. The probability of misclassification of a twin pair based on blood tests in this sub sample was 1.7%.

**Self-reported BMI and waist circumference.** The validity of the self-reported values on BMI and waist circumference were assessed in a sub-sample of FinnTwin16-sample of 566 twins. They participated in another study on the consequences of adolescent alcohol use with a median of 650 days after the self-report. Height was measured without shoes on a stadiometer and weight in light clothes on a calibrated beam balance. Waist circumference was measured standing, halfway between the iliac crest and the lowest rib, at the end of light expiration. The agreement between the measured and reported values was good. The intraclass correlation for BMI was 0.89, mean difference 0.93 (95% CI 0.79 to 1.07) kg/m<sup>2</sup>, for height 0.99 and 0.24 (0.14 to 0.35) cm and for waist 0.75 and 2.48 (0.96 to 3.00) cm, respectively. The kappa coefficient for self-measured and clinically measured abdominal obesity ( $\geq 80$  cm for women,  $\geq 94$  cm for men) was 0.67 (95%CI 0.59 to 0.75).

In the athlete sample height and weight were measured for a sample of 87 athletes in 1992 participating in a laboratory study (Kettunen *et al.*, 2000). Self-reported height and weight agreed closely to measured height and weight; for height,  $r=0.96$  (1985 questionnaire) and  $r=0.98$  (1995), and for weight,  $r=0.90$  (1985) and  $r=0.94$  (1995). To analyse a possible recall bias in reporting body weight at 20 years the correlations were examined between reported weights on different questionnaires. The correlations were greater than 0.91 between all time points.

**Table 2.** Summary of used data sets.

	<b>FinnTwin16</b>	<b>The Finnish Twin Cohort</b>	<b>Cohort of male elite athletes</b>
<b>N (% of women)</b>	<b>4296 (53%)</b>	<b>11055 (54%)</b>	<b>2033 (0%)</b>
<b>BMI (kg/m<sup>2</sup>)</b>	At age 16 17 18.5 24	In year 1990	At age 20 (recalled) In year 1985 1995 2001
<b>Waist circumference (cm)</b>	At age 24	–	–
<b>Smoking</b>	At age 16 17 18.5 24	In year 1990	In year 2001
<b>Dieting</b>	At age 24  “How many times have you intentionally lost $\geq 5$ kg?”	In year 1990  “How many times during your lifetime have you intentionally lost or tried to lose weight?”	During active sporting career. Athletes in sports with weight classes were classified as weight cyclers.
<b>Mean age (years) at last survey (95%CI)</b>	24.4 (24.3–24.34)	43.7 (43.6–43.9)	60.2 (60.0–60.5)
<b>Response rate at baseline</b>	90 %	77 %	84 %

## 8.4 Statistical Methods

Prevalences were estimated using cross tabulations (I, II, III, IV), age-adjusted by direct standardization to the age distribution of the entire sample when needed (III). Statistical analyses to obtain odds ratios and 95% confidence intervals for individual data were performed using logistic (I, IV) and multinomial logistic (II, III) regression models. Linear regression (III, IV) models were used for continuous outcome variables. To examine the impact of environmental and genetic factors on the association under investigation, pairs discordant for smoking were studied using conditional logistic regression analyses and further subgroup analyses were conducted by zygosity (I, II, IV).



Possible interaction terms (age, gender and education) were analysed by comparing models with and without interaction term with likelihood-ratio test (II, III, IV). Logarithmic or natural logarithmic transformations were used for non-normally distributed variables. To compare self-reported and measured values intraclass correlations (I, III, IV) and kappa-coefficients (IV) were calculated.

Participants in twin data are not fully independent but may correlate for study traits within twin pairs. The effect of the twin sampling design on standard error was taken into account in individual level analyses by computing the robust estimate of variance using the cluster-option (Williams, 2000) in Stata®.

All statistical analyses were carried using Stata® statistical software version 8.2 or 9.1 (Stata, 2003; 2005).

## 9 Results

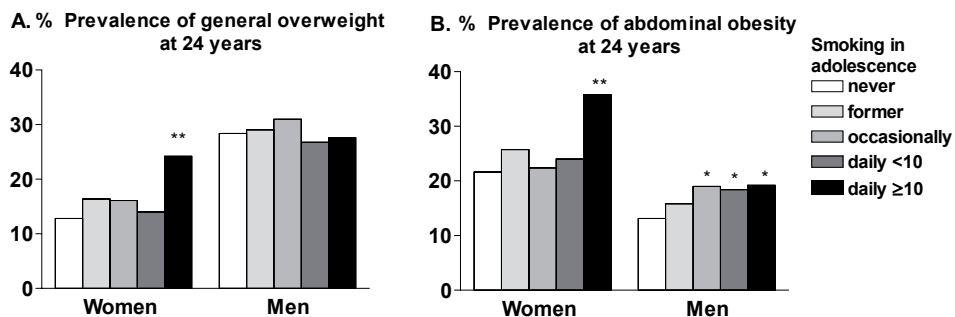
### 9.1 Smoking and obesity

Adolescent smoking was found to predict later overweight in women and abdominal obesity in both sexes (I). Girls who smoked in adolescence were significantly more likely to become overweight women than never-smokers (Odds Ratio (OR) 1.57, 95% Confidence interval (CI) 1.16 to 2.12). The girls smoking at least 10 cigarettes a day had the greatest risk of becoming overweight (OR 2.32, 95% CI 1.51 to 3.58). Adjusting for potential confounders and baseline BMI did not change the result. Among men, adolescent smoking had no effect on the risk of general overweight or obesity measured with BMI (Figure 1).

Smoking in adolescence was found to be a strong predictor of later abdominal obesity (waist circumference  $\geq 80$  cm for women,  $\geq 94$  cm for men) among both genders. The OR for abdominal obesity compared to never-smokers was highest among those smoking at least 10 cigarettes per day, 1.77 (1.39 to 2.26) in the gender adjusted model including both sexes (Table 3). Daily smoking remained a significant predictor of an increased risk of subsequent abdominal obesity after adjustments for potential confounders (Table 3). The risk was not attributable to overall adiposity (BMI), as the adjustment for current BMI did not markedly change the results. Girls smoking at least 10 cigarettes daily as adolescents had an approximately 3.4 cm larger waist circumference when young adults than never smoking girls (Table 4.).

**Figure 1.** Prevalence of A. general overweight (BMI  $\geq 25$  kg/m<sup>2</sup>) and B. abdominal obesity (waist circumference  $> 80$  cm in women and  $> 94$  cm in men) at 24 years by smoking status in adolescence.

\*  $p < 0.05$ , \*\* $p < 0.01$ , tested with logistic regression, never-smokers as a comparison group.



**Table 3.** Odds ratios (95% confidence intervals) for abdominal obesity at age 24 years by smoking status in adolescence

Smoking status in adolescence	Model 1 (N=4296)	Model 2 (N=4296)	Model 3 (n=4296)
<b>Never</b>	1.00	1.00	1.00
<b>Former</b>	1.25 (0.98 to 1.61)	1.17 (0.91 to 1.51)	1.20 (0.87 to 1.66)
<b>Occasional</b>	1.21 (0.95 to 1.54)	1.19 (0.93 to 1.52)	1.13 (0.80 to 1.59)
<b>Daily &lt;10 cigarettes</b>	1.28 (1.00 to 1.64)	1.17 (0.90 to 1.53)	1.34 (0.94 to 1.90)
<b>Daily ≥10 cigarettes</b>	1.77 (1.39 to 2.26)	1.55 (1.20 to 2.01)	1.47 (1.05 to 2.01)

Model 1: Adjusted for gender

Model 2. Adjusted for gender, physical activity, breakfast eating, parents' body mass index, father's socioeconomic status

Model 3: Further adjusted for subject's body mass index at age 24 years

**Table 4.** Mean waist circumference and gender specific OR's for abdominal obesity according to adolescent smoking status

Women (N=2278)	Waist (cm)	Model 1	Model 2
<b>Never</b>	74.4	1.00	1.00
<b>Former</b>	75.4	1.26 (0.92–1.72)	1.10 (0.73–1.66)
<b>Occasional</b>	75.1	1.05 (0.78–1.42)	0.81 (0.53–1.25)
<b>Daily &lt;10</b>	74.9	1.15 (0.83–1.59)	1.13 (0.72–1.76)
<b>Daily ≥10</b>	77.8	2.03 (1.45–2.85)	1.43 (0.90–2.28)
<b>Men (N=2018)</b>	2018	2018	2018
<b>Never</b>	85.0	1.00	1.00
<b>Former</b>	85.6	1.25 (0.82–1.88)	1.31 (0.77–2.24)
<b>Occasional</b>	85.3	1.56 (1.06–2.30)	1.99 (1.14–3.47)
<b>Daily &lt;10</b>	85.5	1.50 (1.02–2.19)	1.79 (1.00–3.18)
<b>Daily ≥10</b>	85.4	1.58 (1.11–2.25)	1.58 (0.95–2.61)

Model 1. Adjusted for gender, physical activity, breakfast eating, parents' body mass index, father's socioeconomic status

Model 2: Further adjusted for subject's body mass index at age 24 years

The discordant pair analyses were run in two settings: comparing pairs, in which one of the twins smoked at least 10 cigarettes daily and the other had 1) never smoked (heavy - never pairs) or 2) belonged to any other smoking category i.e. all who smoked less than 10 cigarettes daily (heavy – other pairs). Among the heavy-other pairs the twin smoking ≥10 cigarettes daily was statistically significantly more likely to have a larger waist compared to his/her co-twin in any other smoking category (OR 1.3 95% CI 1.01 to 1.67). The association was strongest among MZ male pairs (OR 2.7 95% CI 1.04 to 6.81) suggesting that the relationship is

independent of familial effects, both genetic and other factors shared by siblings. Findings among heavy-never pairs were similar but no statistical significance was reached. These results support a causal relationship between smoking and later abdominal obesity but given the relative rarity of pairs discordant for smoking in adolescence, the power of our analyses to fully exclude familial effects or confirm causality was limited (Table 5).

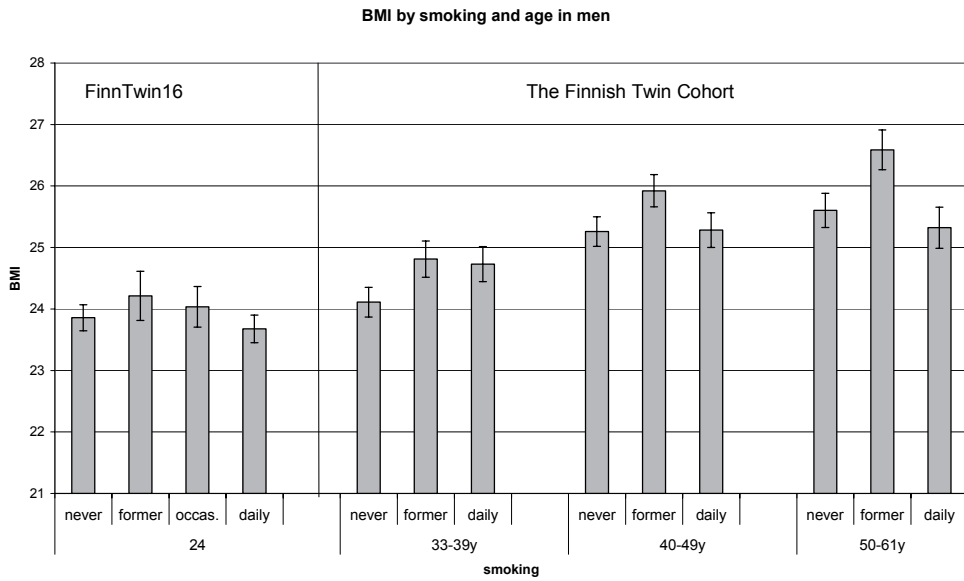
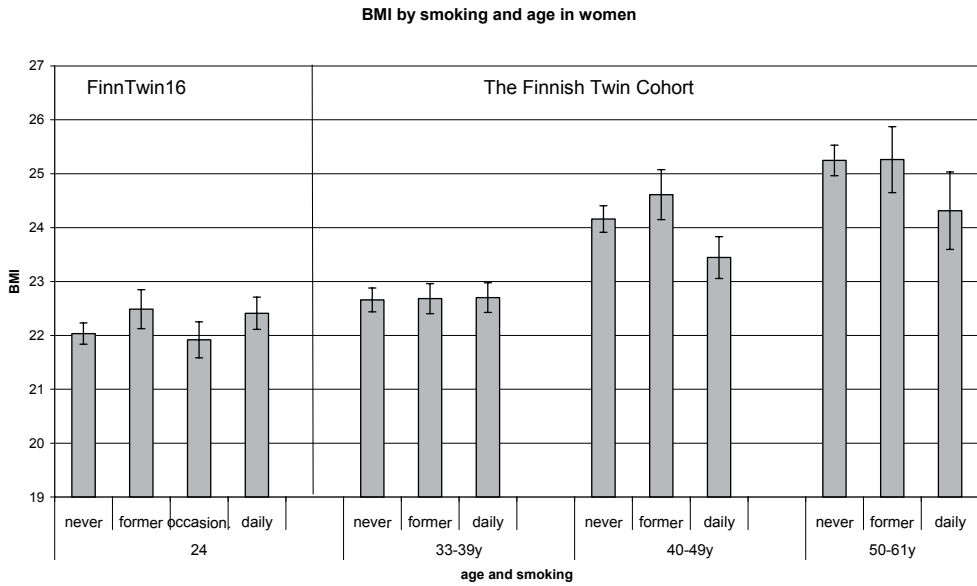
**Table 5.** OR (95% CI) for larger waist circumference (cm) in smoking-discordant pairs in FinnTwin16 data by discordance criteria

	Discordant pairs	
	heavy – other smoking*	heavy – never smoking*
<b>All</b>	1.29 (1.01–1.68)* N=239	1.43 (0.89–2.3) N=136
<b>Women</b>	0.88 (0.53–1.45) N=124	0.83 (0.25–2.73) N=22
<b>Men</b>	0.91 (0.57–0.48) N=134	1.25 (0.49–3.18) N=36
<b>Male MZ</b>	2.67 (1.04–6.81)* N=44	2.0 (0.18–22.1) N=6
<b>Male DZ</b>	0.65 (0.34–1.25) N=76	1.6 (0.52–4.89) N=26
<b>Female MZ</b>	0.4 (0.16–1.03) N=42	0.5 (0.05–5.51) N=6
<b>Female DZ</b>	1.28 (0.69–2.37) N=82	1.33 (0.30–5.96) N=14

\* “Heavy”: smoking >9 cigarettes daily, “other”: all other categories, “never”: never smokers.

In the analysis of the cross-sectional data on adult twins, the association between smoking and body weight differed between the sexes and age groups (II, III) (Figure 2). Among women, the daily smokers were leaner than never-smokers in the older age groups (over 40 years), but at age 24 most smoking women were slightly heavier than never-smokers. Former smokers were heavier than never-smokers only in the 40–49 year age group. Compared to never-smoking men, the former-smoking men were heavier among age groups over 33 years. Moreover, daily-smoking men were heavier than never-smokers in the age-group of 33–39 years, but there was no statistically significant difference in BMI between the daily- and never-smokers in other age groups. Overall, mean BMI increased with age.

**Figure 2.** BMI by smoking status in adult twins at different ages Finn Twin 16 and The Finnish Twin Cohort



## 9.2 Smoking and dieting

Among women there was a trend for increasing smoking prevalence towards younger cohorts. When 76% of women aged 50–61 had never smoked, the corresponding proportion among women aged 24 years was 46%. Among men the proportion of never-smokers was quite stable, about 40%. The highest lifetime prevalence of having dieted was in the age category 33–39 in both sexes, the proportion of those having dieted at least once being 61% and 31%, for women and men respectively (III) (Table 6).



Current smoking was associated with recurrent dieting among young women and men. The OR for recurrent intentional weight losses of current smokers compared to never-smokers was increased among young women 1.74 (1.35, 2.25) and men 1.77 (1.28, 2.47). In comparison, in older cohorts a positive association between current smoking and recurrent dieting was found only among women aged 33–39 years (OR 1.41 (1.10, 1.81) for  $\geq 3$  times dieting). Among men the association of current smoking and recurrent dieting was the opposite among the Adult Finnish Twin Cohort (OR's ranging from 0.78 to 0.57, never smokers as a comparison group) (Table 7).

Among women, former smokers were more likely to have recurrently dieted in all age groups (OR are ranging from 1.31 to 2.82). Among men, former smoking was statistically significantly associated with recurrent dieting only when age groups 33–61 were combined (OR 1.30 (1.05, 1.61)) (Table 7).



**Table 7.** OR's (95% CI's) for recurrent dieting according to smoking in different age categories. All analyses were adjusted for age and BMI. Comparison of different cohorts (FinnTwin16, age 24, and The Adult Finnish Twin Cohort, ages 33–61).

		Women		
Dieting (number of efforts)*		≥2 times	≥3 times	≥3 times
Age (N)		24 y (N=2398)	33–39 y (N=2435)	40–49 y (N=2287)
<b>Smoking</b>				
Never		1.0	1.0	1.0
Former		1.31 (0.94,1.83)	1.52 (1.17,1.97)	1.94 (1.44,2.63)
Current**		1.74 (1.35,2.25)	1.41 (1.10,1.81)	1.09 (0.83,1.42)
* Number of intentional weight losses ≥5kg at age 24 years. Number of weight loss efforts at ages 33–61 years				
**A combination of occasional and daily smokers in the youngest age group (FinnTwin16)				

		Men		
Dieting (number of efforts)*		≥2 times	≥3 times	≥3 times
Age (N)		24 y (N=2123)	33–39 y (N=1834)	40–49 y (N=2010)
<b>Smoking</b>				
Never		1.0	1.0	1.0
Former		1.11 (0.66,1.88)	1.38 (0.91,2.09)	1.12 (0.73,1.72)
Current**		1.77 (1.28,2.47)	0.78 (0.53,1.16)	0.57(0.34,0.98)
* Number of intentional weight losses ≥5kg at age 24 years. Number of weight loss efforts at ages 33–61 years				
**A combination of occasional and daily smokers in the youngest age group (FinnTwin16)				

**Table 7** continues.

Note: subjects with diagnosed diabetes, cancer and hypertensive medication for at least 2 months during the previous year are excluded

In the longitudinal analysis, adolescent smoking was found to predict recurrent IWL at age of 24 even after adjustment for BMI at that age. Girls and boys who smoked at age 18.5 were about 1.5 times as likely to report  $\geq 2$  times IWL at age 24 than non-smokers (Table 8).

**Table 8.** OR for  $\geq 2$  times IWL at age 24 according to smoking status at the age of 18.5. Adjusted for BMI at age 24

<b>Smoking at age 18.5</b>	<b>Women</b>	<b>Men</b>
<b>Never</b>	1.00	1.00
<b>Former</b>	1.24 (0.84, 1.87)	1.15 (0.67, 1.97)
<b>Current</b> (including occasional smokers)	1.47 (1.12, 1.96)	1.60 (1.15, 2.21)

Paralleling results of the twin data, athletes with weight cycling were significantly more likely to be current smokers than the other athletes (prevalence of current smokers among weight cyclers 21.5% vs. 15.5% in other athletes, p-value for difference  $< 0.05$ ) (IV).

The association between smoking status and recurrent dieting in twin pairs discordant for smoking and recurrent dieting (recurrent intentional weight losses in FinnTwin16) was also studied (Table 9). Among the adult twins 1010 twin pairs and among the adolescent cohort 478 twin pairs were found discordant for daily smoking. Of these “daily-other” smoking discordant pairs, 270 adult pairs and 109 adolescent pairs were also discordant for recurrent dieting, i.e. one twin had never dieted and the co-twin reported recurrent dieting. The results of the conditional logistic regression analyses of these discordant pairs paralleled the results of individual-based analyses. Statistical significance was reached only in the analysis of adolescent twin pairs including all zygosity groups (OR 1.57). The within-pair analyses in smoking-discordant MZ and DZ twin pairs were repeated separately to obtain information about possible genetic factors affecting this association. The number of twins in the zygosity groups was small, and no statistically significant differences were found, even though the point estimates were greater than unity in all subgroups (II, III). To further improve the statistical power the adult and adolescent data sets were combined, but no statistical significance was reached.

**Table 9.** Results of discordant pair analysis. Odds ratios for recurrent dieting among the pairs discordant for smoking (one twin a daily smoker, the other not)

	Adult Twins	FinnTwin16	Combined FT16 & Adults
<b>All discord. pairs</b>	0.74 (0.57–0.96)	1.57 (1.03–2.41)	0.91 (0.74–1.14)
<b>Female DZ</b>	1.13 (0.52–2.47)	not computable	1.00 (0.55–1.80)
<b>Male DZ</b>	1.05 (0.47–2.39)		1.46 (0.74–2.85)
<b>Female MZ</b>	not computable	2.78 (0.58–12.81)	1.25 (0.54–2.88)
<b>Male MZ</b>		1.34 (0.35–5.09)	0.85 (0.30–2.41)

Furthermore, the data from young adult twin pairs consistent in their answers about which one is or has been dieting more often during the last 12 months was also analysed. The FinnTwin16 sample found 375 pairs who were unanimously discordant for current dieting i.e. both co-twins were referring to the same twin individual in their answer to the question “which one of you is dieting more often – you or your co-twin?” Of those, 108 pairs were also discordant for daily smoking and included in the statistical analysis. Conditional logistic regression analysis revealed a statistically significant association between daily smoking and dieting (OR for the smoking twin to diet more often 1.82 95%CI 1.23–2.71). In same-sex and opposite-sex DZ pairs, an association of smoking and dieting was found (OR 3.0 95%CI 1.12–9.23 for SSDZ pairs, N=24 and OR 1.86 95%CI 1.08–3.28 for OSDZ-pairs N=63). The number of MZ pairs was small (N=16), and there was no difference between the more and less dieting co-twins in smoking (OR 1.00 95%CI 0.33–3.06) (II).

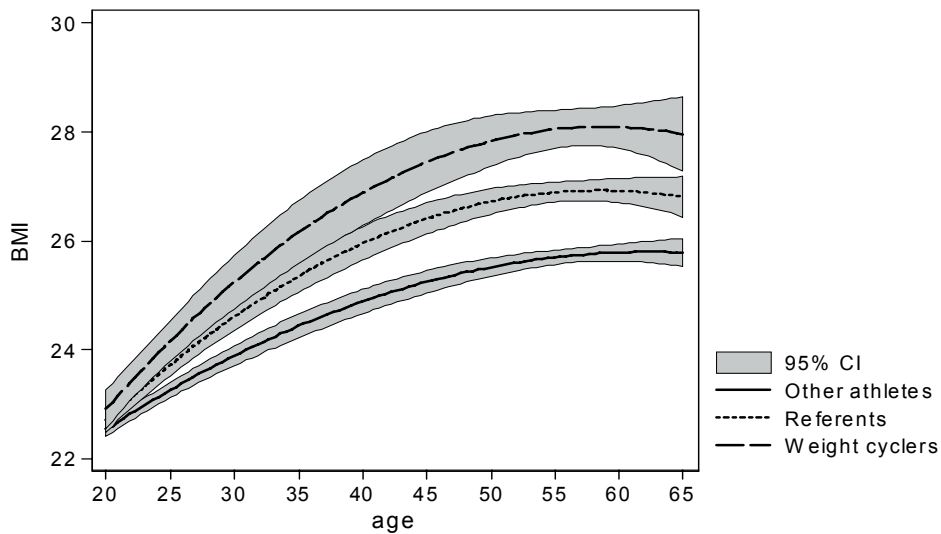
### 9.3 Dieting and obesity

Weight cycling was strongly associated with later weight gain and risk of becoming obese in the sample of former athletes. At age 20 the BMI did not significantly differ between weight cyclers, other athletes or referents. In 1985 and 1995, the weight cyclers had the greatest mean weight gain since age 20 (in 1985 15.1kg 95% CI 13.3–17.0) as compared to other athletes (9.6kg, 8.5–10.6) and the referents (11.8kg, 10.5–13.1) (Table 10). In 2001, the weight cyclers and referents had both a mean weight gain of over 14 kg, whereas the result for other athletes was only 10.4 kg (Table 10, Figure 3). Stratification for smoking status did not change the result (IV).

**Table 10.** The age-adjusted weight change in kilograms since age 20 by group in different study years of subjects aged less than 65 years at the time of the questionnaire (95% CI in parenthesis)

Year	Weight cycling athletes	Other athletes
1985	15.1 (13.9–16.3)	9.6 (8.9–10.2)
1995	15.2 (13.4–17.0)	8.5 (7.7–9.3)
2001	14.2 (11.4–17.0)	10.4 (9.1–11.8)

**Figure 3.** Mean BMI and 95% CI as a function of age. Weight cyclers, other athletes and referents. (Reprinted with permission)



The weight cyclers were significantly more likely to be obese than other athletes at all time points (OR's 2.35–5.05). As compared to the referent men, weight cyclers were twice as likely to be obese in 1985 and 1995, but no difference was found in the relative risk of obesity in 2001 (Table 11). The evolution over time of the weight cyclers' relative risk was not due to the composition of the study group; the same result was seen when only those who had responded to all three questionnaires were considered. These differences in obesity were also observed when the data was stratified by smoking status and no significant interaction between smoking and sport was detected.

In cross-sectional data of young and middle aged twins, greater BMI and recurrent dieting were positively associated. The mean BMI of those who had dieted at least twice was significantly higher than never-dieters. (Table 12)

**Table 11.** OR's (95% CI) and age-adjusted prevalence for obesity (BMI  $\geq 30$ ) of weight cyclers vs. other athletes and referents aged 65 and under at the time of the questionnaire

year	Prevalence of obesity (BMI $\geq 30$ )			Weight cyclers' OR for obesity	
	weight cyclers	other athletes	referents	as compared to other athletes	as compared to referents
1985	24.5	9.3	13.8	3.18 (2.09–4.83)	2.00 (1.35–2.96)
1995	25.0	9.3	16.2	5.05 (2.96–8.60)	2.01 (1.27–3.37)
2001	17.6	13.0	19.1	2.35 (0.99–5.55)	0.90 (0.40–1.99)

**Table 12.** Mean BMI (kg/m<sup>2</sup>) according to number of weight loss episodes among Finnish twins and male elite athletes

	Recurrent Dieting/ IWL			Adult Twins (mean age 43.7)	Athletes (mean age 51.6 at 1985)
	Never	Once	Twice or more	FinnTwin16 (age24)	Referents
Women	Never	21.1 (21.0–21.3)	22.3 (22.1–22.4)	–	–
	Once	22.8 (22.6–23.1)	24.0 (23.8–24.2)	–	–
	Twice or more	24.6 (24.4–25.0)	25.5 (25.3–25.7)	–	–
Men	Never	23.2 (23.1–23.3)	24.4 (2.3–24.5)	26.5 (26.2–26.8)	Referents
	Once	25.5 (25.1–25.9)	26.5 (26.3–26.7)	–	Weight cyclers
	Twice or more	26.8 (26.3–27.3)	27.4 (27.2–27.7)	27.8 (27.4–28.3)	

## 10 Discussion

### 10.1 Summary of key results

Results of this study show that smoking in adolescence is a strong predictor of future abdominal obesity in both sexes and of overweight among young women. Daily smoking of  $\geq 10$  cigarettes in adolescence almost doubled the risk of adult abdominal obesity. The risk of becoming abdominally obese was independent of overall adiposity and possible confounders affecting central fat accumulation included in our model. In cross-sectional analyses the association of smoking and BMI varied between age groups and no clear trends could be found.

Smoking was also found to be associated with recurrent dieting in women at all ages and in young men, but among older men the association was the opposite. Smoking in adolescence was associated with recurrent weight losses in early adulthood. The results of twin data analyses supported the hypothesis of tobacco as an independent causal factor predisposing for recurrent dieting in younger generations, but no firm conclusions could be made due to the small number of smoking discordant pairs.

Furthermore, it was found that weight cycling predisposes to greater weight gain and obesity in later middle age among male athletes. Smoking did not affect the effect of weight cycling on weight gain.

### 10.2 Smoking, body weight and abdominal obesity

There are few previous prospective studies that have examined the association of smoking and abdominal obesity in adolescence or young adulthood (Twisk *et al.*, 1998; van Lenthe *et al.*, 1998; Laitinen *et al.*, 2004; Bornaards *et al.*, 2005; Laitinen *et al.*, 2005; Fidler *et al.*, 2007). Neither the Amsterdam Growth and Health study (Twisk *et al.*, 1998; van Lenthe *et al.*, 1998; Bornaards *et al.*, 2005) nor the Northern Finland Cohort Study (Laitinen *et al.*, 2004; Laitinen *et al.*, 2005) found any association between adolescent smoking and later abdominal obesity. In the most recent study (Fidler *et al.*, 2007), a negative association was found between smoking at age 11 to 12 and waist circumference 4 years later. These differences from our results may mostly be explained by the crude measure of smoking in very early adolescence, when smoking habits are not yet stabilised (weekly vs. non-smokers at age 11 to 14 years). Results of cross-sectional studies on body weight

and smoking behaviour have been inconsistent (Potter *et al.*, 2004; Weitzman *et al.*, 2005), as have those of longitudinal studies with no inclusion of indicators of abdominal obesity (Klesges *et al.*, 1998; Ball *et al.*, 2002; Kvaavik *et al.*, 2003; Potter *et al.*, 2004).

Abdominal obesity and smoking are major risk factors for metabolic dysfunction (Manson *et al.*, 2000) and cardiovascular disease (Mokdad *et al.*, 2004). Furthermore, it is well documented that environmental and biological stress alters the function of the hypothalamic-pituitary-adrenal axis (HPA-axis) and glucocorticoid metabolism, which are responsible for central fat accumulation (Bjorntorp and Rosmond, 2000). Korkeila *et al.* have also shown psychological stress to be associated with later weight gain (Korkeila *et al.*, 1998). Based on this evidence, it can be hypothesized that environmental stress associated particularly with lower socioeconomic status (Cohen *et al.*, 2006) and biological stress due to smoking (Rohleder and Kirschbaum, 2006) both catalyse the vicious cycle leading to abdominal obesity. Results of this study show that smoking in adolescence is a predictor for future abdominal obesity in both sexes and for overweight among young women. Smoking has been reported to be associated with low education (Pierce, 1989; Green *et al.*, 2007), breakfast skipping (Wingard *et al.*, 1982; Keski-Rahkonen *et al.*, 2003) and physical inactivity (Escobedo *et al.*, 1993; Aarnio *et al.*, 2002), all documented risk factors for obesity. However, these confounders explained only a small amount of the association between smoking and later abdominal obesity among men and women and female overweight in this study. This, together with the dose-dependent effect of smoking suggests a causal relationship between smoking and the development of obesity. Though reassuring, these results should be interpreted with caution until repeated in other well conducted epidemiological studies.

### **10.3 Smoking and dieting**

This study shows current smoking to be associated with recurrent dieting among women at all ages. In men this association was found only among the youngest cohort (age 24 years), but in the older age groups the relationship was the opposite.

The results of the few studies concerning the association between smoking and intentional weight loss in adults are somewhat contradictory. This is probably due to methodological differences in measurements and classifications of smoking and weight loss, especially because of the lack of a consistent measure of intentional weight loss (Serdula *et al.*, 1999; von Ranson *et al.*, 2002). Paralleling the current results smoking has been cited as a weight control method by women in many studies (Jeffery and French, 1996; Gerend *et al.*, 1998; Jarry *et al.*, 1998).

Weight concerns are also considered an important factor in smoking initiation and inhibiting smoking cessation not only among adolescents but also among young adults, particularly women (Camp *et al.*, 1993; French *et al.*, 1994; Klesges *et al.*, 1998; Neumark-Sztainer *et al.*, 1998; Austin and Gortmaker, 2001; Pomerleau *et al.*, 2001; Fulkerson and French, 2003). In line with the results presented here, heightened levels of weight concerns (Feldman *et al.*, 1985) and body dissatisfaction (King *et al.*, 2000) have been observed more frequently among female smokers than non smokers (Meyers *et al.*, 1997; Wiseman *et al.*, 1998).

Previous studies have shown the importance of both genetic and common background factors for smoking (Hall *et al.*, 2002). Moreover, Korkeila *et al.* have reported that weight loss attempts have a common familial background, which may, be mediated partly through the genetic component in BMI (Korkeila *et al.*, 1999). It was found that the association between smoking and recurrent intentional weight loss also existed within twin pairs discordant for daily smoking. This finding indicates that the association between intentional weight loss and smoking results neither from common family environment nor from other factors common to siblings alone. The results suggest that the association between recurrent intentional weight loss and tobacco use is real and is not accounted for familial factors. Parallel with these findings were the results of the examination of the association between recent dieting and daily smoking among young twins comparing each others dieting behaviour. These results showed an association in all pairs, particularly in DZ pairs.

Based on data and results of this study, it is difficult to draw firm conclusions whether the variation between age groups is due to cohort effect or perhaps different timing of the survey. However, results of this study suggest that there may be an ongoing transition in the cultures of smoking and dieting, so that smoking is more often associated with intentional weight loss among younger generations and women, who in general are more prone to dieting and health compromising dieting methods than older generations and men (Feldman *et al.*, 1985; Wiseman *et al.*, 1998; King *et al.*, 2000). The youngest female smokers' higher risk of recurrent dieting might be explained by greater concerns about body image. The gender and age group differences found in the current study support the idea of such a transition.

## **10.4 Weight cycling and obesity**

The finding that weight cycling predisposes to later weight gain and obesity was consistent with the two previous prospective population based studies specifically investigating the effect of weight cycling on later weight gain (Kroke *et al.*, 2002;



Field *et al.*, 2004b). The findings of the Framingham Population Study are in concert with results of this study reporting that the association of weight variability and CVD mortality did not significantly vary between smokers and non-smokers (Lissner *et al.*, 1991).

Recurrent weight losses followed by regains have in some animal and human studies shown to reduce energy expenditure (Devlin *et al.*, 1990; National Task Force on the Prevention of obesity, 1994). This has also been shown among young wrestlers, although the findings are not unequivocal (Steen *et al.*, 1988; McCargar and Crawford, 1992). The greater than expected weight gain of the weight cycling athletes could perhaps be explained by lowered basal energy expenditure (Steen *et al.*, 1988; Devlin *et al.*, 1990), even if these men had maintained a physically active lifestyle as compared to the referent men. Another possible or supplementary explanation might be increased energy intake due to increased meal size and energy density associated with bingeing as a consequence of repeated weight cycle periods. Finally, there might be a common factor affecting both weight cycling behaviour and weight gain. A selection bias can not fully be excluded as men choosing wrestling, weight lifting or boxing might be more liable to weight gain even in the first place without the history of weight cycling, as compared to men choosing for example endurance sports or referent men. Further studies on weight cycling on random samples would be needed to further elucidate this problem.

## 10.5 Methodological considerations

A special strength of this study is the use of large, representative samples with very high response rates. In studies I and IV the prospective study design included reasonably long follow-ups. The twin populations studied are representative of the population at large. The athlete data included matched control groups of non-weight cycling athletes and matched non-athletes. The analyses were also adjusted for a large number of possible confounding factors possibly affecting weight or weight changes and smoking behaviour.

Twin data provides the possibility of controlling for the effect of both common environmental and genetic factors and yields more information on the association under investigation than data on singletons only. Previous studies have shown the importance of genetic factors in smoking, body weight and dieting behaviour (Korkeila *et al.*, 1999; Pietiläinen *et al.*, 1999; Hall *et al.*, 2002; Schousboe *et al.*, 2003; Ho and Tyndale, 2007). Twins have slightly lower BMI's than singletons in mid-adolescence (Pietiläinen *et al.*, 1999) but this is unlikely to affect the association between smoking and body composition.

The use of self-reported data can be considered as a limitation, and therefore validation procedures of anthropometrics were conducted and a good agreement between self-reported and measured height, weight and waist circumference was found. Reports on self-reported smoking behaviour among Finns have previously been shown to be reliable. Approximately 95% of self-reported regular smokers had 10ng/ml of cotinine in serum and less than 3% of never-smokers had detectable cotinine levels in their serum (Vartiainen *et al.*, 2002). Unfortunately, weight cycling was not directly assessed in athlete the data. However, weight cycling and unhealthy weight control methods (weight cutting) of young male athletes participating in sports with weight classes are well documented (Tipton and Tch- eng, 1970; Lakin *et al.*, 1990; Fogelholm and Hiilloskorpi, 1999; Kiningham and Gorenflo, 2001; Oppliger *et al.*, 2003; Alderman *et al.*, 2004). Over 80% of high school (Tipton and Tch- eng, 1970) and college (Oppliger *et al.*, 2003) wrestlers have been reported to “cut weight”, and 26.6% to cut more than ten times per season. The effect of weight cutting is usually a loss of several kilograms which is quickly regained (Oppliger *et al.*, 2003; Alderman *et al.*, 2004). There were no measurements of the detailed body composition of the subjects and therefore evaluating changes in body composition over time as their weight changed could not be done.

To investigate weight gain in elite athletes is challenging due to the larger muscle mass of athletes than in other subjects. In order to be sure that the results concerning larger weight gain of weight cyclers could not be attributed to for greater muscle mass of athletes in weight cycling sports, the overweight (BMI 25–29.9) and obese (BMI  $\geq 30$ ) subjects were studied separately. Subjects having BMI over 30 practically always have excess fat, even if some of the elevated BMI was due to large muscle mass. Taking into account the nearly twenty year time span of this study, there may be some period-specific effects on weight gain in our sample, given the general trend for gain in the entire Finnish population (Lahti-Koski *et al.*, 2001). Therefore, the effects of the weight cycling of present day athletes and other young adult men on future weight gain cannot be predicted with certainty. Moreover the sample of athletes is restricted to men, and therefore the results of weight cycling and later weight gain should not be generalized to women.

## **10.6 Implications for further research and health promotion**

In this study smoking in adolescence was found to predispose to later abdominal obesity. Given that smoking is often associated with preoccupation with weight, emphasizing more effectively the metabolic consequences of tobacco use might

strengthen smoking prevention. The results presented above also suggest that different approaches may be needed to promote healthy weight control methods and to prevent smoking in middle aged and young adult men and women. Although a strong explanatory factor for both smoking and being overweight, the educational level was found to have no modifying effect on the association between smoking and recurrent dieting. The association is thus not dependent on education despite the fact that the more educated groups were leaner and smoked less than the less educated groups. Smoking prevention and healthy weight control promotion campaigns should target all levels of society. Further longitudinal studies of the associations between recurrent dieting, body weight and smoking behaviours would be needed to effectively plan interventions.

The possibility must be entertained that the repeated weight losses might cause permanent harm for the weight maintenance. This might alternatively be mediated by hormonal or metabolic pathways affecting basal metabolic rate or the regulation of food intake, but also psychological explanations can not be fully excluded. Regarding certain sports this effect should be taken into account when coaching young men. The weight cycling behaviour of the former athletes engaged in power sports at a young age resembles that of young dieters who lose weight temporarily and soon regain it.

For many young persons with perceived rather than real excess weight, a temporary success in the relentless pursuit for thinness may predict an ever increasing problem with weight maintenance. The discouragement of unnecessary dieting may be one of the means to prevent obesity and eating disorders.

## 11 Conclusions

Among young people, smoking predisposes for detrimental fat accumulation on the waist, i.e. abdominal obesity. Furthermore, smoking is associated with recurrent dieting among women at all ages and among men in the younger cohorts. These results should be implicated in planning of tobacco prevention and promotion of healthy life habits, especially among adolescents and young adults. Dieting and overweight are reciprocally connected: overweight predisposes for dieting but paradoxically dieting and especially the usually following weight cycling may predispose for further weight gain. Thus promotion of moderate weight control methods might be an effective tool in obesity prevention. These results should still be interpreted with caution, until replicated in other well-conducted epidemiological studies.

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# 14 Appendices

## Appendix 1. Relevant parts of the FinnTwin16 questionnaires

### Age 16 years

3 CURRENT HEIGHT \_\_\_\_\_ cm

4 CURRENT WEIGHT \_\_\_\_\_ kg

#### SMOKING

20 HAVE YOU EVER SMOKED (OR TRIED SMOKING)?

1 no ----> go to question 24

2 yes

HOW OLD WERE YOU WHEN YOU FIRST TRIED SMOKING?

\_\_\_\_\_ years old

0 I have not tried smoking

21 HOW MANY CIGARETTES HAVE YOU SMOKED ALTOGETHER UP TO NOW?

1 none

2 only one

3 about 2-50

4 over 50

22 WHICH OF THE FOLLOWING BEST DESCRIBES YOUR PRESENT SMOKING HABITS?

1 I smoke once or more daily

2 I smoke once or more a week, but not every day

3 I smoke less often than once a week

4 I am trying to or have quit smoking

5 I have never smoked

#### EATING HABITS

27 HOW OFTEN DO YOU EAT AN EARLY BREAKFAST (SANDWICHES, MILK, CEREAL OR OTHER SUCH FOODS) IN THE MORNING BEFORE GOING TO SCHOOL OR TO WORK?

1 every morning

2 about 3-4 mornings per week

3 about once a week at the most



28 WHAT KIND OF SPREAD DO YOU USE ON YOUR BREAD?

- 1 usually nothing
- 2 mostly margarine (list of typical Finnish brands)
- 3 mostly butter
- 4 butter/margarine mixtures (list of products)
- 5 light spreads
- 6 other, what? \_\_\_\_\_

29 WHAT KIND OF MILK DO YOU USUALLY DRINK?

- 1 I don't drink milk
- 2 skimmed milk
- 3 1% milk
- 4 2% milk
- 5 whole milk (3.5% fat)

30. HOW MANY CUPS OF COFFEE, TEA, CHOCOLATE OR COLA DO YOU DRINK PER DAY? ANSWER SEPARATELY FOR EACH

COFFEE 0 I don't drink daily

1 about \_\_\_\_\_ cups

TEA 0 I don't drink daily

1 about \_\_\_\_\_ cups

CHOCOLATE 0 I don't drink daily

1 about \_\_\_\_\_ cups

COLA 0 I don't drink daily

(Coke, Pepsi) 1 about \_\_\_\_\_ bottles (1/3 liter)

40 WHICH OF THE FOLLOWING ALTERNATIVES BEST DESCRIBES YOUR PRESENT SPORTS/FITNESS ACTIVITIES? I USUALLY DO SPORTS OR EXERCISE SO THAT:

- 1 I breathe hard and sweat profusely
- 2 I breathe rather hard and sweat somewhat
- 3 I don't breathe very hard and sweat but little
- 4 I don't sweat or breathe hard
- 5 I don't do sports or exercise during my free time

41 HOW OFTEN DO YOU EXERCISE OR DO SPORTS DURING YOUR FREE TIME? (SCHOOL PHYSICAL ACTIVITIES DON'T COUNT HERE)

- 1 not at all
- 2 less than once a month
- 3 1–2 times a month
- 4 about once a week
- 5 2–3 times a week
- 6 4–5 times a week
- 7 just about every day

## Age 18.5 years

### EDUCATION AND WORK

3 ARE YOU PRESENTLY ATTENDING SCHOOL OR STUDYING?

- 1 I don't go to school nor do I study ----> go to question 5
- 2 I go to school or study, I don't work
- 3 I go to school or study, but also work

4 WHAT KIND OF SCHOOL OR INSTITUTION DO YOU ATTEND?

- 1 gymnasium (high-school)
- 2 higher education, university
- 3 trade school (accounting-, technical-, agricultural-, etc. school)
- 4 vocational school (business school, engineering school, nursing school etc.)
- 5 vocational high school
- 6 job training programs, vocational training or equivalent.
- 7 other school or institution, what?

5 IF YOU DON'T PRESENTLY STUDY OR ATTEND SCHOOL,  
WHAT DO YOU DO?

I AM:

- 1 in temporary training in order to continue my studies
  - 2 I work for pay
  - 3 I'm serving in the military
  - 4 I'm unemployed or on forced leave
  - 5 I'm at home
  - 6 other
- what? \_\_\_\_\_

13 WHICH OF THE FOLLOWING CHOICES BEST FITS YOUR PRESENT USE  
OF CIGARETTES?

- 1 I smoke at least 10 cigarettes a day.
- 2 I smoke everyday, however, no more than 9 cigarettes a day.
- 3 I smoke once a week, or more often, however, not every day.
- 4 I smoke less than once a week.
- 5 I have stopped or quit smoking.
- 6 I have never smoked.

## Age 25 years

### HEIGHT, WEIGHT, DIETING

36. What is your current height? \_\_\_\_\_ cm

37. What is your current weight? \_\_\_\_\_ kg

(if pregnant, pregnancy not included)

38. At your current height, what has been your highest weight?

(in females pregnancy not included) \_\_\_\_\_ kg

39. At your current height, what has been your lowest weight? \_\_\_\_\_ kg

40. What do you consider to be your ideal weight? \_\_\_\_\_ kg

41. How many times in your life time have you lost 5 kg or more?

1 none

2 once

3 2–4 times

4 5 or more times

Please measure your waist with the enclosed tape measure. Measure your waist at the narrowest part of the torso. If you cannot find the narrowest part, place the measure at the point halfway between your lowest ribs (A) and the upper margin of your hip bone (B), as shown in the picture.

My waist circumference is \_\_\_\_\_ cm

## Parent's questionnaire

FOLLOWING QUESTIONS CONCERN YOUR HEIGHT AND WEIGHT

- 6 How tall are you? \_\_\_\_\_
- 7 How much is your weight nowadays (without clothes)? \_\_\_\_\_
- 8 How much was your weight when you were about 20? \_\_\_\_\_
- 0—I can't say

THE NEXT QUESTIONS ARE ABOUT EDUCATION AND WORK

- 33 What kind of basic education have you had?
  - 1 less than primary school
  - 2 primary school
  - 3 little less than intermediate school
  - 4 intermediate school
  - 5 part of gymnasium
  - 6 bachelor's degree (=a national exam in Finland)
  
- 34 How long is your vocational training (after the basic education asked in the previous question)?
  - 1 no vocational training
  - 2 only course-like or studies at working place
  - 3 school-like studies not over 2 years
  - 4 school-like studies over 2 years
  - 5 university degree
  
- 35 What is your occupation, or if you are not working, your previous occupation? (describe as accurately as possible)  
occupation: \_\_\_\_\_ description: \_\_\_\_\_
  
- 36 What was your occupation about 17 years ago? (before the twins were born)
  - 1 the same as now
  - 2 something else, what?
  
- 37 Are you at present?
  - 1 working, outside home
  - 2 working at home
  - 3 on pension because of injury or illness
  - 4 other kind of pension
  - 5 student, retraining
  - 6 unemployed, looking for a job

## Appendix 2. Relevant parts of the Finnish Twin Cohort questionnaire

6 How tall are you? \_\_\_\_\_

7 How much is your weight nowadays (without clothes)? \_\_\_\_\_

8 Have you ever dieted to lose weight or lost weight by dieting?

- 1 never
- 2 1–2 times
- 3 3–5 times
- 4 6–10 times
- 5 more often

15 Do you have under school aged children living in the same household with you?

- 1 No
- 2 Yes

16 Do you have school aged children living in the same household with you?

- 1 No
- 2 Yes

25 What kind of basic education have you had?

- 1 less than primary school
- 2 primary school
- 3 primary school plus at least one year of vocational training
- 4 intermediate school
- 5 intermediate school plus at least one year of vocational training (including high school)
- 6 bachelor's degree (=a national exam in Finland)
- 7 bachelor's degree plus at least one year of vocational training (including university studies)
- 8 university degree
- 9 other? Please, describe: \_\_\_\_\_

### SMOKING HABITS

29 Have you in your entire life smoked more than 5–10 packs of cigarettes?

- 1 No – skip to question 33.
- 2 Yes

30 Do you smoke or have you at some time smoked cigarettes regularly, in other words daily or almost daily?

- 1 No – skip to question 33
- 2 Yes

31 How old were you when you began to smoke cigarettes regularly?  
\_\_\_\_\_years old

32 Do you still smoke cigarettes regularly?

- 1 No

How old were you when you stopped smoking?  
\_\_\_\_\_years old

How many did you smoke on average per day before you stopped?

- 1 none
- 2 less than 5 cigarettes
- 3 5–9 cigarettes
- 4 10–14 cigarettes
- 5 15–19 cigarettes
- 6 20–24 cigarettes
- 7 25–39 cigarettes
- 8 more than 40 cigarettes

- 2 Yes

How many cigarettes do you smoke daily on average?

- 1 none
- 2 less than 5 cigarettes
- 3 5–9 cigarettes
- 4 10–14 cigarettes
- 5 15–19 cigarettes
- 6 20–24 cigarettes
- 7 25–39 cigarettes
- 8 more than 40 cigarettes

### **Appendix 3. Relevant parts of the questionnaire for the cohort of male elite athletes**

Questions were similar in 1985, 1995 and 2001

#### **FOLLOWING QUESTIONS CONCERN YOUR HEIGHT AND WEIGHT**

6 How tall are you? \_\_\_\_\_

7 How much is your weight nowadays (without clothes)? \_\_\_\_\_

8 How much was your weight when you were about 20 (at the time of your con-  
scription)? \_\_\_\_\_

0-I can't say

#### **SMOKING HABITS**

29 Have you in your entire life smoked more than 5-10 packs of cigarettes?

1 No - skip to question 33.

2 Yes

30 Do you smoke or have you at some time smoked cigarettes regularly, in other  
words

daily or almost daily?

1 No - skip to question 33

2 Yes

31 How old were you when you began to smoke cigarettes regularly?  
\_\_\_\_\_ years old

32 Do you still smoke cigarettes regularly?

1 No

How old were you when you stopped smoking?

\_\_\_\_\_ years old

How many did you smoke on average per day  
before you stopped?

1 none

2 less than 5 cigarettes

3 5-9 cigarettes

4 10-14 cigarettes

5 15-19 cigarettes

6 20- 24 cigarettes

7 25-39 cigarettes

8 more than 40 cigarettes

2 Yes

How many cigarettes do you smoke daily on average?

- 1 none
- 2 less than 5 cigarettes
- 3 5–9 cigarettes
- 4 10–14 cigarettes
- 5 15–19 cigarettes
- 6 20–24 cigarettes
- 7 25–39 cigarettes
- 8 more than 40 cigarettes

#### PHYSICAL ACTIVITY

51 Next we give you five alternatives, which describe the amount of leisure time physical activity. Which alternative best describes your leisure time activity the year round?

- 1 I practically don't do any exercise in my leisure time
- 2 a little
- 3 moderately
- 4 quite a lot
- 5 a lot

52 The exercise you do in your leisure time is usually as strenuous as:

- 1 walking
- 2 shifting between walking and light running
- 3 light running (jogging)
- 4 active running

53 How long does one round of physical activity in your leisure time last?

- 1 less than 15 minutes
- 2 15 minutes – less than half an hour
- 3 half an hour – less than an hour
- 4 an hour – less than two hours
- 5 more than 2 hours

54 How many times a month do you do exercise in your leisure time nowadays?

- 1 less often than once a month
- 2 1–2 times a month
- 3 3–5 times a month
- 4 6–10 times a month
- 5 11–19 times a month
- 6 more than 20 times a month



55 Which of the following alternatives best describes your present leisure time physical activity? I usually do sports of exercise so that:

- 1 I breathe hard or rather hard during almost all the training
- 2 I breathe rather hard sometimes during the training
- 3 moderate shortness of breath
- 4 I don't breathe hard

56 How much time do you spend in walking, biking, running and/or skiing when commuting daily?

- 1 less than 15 minutes
- 2 15 minutes – less than half an hour
- 3 half an hour – less than an hour
- 4 an hour or more
- 5 I am not currently working

57 Which of the following possibilities best describes the physical activity in your work?

- 1 Almost no physical activity. The work is mainly done sitting or standing and includes no lifting of heavy items.
- 2 Some physical activity or a lot of light physical activity. The work does not cause sweating or shortness of breath
- 3 A lot of physical activity and medium heavy lifting. The work causes some sweating or shortness of breath
- 4 A lot of heavy physical activity. The work causes sweating and shortness of breath

65 How often do you use alcohol nowadays? Which of the following alternatives best describes your use of beer, wine and hard liquor?

NEVER	<2DAYS/ MONTH	3–8 DAYS/ MONTH	9–16 DAYS MONTH	>16 DAYS MONTH
BEER	1	2	3	4
WINE	1	2	3	4
LIQUOR	1	2	3	4

How much on average do you use the following alcohol drinks?

Beer

- 1 never
- 2 less than a bottle during a week
- 3 1–4 bottles during a week
- 4 5–12 bottles during a week

- 5 13–24 bottles during a week
- 6 25–47 bottles during a week
- 7 more than 48 bottles during a week

Wine

- 1 never
- 2 less than a glass during a week
- 3 1 glass – 4 glasses during a week
- 4 1–2.5 bottles during a week
- 5 3–4.5 bottles during a week
- 6 5–9 bottles during a week
- 7 more than 10 bottles during a week

Liquor

- 1 never
- 2 less than 0.5 bottle during a month
- 3 0.5–1.5 bottles during a month
- 4 2–3.5 bottles during a month
- 5 4–9 bottles during a month
- 6 10–19 bottles during a month
- 7 more than 20 bottles during a month

89 WHAT KIND OF MILK DO YOU USUALLY DRINK?

- 1 I don't drink milk
- 2 skimmed milk or 1% milk
- 3 low fat milk
- 5 whole milk