Well-being, Body Perception and Weight Status in Young Swedes

The Grow Up Studies

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”The important thing is not
to stop questioning”
- Albert Einstein

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ABSTRACT

The overall aim of this thesis was to investigate well-being, body perception and weight status in an adolescent Swedish population growing up in a changing society with increasing obesity prevalence. The major aims were to document secular changes in, and investigate factors related to, well-being. A well-being scale was adopted for use in adolescents and three childhood BMI classification systems for identifying children at risk of overweight and obesity were assessed.

About 5000 Gothenburg-area students in their final year of high-school (mean age 18.6 years) were included in the Grow Up 1990 birth cohort study. Height and weight were measured and information about well-being, body perception and lifestyle were self-reported. Health records from birth to the final school grade were obtained. Well-being in the Grow Up 1974 birth cohort served as comparison.

Overweight, including obesity, was more prevalent in boys (19%) than in girls (13.4%). However, half of the boys, compared to one-third of the girls, were often satisfied with their body size. The well-being scale developed in this thesis, consisting of five dimensions (*mood*, *self-esteem*, *physical condition*, *energy* and *stress balance*), revealed that boys experienced higher well-being than girls across all dimensions. Objective body measurements accounted for less of the well-being variance than subjective satisfaction with body size. Regular physical activity, resilience and a happy event during the last year were positively related to well-being, whereas reporting little sleep, dissatisfaction with body size and a sad event during the last year were negatively related to well-being. Well-being was lower, and in particular stress levels were higher, in the later-born cohort than in the 1974 birth cohort. These differences were not explained by the shift in weight status. Girls, however, reported higher self-esteem in the later-born cohort, compared to girls born in 1974. The childhood BMI classification systems varied in ability to predict overweight and obesity at age 18, related to weight

status at age 10, although they all mainly correctly identified those without overweight or obesity.

This thesis documents interrelations among well-being, body satisfaction and weight status in Swedish adolescents. These studies identified important factors and interrelations to consider when designing interventions to promote well-being and physical health in adolescents.

Keywords: adolescent, well-being, body mass index, body image, lifestyle, body size, childhood obesity

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SAMMANFATTNING PÅ SVENSKA

Avhandlingen syftar till att kartlägga välbefinnande, kroppsuppfattning och viktstatus bland svenska ungdomar som vuxit upp i ett samhälle med en ökad andel övervikt och fetma. Välbefinnandet i gruppen jämfördes mot en grupp ungdomar födda 16 år tidigare, och vidare undersöktes vilka faktorer som var relaterade till välbefinnandet. För att mäta ungdomarnas välbefinnande anpassades en skala till denna åldersgrupp och tre BMI klassificerings system för barn, för att identifiera barn i riskzonen för att få övervikt och fetma, utvärderades.

Drygt 5000 studenter i tredje året på gymnasiet i Göteborgsområdet ingick i födelsekohorten Grow Up 1990. Standardiserade längd- och vikt-mätningar utfördes och information angående välbefinnande, kroppsuppfattning och livsstil självrapporterades. Dessutom kopierades tillväxtdata från skolhälsovårdsjournaler. En tidigare födelsekohort, Grow Up 1974, användes för att jämföra välbefinnandet.

Andel med övervikt, inklusive fetma, var högre hos pojkar (19%) än flickor (13.4%). Trots det var hälften av pojkarna men bara en tredjedel av flickorna ofta nöjda med sin kroppsstorlek. Skalan för att mäta välbefinnande som utvecklades i denna avhandling bestod av fem dimensioner (*mood*, *self-esteem*, *physical condition*, *energy* och *stress balance*), och pojkarna hade högre välbefinnande än flickorna i alla dimensioner. Att känna sig nöjd med sin kroppsstorlek förklarade mer av variationen i välbefinnandet än vad de objektiva mätningarna av längd och vikt gjorde. Regelbunden träning, resiliens och en glad händelse senast året var positivt realterat till välbefinnandet, medan lite sömn, en ledsam händelse senaste året och att vara missnöjd med sin kroppsstorlek var negativt relaterat till välbefinnandet. Välbefinnandet var lägre och den upplevda stressen högre i 1990 kohorten jämfört med 1974 kohorten, och skillnaderna förklarades inte av ökningen av övervikt och fetma. Däremot rapporterade flickorna i 1990 kohorten högre självkänsla än flickorna i den tidigare kohorten. Olika klassificeringssystem för BMI hos barn uppvisade varierande förmåga att prediktera övervikt och fetma vid 18 års ålders relaterat till viktstatus vid 10 år. Däremot kunde de till stor del korrekt klassificera individer som inte fick övervikt eller fetma.

Avhandlingen dokumenterar välbefinnande, kroppsuppfattning och viktstatus, samt sambanden dem emellan, hos svenska ungdomar. Studierna identifierar viktiga faktorer och samband som bör beaktas när man designar interventioner för att främja välbefinnande och fysisk hälsa hos ungdomar.

LIST OF PAPERS

This thesis is based on the following studies, referred to in the text by their Roman numerals.

I. Agneta Sjöberg, Marie-Louise Barrenäs, **Ebba Brann**, John E. Chaplin, Jovanna Dahlgren, Staffan Mårild, Lauren Lissner, Kerstin Albertsson-Wikland.
Body size and lifestyle in an urban population entering adulthood: the 'Grow up Gothenburg' study.
Acta Paediatrica 2012; 101(9): 964-72. DOI: 10.1111/j.1651-2227.2012.02722.x

II. **Ebba Brann**, Agneta Sjöberg, John E. Chaplin, Monica Leu Agelii, Kirsten Mehlig, Kerstin Albertsson-Wikland, Lauren Lissner.
Evaluating the predictive ability of childhood body mass index classification systems for overweight and obesity at 18 years.
Scandinavian Journal of Public Health 2015; 43(8): 802-9.
DOI: 10.1177/1403494815596123

III. Sarah Hitz, **Ebba Brann**, Kerstin Albertsson-Wikland, Zita Schillmöller, John E Chaplin.
Development of the Gothenburg Well-Being in Adolescence Scale: the Grow Up Gothenburg Study.
In manuscript.

IV. **Ebba Brann**, John E. Chaplin, Monica Leu Agelii, Agneta Sjöberg, Aimon Niklasson, Kerstin Albertsson-Wikland, Lauren Lissner.
Declining Well-Being in Young Swedes Born in 1990 Versus 1974.
Journal of Adolescent Health 2016; DOI: 10.1016/j.jadohealth.10.009

V. **Ebba Brann,** Agneta Sjöberg, Kerstin Albertsson-Wikland, Monica Leu Agelii, Aimon Niklasson, Lauren Lissner, John E. Chaplin.
Anthropometric Measurements, Subjective Body Satisfaction and Lifestyle in Relation to Adolescent Well-being.
In manuscript.

CONTENTS

ABBREVIATIONS

AIC	Akaike Information Criterion
BMI	Body Mass Index
CFA	Confirmatory Factor Analysis
EFA	Exploratory Factor Analysis
GWBa	Gothenburg Well-Being in adolescence scale
GWBc	Gothenburg Well-Being in children scale
$IOTF_{2000/2012}$	International Obesity Task Force BMI classification system 2000/2012
KMO	Kaiser-Meyer-Olkin measure of sampling adequacy
LR	Likelihood Ratio
NPV	Negative Predictive Value
OwOb	Overweight including obesity
PA	Physical Activity
PPV	Positive Predictive Value
RR	Relative Risk
SD	Standard Deviation
SE_{2001}	Swedish BMI classification system 2001
WHO	World Health Organization
WHO_{2007}	World Health Organization BMI-for-age classification system 2007

1 INTRODUCTION

Adolescence is a time of many changes, both physical and mental, and is often considered a very turbulent period of life. Young children adopt the lifestyle and habits of their closest family, but as they become more independent during adolescence they start to develop their own lifestyle. Thus, this period of life creates the basis for good health later on. Likewise, prevalent societal norms and values influence adolescents' attitudes and behaviours, which, together with the circumstances in which they live, may also affect their well-being. This implies that well-being may potentially differ between populations born in different periods. Furthermore, it has been suggested that higher well-being during adolescence can be a predictor of better perceived general health and can lower the likelihood of risky health behaviours during young adulthood (1).

One of the societal changes that may impact on the well-being of adolescents is the rapid increase in overweight and obesity levels occurring among young populations in many parts in the world. The consequences of childhood obesity for physical health in adult life are numerous and known. However, the effects of obesity on well-being are less clear and there is some lack of agreement between studies. It is sometimes believed that obesity may lead to lower well-being since it is a stigmatized condition, with possible consequences such as victimization and discrimination (2).

In contrast, the effect of obesity on body satisfaction has been studied much more. It is a common assumption that excess weight is related to body dissatisfaction, particularly in girls. Boys can also be dissatisfied with their bodies and this is known to relate both to excess weight and the wish to become bigger, i.e. develop more muscles (3).

This research was undertaken in an adolescent Swedish population growing up in a society with increasing obesity prevalence as well as other changes. The general objective was to better understand which factors are related to well-being and in particular how well-being, body perception and weight status are interrelated.

1.1 Adolescence

According to the World Health Organization (WHO), adolescents are defined as young people between the ages of 10 and 19 years (4). This is a large group in society, constituting about 13% in Sweden in 2009 (5). The word

adolescence originates from the Latin “adolescere”, which means “to become adult, grow up”. It is a phase in life involving many developmental transitions and includes biological, social and cognitive changes (6). Puberty, in the biological sense, involves biological events such as neuroendocrine development, leading to gonadal maturation and steroid hormone productions. It involves the pubertal growth spurt, entailing a rapid increase first in height and later in weight. The onset of the growth spurt occurs earlier in girls than boys and adult height is usually reached in the third decade of life (7), occurring earlier in girls. In puberty, girls gain more adipose tissue than boys, especially in the area of the hips, thighs, buttocks, waist and breasts, while boys develop more muscles. In this way body shape and composition both change differentially in boys and girls.

The social transition from childhood to adulthood is a period in life when the individual becomes more independent and gains increased freedom. Adolescents spend more time with peers and distance themselves from their parents (8). Close friendship with peers may help them to cope with everyday problems and with the pressure to become adults. Parents may be perceived as less important (9) while the influence of peers, the media and society become more important. At the same time, cognitive behaviours involving logical and abstract thinking are developed (6), as well as understanding others’ thoughts or emotions. These improvements in cognitive behaviours occur in functions including organization, decision making and planning and response inhibition (10). The cognitive development is a lengthy process, and an important observation is that adolescents, in a historical perspective, are now confronted earlier with situations demanding high cognitive skills (11). This may be related to the wide variety of choices to be made in everyday life and a decline in monitoring from parents (11). In addition, there has been a secular trend in timing of puberty, often estimated as menarche, which occurs earlier compared to a century ago (12). Altogether, society has become more complex and the biological transition of adolescence now precedes the mental and social components of maturity more than previously (6) and this mismatch may be of significance for health (13).

During adolescence, boys and girls may be under increased pressure to adapt to gender roles in society (14). These include identity (an individual’s own beliefs about his or her gender identity), attitudes (the roles in society as a male or a female), behaviour (leisure activities, appearance maintenance, etc.) and sexual identity. This is also likely to affect body perception and satisfaction, as well as general health and well-being.

Against the background of this transitional stage, including rapid physical, social and cognitive developmental changes, adolescence is a period of crucial importance regarding the establishment of life-long lifestyle habits (15). It is thus important that society promotes a healthy lifestyle in adolescents that will contribute to good health later in life. Healthy, well-educated and skilled adolescents serve as an important resource both to their families and to society. Young people obtain support from, but will also be exposed to health-risks by, their closest family, peers, and school. Lifestyle during adolescence will influence adult health and thus also have consequences for public health.

1.2 Well-being

An early description of well-being refers to people's subjective evaluations of their lives and focuses both on cognitive and emotional aspects (16). By this definition the three main components were described as: positive affect, negative affect and satisfaction with life. The same author recently updated his description of well-being and described it as "an umbrella term for different valuations that people make regarding their lives, the events happening to them, their bodies and minds, and the circumstances in which they live" (17). In early research, well-being was sometimes described by the informal term happiness (16). However, the sense of happiness included in the concept of subjective well-being may also be referred to as a mood (18), which can be thought of as a deep, positive feeling of happiness that is always present. It is a stable feeling and, although it can be temporarily affected, it still remains in the background. It helps individuals see the positive aspects in life and is important when evaluating the perceived life situation.

It has been suggested that happiness is positively correlated with several indicators of mental and physical health. This is probably due to its effects on social relationships, the liking of self and others, healthy behaviour and stress (19), as well as to its possible effect on the immune system (20). Furthermore, results from longitudinal studies show that happiness is a predictive indicator of success measured, for example, as meaningful work, good relationships, good mental and physical health and longevity (19).

The concept of subjective well-being, as described above, stems from the tradition within the hedonic approach, focusing on experiencing a high level of positive affect, a low level of negative affect, and a high degree of satisfaction with one's life (21). Another research tradition is the eudaimonic approach, which focuses on human development, the meaning with life and

self-realization and has been seen as the full functioning of an individual (22). Psychological well-being is a central concept in this tradition (23). Because well-being is a complex construct and described by different concepts the exact definition remains unclear (24).

Studies on well-being at different ages have observed a U-shaped curve across the life span. The subjective feeling of well-being is high in youth, falls in midlife, but appears to start rising again in old age (25). Thus, the level of well-being at around age 80 years seems to be similar to that at around age 20 years. However, these well-recognized findings have been challenged by those suggesting more stable development from age 20 years until around age 55 years, followed by an increase and then a subsequent decline around the age of 75 years (26). These inconsistent results do not reveal whether adolescent have low or high well-being, compared to individuals of other ages. However, generally high well-being of Swedish children and adolescents was observed in a systematic overview of Swedish studies (27).

It is recognized that successful adaptation to changes is important for sustained well-being. This adaptation to changes can be described in terms of resilience in the individual. Resilience can broadly be defined as the capacity of a dynamic system to adapt successfully to events that threaten system function or development (28). Furthermore, the term refers to an individual's ability for positive adaptation when facing adverse conditions (29) and can be regarded as a personality characteristic that moderates the negative effects of stress and promotes adaption (30). Resilience is considered an important component to maintaining and promoting mental health among children and youths, and as an individual strength protecting well-being over time and transition (31). This concept builds on an individual's strengths rather than on emphasizing deficits. It has been suggested that there is a positive relationship between an individual's resilience and well-being (32). However, the relative importance of resilience as opposed to other factors in promoting well-being in adolescents is not fully understood.

Early studies of well-being often consisted of single-item survey questions. The drawbacks of these scales are related to the lack of reliability within and across individuals, leading to high variance in results (16). A single-item scale misses the complexity of the concept and will be less sensitive to change than a multi-item, multi-dimensional scale. Thus, measures of subjective well-being are suggested to comprise three hallmarks (16). Firstly, they should be concerned with the experience within the person. Furthermore, they should focus not only on the absence of negative factors

but instead include both positive and negative measures. Lastly, they should include individuals' overall assessment of their lives. Several instruments using multiple items to measure different dimensions of well-being are presently available (33). In addition, due to the lack of consensus about how well-being should be defined, each instrument uses a specific description of well-being as the basis for the respective instrument. Therefore, comparison between studies is difficult, as different scales reflect various dimensions of well-being (34).

1.3 Body perception

Satisfaction with one's body can be a question of the degree of satisfaction with specific measurable parameters, such as weight and height, but can also include a more complex concept, such as body image. Body image is a multidimensional and complex construct (35) consisting of individual's self-evaluation of their appearance, body size and height. Due to this subjective evaluation, it can be different from how others perceive them. Likewise, body image can be regarded as the subjective "picture" that people have of their own bodies, regardless of how their bodies actually look. The concept includes thoughts, beliefs, feelings, and behaviours in relation to the body (36), such as feelings of joy, shame or contentment. Body image influences how a person is psychologically affected by their "outside" appearance (37), and is an important part of everyday life, impacting on thoughts, beliefs and feelings beginning from early childhood (35).

This self-evaluative characteristic is not static, instead, it changes over the lifespan (38). Body image development starts early in childhood, and children as young as six years of age can express body dissatisfaction and concern about weight (39). Adolescence, due to its many development transitions, is a critical period for healthy body image development (40). Biological changes in body shape at puberty distance girls in our society from the ideal slender female body shape. On the other hand, boys' development moves them closer to the tall, muscular and broad-shouldered ideal body. As a result, girls' body dissatisfaction increases during this period, whereas boys become more satisfied with their bodies (41). However, it has been shown that late-maturing boys report more body concerns compared to boys who mature early (42). Peers may also play an important role in body perception, and being teased about appearance has been found to have consequences on body dissatisfaction development (43). In addition, another source that communicates this unrealistic standard of female beauty is mass media. It has

been shown that girls that were exposed to thin-ideal commercials had greater dissatisfaction than girls' watching non-appearance commercials (44).

Importantly, weight status in adolescence is strongly related to body image. There is evidence that excess weight is related to body dissatisfaction in both boys and girls (45). Moreover, results from a longitudinal study in adolescent boys and girls showed that body satisfaction decreased with increasing BMI (46). Concerns about being obese may be more prevalent in girls while boys may also be concerned when being underweight (47). Body dissatisfaction, especially concerns about being or becoming overweight or obese is, at least in girls, related to depression and eating disorders (48, 49).

There are a wide variety of existing instruments to measure body perception (50). One simple method is to compare actual weight with the individual's perceived ideal weight in order to estimate weight satisfaction. There are also different figural rating methods to measure discrepancies between perceived and ideal body size. Furthermore, there are questionnaires aimed at measuring dissatisfaction with different parts of the body or that include components which are important for body image.

1.4 Weight status

Starting in the 1970s, childhood overweight and obesity prevalence have increased worldwide (51). In several large regions including Canada, United States, Western Pacific and Southern Europe, the prevalence of overweight and obesity was seen to double or even triple from the 1970s to the end of 1990s. In Sweden, results from a long-term comparison of 18-year-old boys, showed that from 1971 to 1995, prevalence of overweight more than doubled and obesity increased 3.5 times (52). Overweight and obesity prevalence in Swedish schoolchildren were estimated to be 17% and 3%, respectively (53).

One possibility of measuring overweight and obesity is by using body mass index (BMI), calculated by dividing weight in kilograms by squared height in meters. This measure relates body mass to weight and height (54) and is used as an indirect measure of body composition. However, BMI does not distinguish whether weight is associated with muscle or fat. BMI is commonly used for classification of underweight, overweight and obesity, by using pre-defined cut-offs, based on the increased risk of disease at higher BMI levels. Other indirect measures of body composition are skin-fold thickness, waist circumference and waist-to-hip-ratio (55).

Among the methods for directly measuring body composition are underwater weighing, magnetic resonance imaging (MRI) and dual energy X-ray absorptiometry (DEXA) (56). In addition, multi- or bio-electric impedance analysis (BIA) measures impedance of the body to a small electric current, although less accurate than the more sophisticated measurements. These methods are all suitable but some of them require expensive equipment and others may require substantial experience in those performing the tests. BMI has been argued to be a suitable parameter for larger population-based studies, as it is easy to perform and relatively inexpensive (57).

BMI in adults is relatively stable, mainly influenced by weight gain or weight loss, compared to growing children in whom different tempo of height gain also influence the BMI calculation. Therefore, in adults the same cut-offs are used to classify underweight, normal weight, overweight and obesity, regardless of sex or age. In contrast, children's BMI fluctuates dramatically as they grow. Growth patterns in boys and girls also differ and the classification of weight status must thus take both sex and age into consideration. The BMI of a child may be compared to that of a reference population, and classified according to the age- and sex-adjusted distribution of BMI in that population. Many countries, including Sweden, have their own national childhood BMI classification systems. A commonly used Swedish BMI classification system, (SE_{2001}) (58), is based on longitudinal growth data from Swedish children taking part in the Grow Up 1974 birth cohort study. It is used as a national reference to facilitate clinical application and to be used in the evaluation of growth and nutrition among children and adolescents within the Swedish health care system (58). There are also international BMI classification systems that are used worldwide. The International Obesity Task Force (IOTF) (59-61) and the WHO BMI-for-age classification system (WHO_{2007}) (62) are two of these. The IOTF is based on international cross-sectional data and was developed to provide a common basis for prevalence estimates internationally. The WHO_{2007} is based on cross-sectional data from the US. It was developed for clinical and public health applications and meant to be used worldwide.

The classification of weight status in children is important in view of the serious consequences of childhood overweight and obesity. For example, obesity has been associated with increased risk of later diabetes, stroke, coronary heart disease, hypertension and premature mortality in adult life (63, 64). In addition, psycho-social factors found to be related to overweight and obesity include body dissatisfaction, weight-related stigmatization, being teased about weight and unhealthy eating behaviour (65, 66). These consequences not only have an impact on the individual but also on society.

It has been shown that obesity in childhood often remains into adulthood (67, 68). With increasing levels of childhood overweight and obesity there is a concern that future health comorbidities will increase and thereby increase health-care costs. With the knowledge about both physical and psychological health risks associated with obesity, monitoring of weight status is important for early intervention in children with obesity, as well as primary prevention in children with overweight.

2 AIM

The overall aim of this thesis was to investigate well-being, body perception and weight status in an adolescent Swedish population growing up in a changing society with increasing obesity prevalence.

Using a contemporary adolescent population taking part in Grow Up 1990, a birth cohort study based on cross-sectional data and longitudinally anthropometric data, the specific aims were to:

- describe the Grow Up 1990 birth cohort in terms of weight status, body image and lifestyle variables
- evaluate the performance of three childhood BMI classification systems by using weight status at age 10, for predicting overweight and obesity at around age 18
- adapt and further develop an established childhood well-being scale, for use in an adolescent population
- compare well-being in the Grow Up 1990 study to a similar cohort born 16 years earlier, the Grow Up 1974 birth cohort, in relation to weight status
- assess the effects of objectively measured height and weight, in comparison with perceived satisfaction with height and body size respectively, in relation to well-being. In addition, to explore other factors associated with well-being.

3 METHODS

3.1 Study samples

The papers in this thesis were based on data from a Swedish school-based study, the Grow Up 1990 Gothenburg study. Furthermore, data from a study performed under a similar protocol, the Grow Up 1974 Gothenburg study, were included in Paper IV. The target population in both studies was students, around 18 years old, attending all high schools in Gothenburg and, in the Grow Up 1990 study, also the adjacent municipalities (Kungsbacka, Kungälv, Lerum, Mölndal, Mölnlycke and Partille).

In the Grow Up 1990 study, data were collected in high school students, most of whom were born in 1990, examined during their last year of high school (12^{th} grade). There were 47 high schools in the area, of which five declined to participate and two were excluded due to regular vocational training outside the schools. This resulted in 40 schools and 9179 invited participants (Figure 1). Some (4.8%) of the students actively declined to participate, while some (32%) were absent from school on the examination day. The final participation rate was 63% for questionnaires and 59% for anthropometric measurements. Participation rates were similar in girls and boys. Most (84.8%) of the participating students were born in 1990. Of the 5686 participants, 84.2% (4690) were of Nordic origin, 14.1% (801) were of non-Nordic origin and 1.7% had no available information on country of origin. Of the participants of non-Nordic origin, 46.6% were born in Sweden. Participants not born in Sweden were mainly born in Bosnia-Hercegovina, Iraq and Colombia, followed by a number of countries in various regions. Additional details are given in Paper I.

In the Grow Up 1974 study, data were collected in high school students, mostly born in 1974, in their 11^{th} or 12^{th} school year in Gothenburg. A total of 5111 students were eligible and were invited to participate. Some (3.4%) actively declined to participate while some (8.8%) were absent from school on the examination day (Figure 1) (69). The participation rate was 86% for questionnaires and 88% for measurements. Seventy six percent of the participating students were born in 1974. Approximately 97% of the participants were born in Sweden and could therefore be traced in the Medical Birth Register. All healthy participants, born at term, with growth data both at birth and at final measurement (3650) formed the population in the Swedish growth reference, hereafter referred to as the SE_{2001} (70).

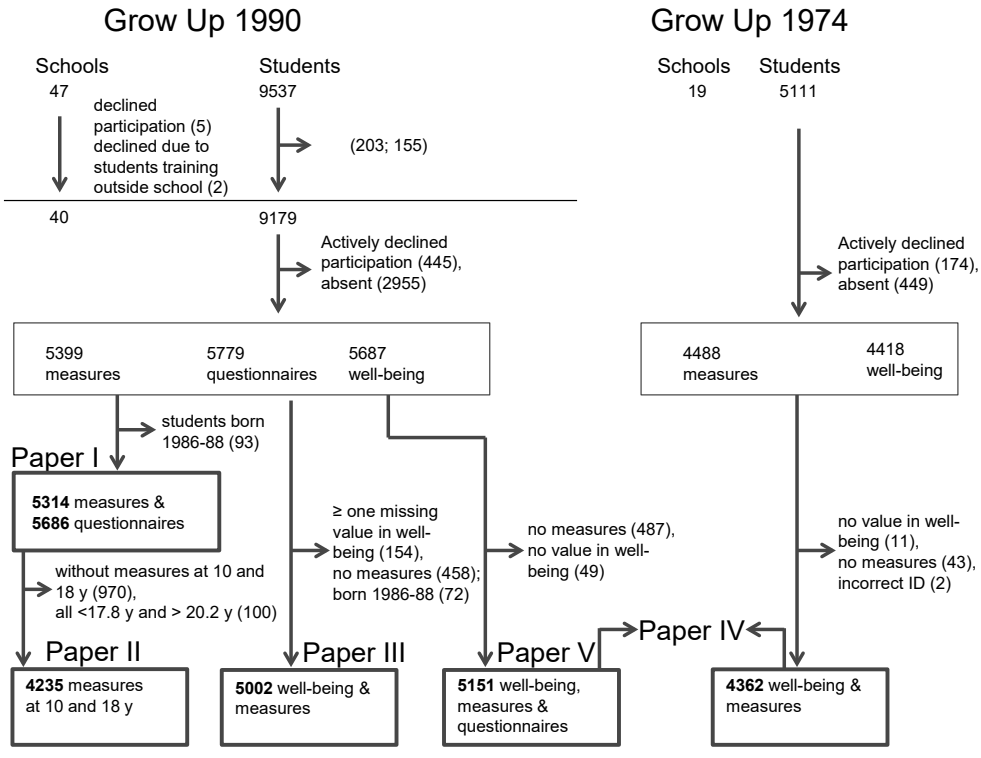

Figure 1. Flow chart of the Grow Up 1990 and 1974 studies

3.2 Study procedure

3.2.1 Grow Up 1990 (Papers I, II, III, IV, V)

The Grow Up 1990 data collection was performed during the academic years 2008-2009. In the period between October 2008 and June 2009, study teams visited the schools at least twice. During a lesson, students filled in a questionnaire and anthropometric measurements were taken. The questionnaire consisted of 17-pages of questions concerning health, origin (country of birth for subjects and parents), lifestyle (diet, meal pattern, sleep duration, physical activity), body perception, resilience and well-being. School health care records including records from child health centres were copied to obtain the individual growth curves. This study was partly a replication of the Grow Up 1974 study.

3.2.2 Grow Up 1974 (Paper IV)

The Grow Up 1974 study was carried out from April to November, 1992. Study teams visited the schools and students were measured and filled in a questionnaire during a lesson. The questionnaire contained questions about health (chronic illness) and well-being. School health care records including records from child health centres were copied to obtain the individual growth curves.

3.3 Measurements

3.3.1 Anthropometric measurements

Height and weight measurements were taken using the same instruments and procedures in both the Grow Up 1990 and 1974 studies. The descriptions of weight and height measurements below thus refer to both studies.

Portable equipment was brought to the schools and standardized measurements were taken by trained study teams. Participants were dressed in indoor clothes with no shoes and measurements were carried out in a separate room during school hours. Height was measured to the nearest 0.1 centimetres (cm) using a calibrated Harpenden stadiometer, and three independent measures were recorded, based on which mean values were calculated. Weight was measured to the nearest 0.1 kilograms (kg) using Seca 862 digital weighing scales (Seca United Kingdom, Medical Scales and Measuring Systems, Birmingham, United Kingdom). The scales were calibrated by the supplier. The precision of the scales was checked over the

course of the study and no discrepancies were found when compared to a stationary, calibrated scale.

Standard deviation scores for height, weight and BMI

Standard deviation (SD) scores for height, weight and BMI were calculated based on the distribution of the reference population (mean and SD). Because of the standardized quantities, SD scores are compared across ages and sexes and can be used as continuous variables.

Weight status and height

Weight status at around age 18 years was classified according to different classification systems: the WHO adult BMI classification (Paper II), the WHO adult BMI classification system together with the $IOTF_{2000}$ (Paper I) or together with the WHO_{2007} (Papers IV and V). The WHO adult BMI classification is valid from the age of 18 years and is based on the calculated BMI and defines underweight as BMI <18.5, overweight as BMI ≥25 - <30, and obese as BMI ≥30 (54). The two other classification systems are age- and sex-adjusted. When the $IOTF_{2000}$ was applied, participants younger than 18 years were classified using sex- and half-year age-specific cut-offs. Older participants were classified according to the WHO adult BMI classification (Paper I). When the WHO_{2007} was applied, the crude BMI was transformed into a SD score (Table 1). Participants younger than 19 years were classified by the predefined BMI SD score cut-offs (underweight = <-2SD, overweight = >+1SD - ≤+2SD, obese = >+2SD), while older participants were classified according to the WHO adult BMI classification (Papers V, IV).

Weight status at ten years of age was classified according to the $IOTF_{2012}$, the WHO_{2007} and the SE_{2001} (Table 1). The $IOTF_{2012}$ is an updated version of the $IOTF_{2000}$, and we used sex- and monthly age-specific cut-offs. Like the WHO_{2007}, the SE_{2001}, is based on the crude BMI and then transformed into a SD score. The -2 SD, +1SD and +2SD are marked on the BMI charts used for monitoring children in paediatric health care centres and in school health care. These levels were therefore used for comparison purposes.

Height at around age 18 years was evaluated by using the height SD score. In addition, a categorized variable was constructed, by dividing the study population into 3 approximately equally sized groups based on their SD-score. These groups were defined as short, normal and tall.

Table 1. Childhood BMI classification systems used in the thesis, according to purpose, reference population, age-range and cutoffs for weight status groups. Note $IOTF_{2000}$ was used in Paper I before the updated $IOTF_{2012}$ became available and there are only minor differences between the two versions.

	$IOTF_{2012}$	**WHO_{2007}**	**SE_{2001}**
Intention	Common set of definitions for descriptive and comparative purposes internationally	International growth reference for screening, surveillance and monitoring	Evaluation of growth and nutrition in clinic, national growth reference
Reference population	Cross-sectional data from 6 countries (Brazil, Great Britain, Hong Kong, the Netherlands, Singapore, United States) (born mainly 1970s – 1980s), n: ~192000	Cross sectional data from 3 separate samples of children and adolescents surveyed in the US (born: 1950s, ~1949-1963 and 1960s), n: 22917	Longitudinal growth study of full-term healthy Swedish children born 1973-1975, (Grow Up 1974 birth cohort) n: 3650
Cut-offs	2-18 years Age and sex specific cut-off points defined by values of BMI at age 18 i.e.: underweight BMI<18.5, overweight BMI ≥25 - <30, obese BMI≥30	5-19 years Calculation of SD scores. Cut-offs underweight <-2SD, overweight: >+1SD, obesity: >+2SD	0-18 years Calculation of SD scores. Cut-offs underweight <-2SD, overweight: >+1SD, obesity: >+2SD

3.3.2 Questionnaires

Absence of chronic disease (Papers I, V)

The students were asked if they had ever had a chronic disease (yes/no) and, if yes, about the type of condition and medication. In Paper I, if a student for instance reported asthma/allergy but was only taking over-the-counter medication she/he was considered not to have a chronic disease. In Paper V, the type of condition and medication were not evaluated and the participants' own response on chronic disease (yes/no) was used.

Parental origin/country of birth (Paper I)

The parents' country of birth was used to classify participants as Nordic or non-Nordic. If at least one parent was born in Sweden, Denmark, Finland, Iceland or Norway, the origin was defined as Nordic. Participants could note their own country of birth.

Lifestyle factors (Papers I and V)

A short (19 items) food frequency questionnaire was used to assess habitual intake (last three months) of vegetables, fruit and sweetened beverages. Dichotomized variables were constructed (yes/no) for assessment of daily consumption. Breakfast daily (Paper I) and regular meals (Paper V) were assessed using a dichotomized variable (yes/no). Smoking was divided into three categories (never, occasionally and daily). Two questions concerning consumption of spirits and other types of alcohol were dichotomized (never compared to all other alternatives). Regular physical exercise during leisure time was reported as yes or no. Sleep duration was assessed both by a dichotomized variable (<8h: yes/no in Paper I) and by three categories (<7h, 7-8h, >8h in Paper V). Cell phone switched on at night and computer connected at night were assessed, both by a dichotomized variable comparing yes to all other alternatives (often, sometimes never) (Paper I) and a variable comparing no to all other alternatives (Paper V).

Being teased (Paper V)

The experiences of having been teased about being short, fat or thin were each assessed based on the possible responses of often, sometimes or never.

Body perception (Papers I and V)

Body perception was evaluated using different kinds of measurements; the body image scale and two questions about satisfaction with height and body size. The body image scale was based on the "I Think I Am" instrument (71). Eight statements from the physical characteristics component relating to body image were used, including five positive and three negative statements. Example of statements: "*I like the way I look",* "*I would like to change a lot of things about my body"*. There were four response alternatives (true, partly true, partly not true, not true). Negative statements were reversed and a summary variable was constructed. This was transformed to a score between 0 and 100, where 100 represented the most positive perceived body image. At least six of the eight statements had to be answered for the summary score to be calculated. Having very high body satisfaction was defined by a score ≥ 90. Furthermore, the four responses were dichotomized into the most positive alternative, compared to the other three. Participants' subjective perceptions of their body size and height were specifically evaluated by the question "*Are you satisfied with your body size*" (often, sometimes, never) and there was a similar question for the perception of height. These two single-item questions were chosen in order to compare objective height and weight status to perceived satisfaction with height and body size.

Well-being (Papers III, IV, V)

The origin of the Gothenburg Well-Being in adolescence scale (GWBa) is an item pool of word pairs developed in the early 1990s as a paediatric self-assessment instrument for children and young people (72). The selection of word pairs aimed at describing behavioural attributes, feelings and attitudes important to the well-being of children, particularly those of short stature. The chosen word pairs were used in visual analogue scales, with endpoints defined by words denoting the extreme opposites of the attribute to be measured. The word pairs were initially discussed with teachers and children in order to ensure that they were fully understood by children aged nine years and upwards. A pilot study conducted with school children aged from nine to thirteen years resulted in the removal of certain words and the identification of new ones as complemental attributes of interest. The remaining pairs of words, 35 items, constitute the Gothenburg Well-Being in children scale (GWBc), which consists of six dimensions and has been used in previous studies (73, 74). In order to evaluate the factor structure of the GWBc on an older age group it was necessary to test all of the original items, as some of these may have been rejected due to age-related issues. Therefore, all 49 items were included in the current questionnaire. The suitability of the GWBc structure was tested on data obtained from the Grow Up 1990 study and failed to produce any evidence of a good fit. The subsequent analyses performed for the development of the GWBa are described in section 3.4 (Statistical analysis).

The GWBa was developed in Paper III, and utilized in Papers IV and V. It consists of a total score and five dimensions: *mood* (based on 4 items e.g. sad-happy), *physical condition* (4 items e.g. slow-quick), *energy* (4 items e.g. uninterested-interested), *self-esteem* (6 items e.g. fearful-brave), and *stress balance* (4 items e.g. stressed-unstressed). Dimension scores and the total score are given in the range of 0-100, with a higher score indicating a higher level of well-being.

Happy and sad events (Paper V)

The participants' own perception of having experienced a happy or sad event during the last year was assessed by two separate questions for happy and sad events, answered by a yes/no response. This was used as an example of external factors that are likely to affect well-being, as opposed to internal factors, e.g. resilience, below.

Resilience scale (Paper V)

Resilience was measured by an 11-item resilience scale (75, 76), which is based on an earlier 25-item scale, the Resilience Scale, developed by

Wagnild and Young (30). The 25-item Resilience Scale was originally constructed to measure internal resources within the individual (30). Responses to each item were on a 10-point scale where 1=disagree and 10=agree. All statements were positively worded and a summary score was calculated. This score was transformed into a scale between 0-100 where 100 represented the highest level of resilience. Sample items include: "*I usually manage one way or another*"; "*I can usually look at a situation in a number of ways*"; and "*I am friends with myself*".

3.4 Statistical analyses

In all papers, p-values <0.05 were considered statistically significant (two-sided) except pairwise comparisons of sensitivity, specificity and likelihood ratios (LR) (Paper II) and multivariate linear regression (Paper IV), for which Bonferroni correction was applied ($p < 0.017$ and $p < 0.01$, respectively). Likewise, Bonferroni correction was applied in the generalized linear model mixed model (Paper V).

Cohen's d (with the pooled SD as the denominator) was calculated to estimate the effect size (Paper IV and in section 4.3.1). Effect sizes under 0.2 were considered small, effect sizes up to 0.5 were considered medium and those exceeding 0.8 were regarded as large.

Weight status was described as prevalence of different weight class categories (underweight, normal weight, overweight, obese) with 95% confidence intervals. In the regression analyses in Papers IV and V, the normal weight was used as the reference category.

Most statistical analyses were performed using the SPSS statistical packages 18.0 and 23 (SPSS Inc., Chicago, IL, USA). Moreover, the SD scores for the SE_{2001} were calculated using SAS 9.2 (SAS Institute INC., Cary, NC, USA). The SD scores for the $IOTF_{2012}$ reference and the overall comparison of LRs were performed using the R version 3.1.1, The R Project for Statistical Computing: http://cran.r-project.org accessed 14.08.2014. The confirmatory factor analysis was done using IBM SPSS AMOS 23.0.

Paper I

For studying anthropometric measures, lifestyles, body image and health, the differences between sex, origin and the sex-origin interaction were estimated using generalized linear models. Furthermore, if the interaction term was significant, additional generalized linear models analyses were undertaken to specify the effect of sex in the Nordic and non-Nordic origin groups and the

effect of origin in the groups of boys and girls. It was assumed that responses within each school were correlated; therefore, all analyses were adjusted for this effect.

In order to investigate the relation between objectively measured height and weight with body image scale and satisfaction with height and body size, additional analyses were undertaken (not reported in Paper I). P-values for differences in body image score between adolescents of short, normal or tall stature were obtained from a linear regression model with normal height as the reference category. Furthermore, the relation between height SD score and satisfaction with height was analysed by means of linear regression with "often satisfied with one's height" as the reference category. P-values for the differences in body image score between the underweight, normal weight, overweight and obese groups were obtained from a linear regression model with normal weight as the reference category. In addition, the proportions of being satisfied with one's body size across weight status groups are shown.

Paper II

The accuracy of the three childhood BMI classification systems was analysed using the weight status classification at age ten years, as the test criterion and weight status at age 18 years as the outcome. Sensitivity was defined as the proportion of obese 18-year-olds classified as obese at age ten years (true positives). Specificity was defined as the proportion of non-obese 18-year-olds classified as non-obese at age ten years (true negatives). The positive likelihood ratio (LR+) estimates the likelihood of an obese 18-year-old to be classified as obese at age ten years, compared to a non-obese 18-year-old, and was calculated as the ratio between sensitivity and [1-specificity]. The negative likelihood ratio (LR-) calculated as the ratio between [1-sensitivity] and specificity, estimates the likelihood of a non-obese classification. A LR+ or LR- value close to 1 indicates that the classification at age ten years provides little additional information regarding the presence or absence of obesity at age 18 years. Additionally, the relative risk (RR) of obesity at age 18 years in individuals classified as obese at ten years of age, was calculated according to the three different BMI classification systems. All parameters (sensitivity, specificity, LR+, LR-, RR) were also calculated for overweight including obesity (OwOb).

In addition, the positive predictive value (PPV) and negative predictive value (NPV) was also estimated (not reported in the Paper II). It determines the probability of the test result being correct and is a clinically useful test. The PPV was calculated as (obese at ages 10 and 18 years/all obese at age 10 years), and the NPV was calculated as (not obese at ages 10 and 18 years/all

not obese at age 10 years). Thus, PPV is the proportion of the ten-year-olds classified as obese who are obese at age 18 years, and NPV is the proportion of non-obese ten-year-olds that are not obese at age 18 years. The same calculations were made for OwOb.

Paper III

The structure of the GWBc was tested on the Grow Up 1990 study data by a confirmatory factor analysis (CFA) and evaluated by indices of model fit. Because no evidence of fit was shown, the analyses proceeded to explore the underlying latent structure in the adolescent population using all 49 items. An additional objective was also to identify items that could be removed from the final version of the questionnaire in order to reduce the burden on the respondent.

Where a negative word constituted the highest endpoint on the visual analogue scale, it was reversed in order to have all items evaluated on the same basis of 100=good, 0=bad. Before the analysis began, 154 questionnaires were omitted due to one or more missing item. In order to assess the suitability of the data for the factor analysis, the Kaiser-Meyer-Olkin (KMO) measures of sampling adequacy and the Bartlett's test of sphericity, were calculated; a KMO value of at least 0.5 and a significant Bartlett's test of sphericity were the targets. The data set was randomly split in approximately two halves to allow for a test and confirmation sample. The first subsample (n= 2505) was explored for a latent structure in an exploratory factor analysis (EFA) using principal axis factoring (PAF), with an oblique rotation (promax), as we assumed that the factors (dimensions) would be related. The number of factors to retain was determined by the Kaiser criterion (eigenvalue >1) and the scree test. Factor pattern matrices were examined for simple structure and interpretability. Items with factor loading ≥0.45 were considered salient and factors with more than three items were accepted in the new structure, where deletion did not reduce the Cronbach's alpha. The second part of the dataset (n=2749) was used for the CFA to provide further evidence that the observed relationship in the EFA was consistent with the data obtained from a new sample. The structure was evaluated by indices of model fit described below.

The most common used test to control global fit is the chi-square test. However the chi-square test is sensitive to sample size and rejects reasonable models in large samples. Therefore, several fit indices were used to evaluate the model with suggested cut-offs for an adequate fit. The Tucker-Lewis index and the incremental fit index are adequate if >0.90 (77). The suggested standardized root mean square residual is acceptable if <0.08. The root-mean-

square of approximation examines closeness of fit and the suggested target level is ≤0.06 (78). The root mean square residual indicates better fit with lower values <0.08 (78). The suggested goodness of fit index and suggested adjusted goodness of fit index are >0.9. Moreover, the Akaike information criterion (AIC) was used for comparing multiple models (not reported in Paper III). A lower AIC value indicates a better fit.

Cronbach's alphas were calculated to provide estimates of factor reliability. Cronbach's alpha was calculated for boys and girls separately (not reported in Paper III).

Paper IV

Mean well-being scores were compared between the cohorts using the independent sample t-test and effect sizes were calculated to estimate the magnitude of the difference. Dimension-specific differences between boys and girls, by cohort, were evaluated through age-adjusted multivariate linear regression (with the five dimensions as the multiple dependent variables). This model was used to calculate the true difference within each dimension, while taking all other dimensions into consideration. A simple age-adjusted linear regression analysis was used to compare total well-being scores between boys and girls, by cohort. Due to consistent differences in well-being between boys and girls, analyses of well-being using the dimensions and the total score were thereafter stratified by gender. To determine whether differences between the cohorts could be explained by a shift in weight status, multivariate linear regression and a simple linear regression (total score), adjusted for cohort, age and weight status, were used. Furthermore, the pairwise comparisons between the *stress balance* versus the other four dimensions were evaluated by the p-values according to Hotelling's Trace.

To illustrate how weight status was related to the dimensions within each cohort, an additional analysis was made (not reported in Paper IV). Separate linear regression modelling was used for each dimension, adjusted for age, with normal weight as the reference categories, by cohort and gender.

Paper V

Because of the observed differences in well-being between boys and girls, analyses of factors related to well-being were stratified by gender. A one-way ANOVA was used for comparison of mean well-being scores in the categories of anthropometric measurements, satisfaction with height and body size and additional factors hypothesized to be related to well-being. The association with the resilience score (continuous) was evaluated by a simple linear regression. Linear regression models were also used to estimate the

effect of objectively measured height and weight, as well as perceived satisfaction with height and body size on well-being. To evaluate which well-being dimensions were most affected by weight status and also by the joint contribution of weight status and satisfaction with body size, separate linear regression models were used for each dimension, with normal weight and "often satisfied with body size" as the reference categories.

Moreover, in order to explore the extent to which objectively measured height and weight, satisfaction with height and body size and other factors contributed to mean well-being, a stepwise regression analysis was performed based on all these covariates, which were significant in the univariate analyses (at a 0.1 significance level). Factors selected by the stepwise procedure were finally included in a generalized linear mixed model in which school was treated as a random effect in order to account for potential within-school correlations regarding the different factors.

3.5 Ethical considerations

In 2008, the Grow Up 1990 birth cohort study was approved by the Regional Ethics committee in Gothenburg, Sweden (Dnr 444-08). In addition, ethical approval was obtained to retrieve growth data from school health records for all students in the final grade in the schools included in 2008 (T 062-09 add 444-08). This enabled non-participation analyses regarding height and weight.

The Grow Up 1974 birth cohort study was approved by the Ethics Committee for Research at the University of Gothenburg, Sweden (now renamed the Regional Ethics Committee in Gothenburg, Sweden) (Dnr 91-92). The examinations in this study took place in 1992.

Informed consent was obtained from all participants prior to administering questionnaires and undertaking measurements. No invasive methods were involved in the studies. However, measurement of weight, height and waist can be a sensitive issue and requires skilled and attentive study teams. Therefore, study staff was trained before the study started.

4 RESULTS

4.1 Characteristics of the study population

Most of the boys (91%) and girls (85.5%) reported no history of chronic disease (Paper I). In Paper V, where the type of condition and medication were not evaluated and the participants' own responses were recorded, 78% and 76% of boys and girls respectively reported no history of chronic disease. More than two thirds of the boys and girls had breakfast on a daily basis (Paper I) and regular meals were reported by 58% of the boys and 54% of the girls (Paper V). Two-thirds of the boys and 61% of the girls reported never smoking while 21% of boys and 23% of girls responded that they never consumed spirits, with corresponding figures of around 11% in both boys and girls for other forms of alcohol (Paper V). Over 70% of adolescents reported that they engaged in regular physical exercise during their leisure time (Papers I and V).

In response to the dichotomized sleep variable (section 3.3.2), approximately 30% of boys and 30% of girls reported sleep duration of at least eight hours (Paper I). However, only 4% to 6% reported sleeping more than eight hours (Paper V) when the sleep duration was categorized into three groups (section 3.3.2). More than 80% of boys and girls answered that they always had their cell phones switched on in their bedroom at night (Papers I and V). More boys than girls reported always having their computers switched on in their bedrooms at night (Papers I and V).

About 80% of boys and 60% of girls reported having no experience of being teased about being of short stature (Paper V). The corresponding percentages for never having experienced teasing about being thin were 65% and 50%, in boys and girls, respectively. Over 80% of boys and girls reported that they had not experienced being teased for being fat.

4.2 Weight status

Boys had a higher prevalence of overweight and obesity (15.4% and 3.7%, respectively) than girls (11.1% and 2.3%, respectively) when the $IOTF_{2000}$ was applied to participants aged <18 years and the WHO adult BMI classification was applied to older participants (Paper I). Similarly, the two other classification methods used in Papers II, IV and V also showed higher prevalence in boys than in girls in the combined group with overweight

including obesity (OwOb) (Table 2). In contrast, the prevalence of underweight was higher in girls (9.2%) than in boys (5.7%) when the $IOTF_{2000}$ was applied to participants aged <18 years and the WHO adult BMI classification was applied to older participants (Paper I), as well as when the WHO adult BMI classification was applied to all participants (Table 2). However, when the WHO_{2007} was applied to participants aged under 19 years and the WHO adult BMI classification was applied to older participants, there were no differences between boys and girls.

Regarding country of origin, non-Nordic boys had lower height- and weight SD score than Nordic boys but the BMI SD score did not differ between the two groups (Paper I). Similarly, non-Nordic girls had lower height- and weight SD score than Nordic girls. This was reflected in a lower BMI SD score for the non-Nordic girls than for Nordic girls, although there was no difference in the prevalence of underweight (Paper I).

Table 2. Weight status at age 18 years according to classification system

	WHO adult BMI classification and $IOTF_{2000}$ <18 years ***Paper I***		**WHO adult BMI classification** ***Paper II***		**WHO adult BMI classification and WHO_{2007} < 19 years** ***Paper IV, V***	
Weight status, %	Boys n=2706	Girls n=2558	Boys n=2169	Girls n=2066	Boys n=2645	Girls n=2506
Underweight	5.7	9.2	5.3	9.6	2.4	2.0
95% CI	4.8-6.6	8.1-10.3	4.3-6.3	8.3-10.9	1.8-3	1.4-2.6
Normal weight	75.3	77.4	75.2	76.7	79.4	83.5
95% CI	73.7-76.9	75.8-79	73.4-77	74.9-78.5	77.8-81	82-85
Overweight	15.4	11.1	15.7	11.3	14.0	12.1
95% CI	14-16.8	9.9-12.3	14.1-17.3	9.9-12.7	12.7-15.3	10.8-13.4
Obese	3.7	2.3	3.7	2.4	4.2	2.4
95% CI	3-4.4	1.7-2.9	2.9-4.5	1.8-3.1	3.4-5	1.8-3
OwOb	19.0	13.4	19.4	13.8	18.2	14.5
95% CI	17.6-20.6	12.1-14.7	17.7-21.1	12.3-15.2	16.7-19.7	13.2-16.0

OwOb: Overweight including obesity; CI: 95% confidence interval

Compared to the Grow Up 1974 birth cohort, boys in the 1990 cohort had a higher prevalence of overweight and obesity and a lower prevalence of underweight, when the WHO_{2007} was applied up to age 19 years (Paper IV). However, no significant differences between the cohorts were found in girls. Comparison of boys and girls in the 1974 birth cohort failed to reveal any significant differences in prevalence in any of the weight status groups (Table 3).

Table 3. Weight status in the Grow Up 1974 cohort

	Boys	**Girls**
Weight status, %	n: 2186	n: 2176
Underweight	1.1	1.3
95% CI	0.6-1.6	0.8-1.8
Normal weight	87.0	87.0
95% CI	85.6-88.4	85.6-88.4
Overweight	9.9	9.9
95% CI	8.6-11.2	8.6-11.2
Obese	2.0	1.7
95% CI	1.4-2.6	1.1-2.3

Weights status for <19 years according to the WHO_{2007}, older participants are classified according to the WHO adult BMI classification
CI: 95% confidence interval

In the Grow Up 1990 study, prevalence of underweight, normal weight, overweight and obesity in children aged around ten years varied according to the three childhood BMI classification systems applied (Table 4). The $IOTF_{2012}$ indicated the lowest prevalence of overweight and obesity, while also indicating a high prevalence of underweight. Comparison of boys and girls revealed that, regardless of classification system, the prevalences of obesity were higher in boys (2.6%, 8.3%, 10.2%, respectively) than in girls (1.5%, 4.0%, 5.5%, respectively), according to the $IOTF_{2012}$, WHO_{2007} and SE_{2001} (Paper II). In addition, the prevalence of OwOb was higher in boys, compared to girls, except when the $IOTF_{2012}$ was applied.

Table 4. Weight status at age ten years, according to the $IOTF_{2012}$, WHO_{2007} and SE_{2001}

	$IOTF_{2012}$		WHO_{2007}		SE_{2001}	
	Boys	Girls	Boys	Girls	Boys	Girls
Weight status, %	n:2169	n:2066	n:2169	n:2066	n:2169	n:2066
Underweight	5.7	8.6	0.9	1.5	1.5	2.0
95% CI	4.7-6.7	3.4-9.8	0.5-1.3	1-2	1-2	1.4-2.6
Normal weight	77.8	74.4	71.0	76.2	68.7	73.6
95% CI	76-79.6	72.5-76.3	69.1-72.9	74.3-78.1	66.7-70.7	71.7-75.5
Overweight	13.9	15.4	19.8	18.3	19.6	18.9
95% CI	12.4-15.4	13.8-17	18.1-21.5	16.6-20	17.9-21.3	17.2-20.6
Obesity	2.6	1.5	8.3	4.0	10.2	5.5
95% CI	2.0-3.3	1-2.0	7.1-9.5	3.2-4.9	8.9-11.5	4.5-6.5
OwOb	16.6	16.9	28.1	22.4	29.8	24.4
95% CI	15.6-17.9	15.3-18.6	26.2-30.0	20.6-24.2	27.9-31.7	22.5-26.3

OwOb: Overweight including obesity; CI: confidence interval

4.2.1 Predictive ability of childhood BMI classification systems

The WHO adult BMI classification at age 18 years and retrospective classification according to the childhood BMI classification system at age ten years showed that 40-46% of the overweight (excluding obese) 18-year-olds had been classified as overweight (excluding obese) at age 10 years (Paper II). Among the obese 18-year-olds, 29%, 63%, and 70% had been classified as obese at age ten years by the $IOTF_{2012}$, WHO_{2007} and SE_{2001}, respectively, which corresponds to the sensitivity for predicting obesity using the three systems for children.

The $IOTF_{2012}$ had lower sensitivity for predicting OwOb (53%), compared to the WHO_{2007} and SE_{2001} (68% and 71%, respectively) (Paper II). However, the $IOTF_{2012}$ had higher specificity (91%) when compared to the WHO_{2007} (82%) and the SE_{2001} (81%). The positive predictive value (PPV) for the $IOTF_{2012}$ was 53% and the respective PPVs were even lower (45% and 43%) for the WHO_{2007} and the SE_{2001} (Table 5). The negative predictive values (NPV) were higher, 91-93% for all systems.

When it came to predicting obesity, the $IOTF_{2012}$ had low sensitivity (29%), compared to the WHO_{2007} (63%) and the SE_{2001} (70%) (Paper II). On the other hand, the $IOTF_{2012}$ had very high specificity (>99%), although specificity levels were also high for the WHO_{2007} (96%) and the SE_{2001} (94%). The LR+, indicating how much the classification as obese at age ten

years changes the likelihood of obesity at age 18 years, was high for all systems, (12-24), and highest for the $IOTF_{2012}$. In contrast, the PPVs were low (43%, 32% and 27% for the $IOTF_{2012}$, WHO_{2007} and SE_{2001}, respectively) whereas the NPVs were high, 98% to 99% for all three systems (Table 5).

Table 5. Positive predictive value (PPV) and negative predictive value (NPV) derived from the $IOTF_{2012}$, the WHO_{2007} and the SE_{2001} classification of overweight including obese (OwOb), and obese at age 10 years to predict OwOb and obesity at age 18 years, according to the WHO adult BMI classification

	Overweight incl. obese at 18 years			Obese at 18 years		
	IOTF 2012	WHO 2007	SE 2001	IOTF 2012	WHO 2007	SE 2001
All 10 years						
PPV	52.8	44.7	43.3	43.2	31.6	27.2
95% CI	49.1-56.4	41.7-47.7	40.4-46.2	32.8-53.5	25.9-37.2	22.4-31.9
NPV	90.6	92.9	93.3	97.8	98.8	99.0
95% CI	89.7-91.6	92.0-93.8	92.4-94.2	97.3-98.2	98.5-99.1	98.7-99.3
Girls 10 years						
PPV	43.7	38.7	38.1	51.6	28.9	25.4
95% CI	38.5-48.9	34.3-43.2	33.9-42.3	34.0-69.2	19.2-38.7	17.4-33.4
NPV	92.4	93.5	94.1	98.3	98.7	98.8
95% CI	91.1-93.6	92.2-94.7	92.9-95.3	97.8-98.9	98.2-99.2	98.5-99.4
Boys 10 years						
PPV	61.6	49.2	47.4	39.0	32.8	28.1
95% CI	56.5-66.6	45.2-53.1	43.5-51.2	26.0-51.2	25.9-39.6	22.1-34.0
NPV	89.0	92.2	92.4	97.2	98.9	99.0
95% CI	87.5-90.4	90.9-93.6	91.1-93.8	96.5-97.9	98.4-99.3	98.6-99.5

PPV: Positive predictive value
NPV: Negative predictive value
CI: 95% confidence interval

The number of ten-year-olds classified as obese, according to the three classification systems, in relation to obesity at age 18 years, is shown in Figure 2. Sensitivity estimates the proportion of all obese 18-year-olds who are classified as obese at age ten years. In contrast, the PPV is the proportion of the ten-year-olds classified as obese who are obese at age 18 years.

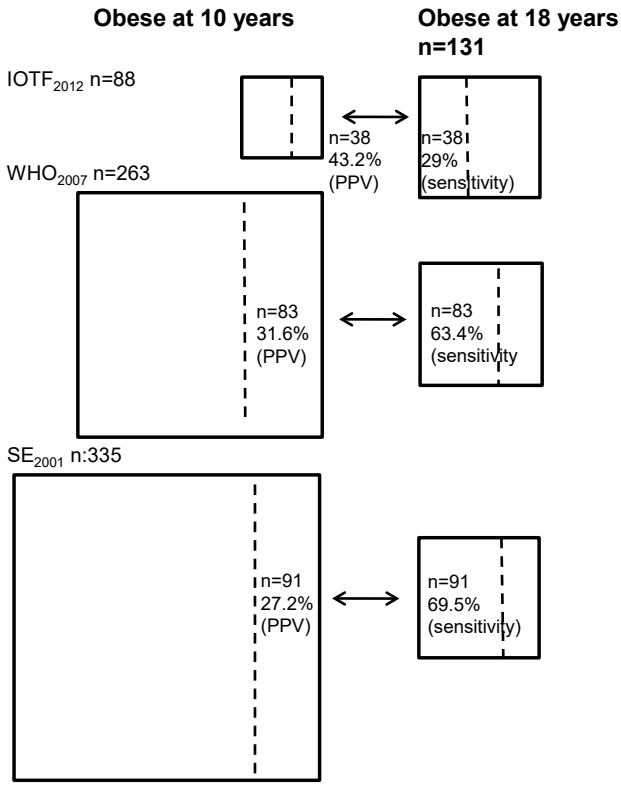

Figure 2. Number of obese participants at age 10 years, according to the childhood BMI classification systems, as well as the positive predictive value (PPV). All obese participants at age 18 years, according to the adult BMI classification, as well as sensitivity.

The three classification systems indicated a similar relative risk (RR) of OwOb at age 18 years, i.e. 6-7 times greater for the ten-year-olds classified as OwOb, relative to the ten-year-olds classified as not OwOb (Paper II). The children classified as obese at age ten years had a 19-27 times higher risk of being obese at age 18 years than ten-year-olds classified as none-obese.

4.3 Body perception

4.3.1 Body perception

When body perception was evaluated using the body image scale, the mean body image score was more positive in boys than in girls, i.e. 76 and 67.2, respectively, of a total of 100 (Paper I). The differences were relevant, as indicated by the effect size, 0.5 (not reported in Paper I). The proportion of boys with a score ≥90 was 23% (Paper I). The corresponding proportion for girls was much lower, 13%. More boys than girls indicated the most positive body image, i.e. chose the most positive response alternative, in response to each of the eight statements about body image. In fact, between 44% and 63% of the boys chose the most positive alternative, with one exception. In response to the statement "*I would like to change a lot of things about my body*", only 24% of the boys and 12% of the girls chose the "*not true"* alternative (Paper I).

Responses to the single-item questions about satisfaction with height and body size showed that 70% of the boys and 60% of the girls were often satisfied with their height (Paper V). In contrast, only half of the boys and 33% of the girls were often satisfied with their body size. Ten percent of the boys were never satisfied with their body size, compared to twice as many girls.

4.3.2 Body perception in relation to height and weight status

Among boys, being short, here defined as belonging to the shortest tertile of the study population, was related to lower body image scores evaluated by the body image scale, compared to being of normal height (not reported in Paper I). On the other hand, score on the body image scale was not related to height in girls. Subjective satisfaction with their height in relation to objectively measured height, evaluated as height SD score showed that boys being sometimes and never (compared to often) satisfied with their height was related to shorter stature (-0.56 and -0.98 $p<0.001$, respectively). A similar pattern was seen in girls but of a slightly lower magnitude.

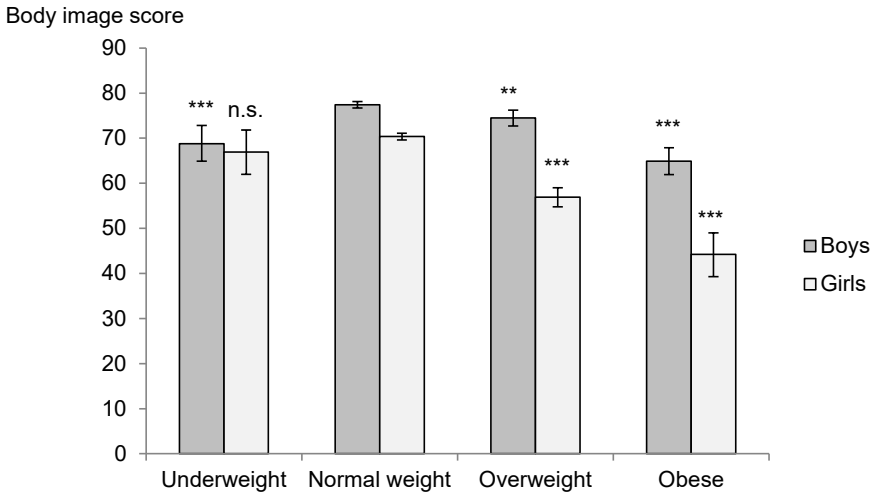

*Figure 3. Mean body image score and 95% confidence interval in each weight status group by gender. P-values for differences between weight status groups are from a linear regression with normal weight as the reference. ** p<0 .01*** p<0.001.*

Further analysis of body image in relation to weight status (not reported in Paper I) showed that normal weight and overweight boys had the most positive body image scores (Figure 3). Lower scores were found among the underweight and obese boys, compared to the normal weight boys. In girls, the highest body image scores were found in the underweight and normal weight groups. Much lower scores were found in overweight and obese, compared to normal weight girls, with the lowest scores in the obese group. Comparison of boys and girls showed that boys constantly scored higher than girls, except in the underweight group. This was the only group in which there were no differences in body image scores between boys and girls.

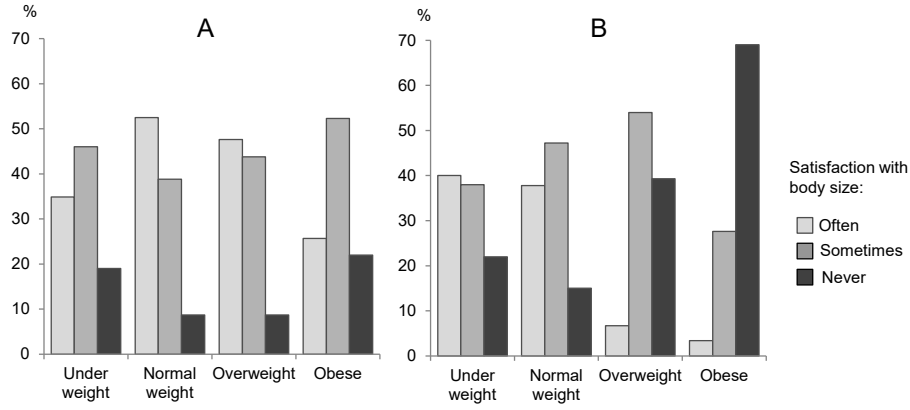

Figure 4. Satisfaction with body size, by weight status for (A) boys and (B) girls

In all weight status groups, 75% to 90% of all boys reported being often or sometimes satisfied with their body size (not reported in Paper I). In girls, 75% to 80% of the underweight and normal weight groups reported being often or sometimes satisfied with their body size (Figure 4). However, among girls about 40% in the overweight group and 70% in the obese group reported never being satisfied with their body size.

4.4 Well-being

4.4.1 Development of the Gothenburg Well-Being in adolescence scale

The GWBc six-factor structure, including 35 items, was tested on the Grow Up 1990 study population for model fit (Paper III). A confirmatory factor analysis (CFA) failed to yield any evidence of a good fit, and the model was therefore rejected. In order to explore the underlying latent structure, an exploratory factor analysis (EFA) was conducted in a subsample of the study population. The KMO measure of sampling adequacy was 0.957 and Bartlett's test of sphericity was significant (<0.05), indicating that the data was suitable for factor analysis. Different factor solutions were tested and a five-factor structure was finally identified as the best fit, explaining 43% of the total variance. Following the analysis, 22 items remained and the factors were defined as: *mood*, *physical condition*, *energy*, *self-esteem* and *stress balance* (Table 6). A CFA was undertaken to examine whether the observed five-factor structure could be applied to another subset of the study

population. Goodness of fit measures showed a satisfactory result for the five-factor model. In addition, the AIC was lower for the new factor structure in the GWBa (2166.7) than when the factor structure of the GWBc was used (16155.9) (not reported in Paper III). Cronbach's alpha for the total well-being score was 0.90, with individual dimensions having a range of between 0.72 and 0.89. Cronbach's alpha for the total score was similar in boys and girls, 0.90, which was also observed in the individual dimensions having a range of between 0.71 and 0.88 in boys and 0.73 and 0.88 in girls.

Table 6. Factor loadings of the five-factor GWBa

Item	Mood	Physical condition	Energy	Self-esteem	Stress balance
Glad	.917				
Good-tempered	.794				
Happy	.766				
Contented (Content)	.657				
Physically fit		.793			
Quick		.617			
Active		.588			
Strong		.566			
Innovative (Enterprising)			.608		
Attentive (Careless)			.522		
Interested			.520		
Enthusiastic (Exhilarated)			.486		
Confident (Secure)				.796	
Fearless (Tough)				.625	
Brave				.573	
Talks in groups				.530	
Sociable (Talkative)				.513	
Unafraid (Fearless)				.513	
Calm					.832
Unconcerned					.739
Unstressed (Unwinded)					.711
Relaxed					.661

Words in parenthesis are for traceability to the GWBc

4.4.2 Comparison of well-being in the 1990 and 1974 cohorts

The two cohorts, born around 16 years apart, were compared in respect to well-being, using the GWBa score ranging from 0-100 (Paper IV). Overall, the total well-being score was lower in the later-born cohort (60.6) than in the earlier-born cohort (63.6), albeit with a small effect size. The lower level in the later-born cohort was seen in all dimensions except *self-esteem* (confident, fearless, brave, talks in groups, sociable, and unafraid). The dimension *stress balance* exhibited the greatest difference between the cohorts in both boys and girls.

In the gender-stratified analysis, well-being in boys was significantly lower in all dimensions in the later-born cohort. In girls, the scores were significantly lower in all dimensions except *self-esteem*, which was significantly higher in the later-born cohort. In both cohorts, boys reported higher well-being, compared to girls, for all dimensions. After adjusting for weight status, similar cohort differences were seen, confirming that weight status did not explain the differences between the cohorts (Paper IV).

In additional analyses (not reported in Paper IV), the effect of weight status on well-being within each cohort was investigated, for boys and girls separately (Figure 5). In both cohorts, underweight boys, compared to normal weight boys, had lower well-being in the dimension *physical condition*. Moreover, boys with obesity, compared to normal weight boys, had higher well-being in the dimension *stress balance*. Among girls in both cohorts, well-being was similar across all weight status groups, with some exceptions.

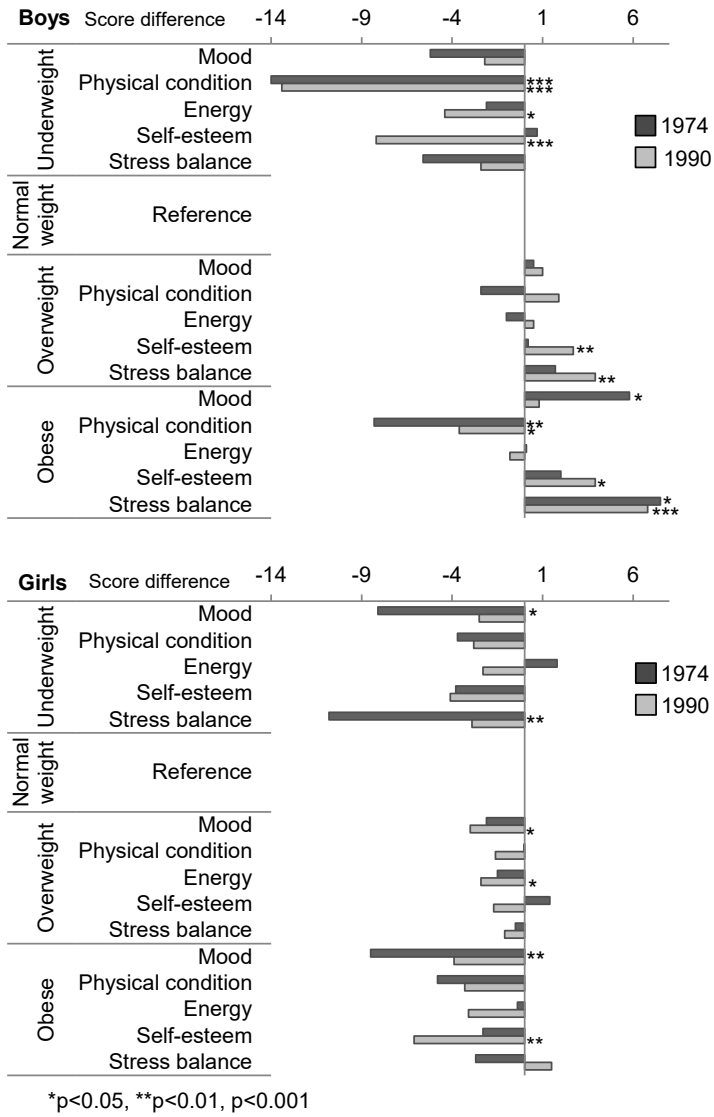

*Figure 5. Differences in well-being score between weight status groups, with normal weight as the reference group, in the 1974 and 1990 Grow Up studies. P-values are from separate linear regression model for each dimension, adjusted for age, with normal weight as the reference category.*p<0.5, **p<0.01, ***p<0.001*

4.4.3 Well-being in relation to height and weight status

When the joint effects of height and weight status on well-being was analysed, height was not related to well-being in either boys or girls (Paper V). On the other hand, weight status was related to well-being in both boys and girls, but in different ways. In boys, overweight was related to higher well-being and underweight to lower well-being as compared to being normal weight. Overweight girls had lower well-being than normal weight girls. These objective measurements explained only about 0.8% (boys) and 0.3% (girls) of the variation in well-being. The contribution of weight status to the different dimensions of well-being revealed that most of the effect originated from the dimensions *physical condition*, *self-esteem* and *stress balance* in boys. In girls, the effect of weight status remained mainly non-significant with the exception of the dimensions of *self-esteem, mood* and *energy* (Paper V).

4.4.4 Well-being in relation to satisfaction with height and body size

Never or sometimes, compared to often, being satisfied with one's body size was related to lower well-being in both boys and girls (Paper V). Moreover, in girls, never or sometimes being satisfied with one's height was related to lower well-being. Subjective satisfaction with height and body size explained about 7% of the variation in well-being in both boys and girls.

4.4.5 Well-being in relation to lifestyle and other factors

All factors associated ($p<0.1$) with well-being, when analysed separately, were included in a combined model, one for each gender (Paper V). This final model accounted for 35.5% and 31.9% of the variance in well-being in boys and girls, respectively. Among both boys and girls, it was found that resilience, engaging in regular physical activity and having experienced a happy event during the last year were positively related to well-being. Moreover, few hours of sleep and having experienced a sad event during the last year were negatively related to well-being. Nevertheless, some gender differences were also identified. In boys, the absence of a chronic disease and having one's cell phone switched on at night were positively related to well-being, whereas having sometimes been teased about being thin was related to lower well-being, compared to never having been teased. Among girls, having been teased about short stature was negatively related to well-being.

Resilience was the main contributor to the variance in well-being, accounting for more than 26% of the variance in both boys and girls.

5 DISCUSSION

5.1 Weight status

The weight status distribution found in the Grow Up 1990 study (Paper 1) was comparable to that in adolescents born 1992 in Western Sweden (79). Consistent with our results, the observed differences between boys and girls mainly concerned underweight, with a higher prevalence in girls. Boys had higher prevalences of overweight and obesity. In addition, overweight and obesity prevalences in the Grow Up 1990 cohort were similar to those in a study among 15-year-olds born in 1991 in the eastern part of Sweden (80). In a longitudinal perspective, when the 1990 birth cohort was compared to the cohort born around 16 years earlier (the Grow Up 1974 birth cohort), levels of overweight and obesity in the 1990 study were significantly higher only among the boys (81). More stable prevalence of overweight and obesity has been shown in ten-year-olds (82) and a recent study showed a lower prevalence of overweight and obesity in 2011 compared to 2003 in eight-year-old children living in Stockholm County (83). Similarly, a study of Danish children found a tendency for declining prevalence of overweight and obesity (84). However, even if the prevalence seems to be stable, there are still differences in certain groups of children, for example children in rural and lower socioeconomic areas (53, 82, 83).

Because of the rapid increase in BMI, much focus has been on the prevalence of overweight and obesity. However, prevalence of underweight in the Grow Up 1990 study was about 5% in boys and 9% in girls (Paper 1). Compared to the Grow Up 1974, the prevalence of underweight in both boys and girls was higher in the later-born cohort (81). It should be underscored that increasing prevalence of underweight would also be a public health concern. In a study of trends in underweight prevalence in ten European countries and the United States, it was found that, in contrast to most countries, prevalence of underweight had increased in France, Sweden and Greece, although not significantly (85). Socio-cultural factors and pressures associated to beauty ideals, adolescent body dissatisfaction, unhealthy weight control and eating disturbances were proposed as possible explanations for these trends. In addition, it has been observed that low physical activity during leisure time may be related to increases in underweight, as suggested in a study among Swedish adolescents (86).

Although we used three different systems for classification of weight status at around age 18 years, there was only a statistically significant difference

between the systems in terms of underweight prevalence and, consequently, of normal weight prevalence, when the WHO_{2007} reference was applied to those aged under 19 years, and the WHO adult classification was applied to older participants (Table 2, Section 4.2). The IOTF and the WHO_{2007} classification systems approach the WHO adult BMI classification with advancing age and only marginal differences would therefore be expected at ages around 18 years. The lower prevalence of underweight according to the WHO_{2007} might be explained by the lower cut-off for underweight according to the reference (-2 SD). At age 19 years, this corresponds to a BMI of 16.5 in girls and 17.6 in boys, compared to the WHO adult BMI classification of underweight as BMI <18.5. However, it has been suggested to define "adult", at a later age as there is evidence of increasing BMI between ages 18 and 23 years (87). Consequently, particular in boys, using cut-offs based on age 18 years instead of higher ages will underestimate levels of overweight and obesity.

In contrast, at age ten years, the difference in prevalence between the three classification systems was more obvious (Paper II). The higher prevalence of overweight and obesity when applying the $IOTF_{2012}$ compared to the WHO_{2007}, has been confirmed previously (88, 89).

5.1.1 Predictive ability of childhood BMI classification systems

In terms of predictive ability, the SE_{2001} and WHO_{2007} yielded comparable results and exhibited a relatively high degree of sensitivity for classifying overweight and obesity (Paper II). Classification systems with high sensitivity will result in a major part of the children at risk of overweight and obesity being identified. This may be preferable in health promotion and other public health initiatives (90). However, the PPV from observational data indicated that only a minor part of all those identified at risk at age ten years actually became obese at age 18 years. On the other hand, the $IOTF_{2012}$ had high specificity, minimizing the risk of identification of children who are not likely to be obese at 18 years. All three classification systems had a high LR+ for predicting obesity, indicating a large increase in the likelihood of being obese at 18 years if classified as obese at ten years. However, none of the systems had a LR- that ruled out the possibility of obesity at age 18 years, even in those classified as non-obese at age ten years. In conclusion, none of the systems performed well in all parameters i.e. sensitivity, specificity, LR+, LR-, PPV and NPV.

Weight status in children must be classified with a clear purpose. For comparing prevalence on a population level, these results are very important and serve as a basis and support for policy makers. However, if children are classified as obese on an individual level, advice and resources should be offered at the same time. Furthermore, labelling a child as obese may create unnecessary stigmatization of the child (57). On the other hand, supporting children identified as overweight and obese might actually reduce the risk of a future stigmatization as the goal is to reduce the risk of future overweight and obesity.

5.2 Body perception

The lower level of body satisfaction found in girls, compared to boys, concurs with previous studies (41, 91-94). In fact, already a study dating back to 1971 reported more dissatisfaction among girls, compared to boys (92). Moreover, the two measures of body perception used in the present thesis, i.e. body image and the subjective question about height and body size satisfaction, showed similar gender differences.

Striving towards thinness seems to be less central for boys than for girls. Girls tend to overestimate their body size and are concerned even at low body weights, while boys instead underestimate their body size even if they are overweight (95, 96). There are consistent findings of higher BMI being related to higher body dissatisfaction, which we confirmed in our study, particularly among girls (41).

One serious consequence of body dissatisfaction is depression. Studies have demonstrated that being dissatisfied with one's body may trigger depression, both in girls (97) and in boys (98). However, this vulnerability may occur at different ages in boys and girls (98).

The more negative body perception in girls, despite their lower prevalence of overweight and obesity as compared to boys, may be regarded from a gender perspective. Individuals generally adjust themselves to subordinate into societal and cultural gender roles including constructions of femininity and masculinity, a process that starts already in childhood (99). Along with the bodily changes during puberty, the concern of becoming obese might increase in girls, leading to greater body dissatisfaction. The negative body image in girls partly explains gender differences in depressed mood (100), which may in turn contribute to eating disorders such as anorexia nervosa, that are more prevalent in girls. Nevertheless, as in girls, body dissatisfaction among boys may also be due to social pressure to conform to the ideal male

body. As a consequence of this social pressure, health-threatening behaviours, such as intake of substances for a faster development of muscles, are more likely to occur in boys (101, 102)

5.3 Well-being

5.3.1 Gothenburg Well-Being in adolescence scale

To be able to measure and monitor well-being from childhood throughout adolescence, the GWBc was further developed and adapted for use in the adolescent population of the Grow up 1990 study (Paper III). It has been proposed that the assessment of well-being in children and youth should take into consideration their different phases of development (34). When exploring the structure of our data, it was evident that what constituted well-being in children differed from that in adolescents, even if some dimensions remained similar in both age-groups *(mood*, *self-esteem* and *stress-balance*).

When the GWBc was developed, the aim was to identify constructs of well-being that are important for children, which could be used in studies of short stature. Children of normal stature were the reference population, making it possible to use the GWBc to investigate how well-being in children of short stature differs from well-being in a reference population (103). In a similar way, the GWBa developed on an adolescent population has the potential to be used as a reference for future comparison with a clinical sample.

The final structure of the GWBa consisted of the five dimensions: *mood*, *physical condition*, *self-esteem*, *energy* and *stress-balance*, and a total scale. These dimensions can be understood as covering emotional, physical, and behavioural aspects associated with well-being and therefore reflect some of the complexity of the well-being concept. Furthermore, the GWBa follows, to some extent, the hallmarks of an instrument measuring subjective well-being as stipulated by Diener (16). First, it is a multi-item, multi-dimensional scale. Secondly, it is concerned with the experience within the person. Finally, it focuses not only on the absence of negative factors but also includes positive factors.

Another important aspect of the use of self-reported scales is the length of the instrument. As the attention span is limited, particularly in children, the number of items should be limited (104). In addition, if the instrument will be included as part of a questionnaire, it is important to cover the concept to be measured but at the same time keeping it to a minimum. Therefore, the GWBa was further developed to minimize the respondent burden. With its 22

items, it has a suitable length to be used as a tool either for screening or monitoring of well-being in adolescents.

5.3.2 Comparison of well-being in the 1990 and 1974 cohorts

The overall finding of generally lower well-being in the Grow Up 1990 birth cohort as compared to the Grow Up 1974 birth cohort (paper IV) agrees with a previous study of changes in quality of life from 1984 to 1996 in children aged two to 17 years in the five Nordic countries (105). However, in the subsample of 13 to 17-year-olds, the difference was not significant.

In particular, the well-being dimension that had deteriorated most in the 1990 birth cohort compared to the earlier birth cohort was *stress balance*, which was observed in both boys and girls separately. The change in perceived stress (e.g. *feeling worried*, *concerned*, *stressed* and *tensed*) was independent of weight status in both genders, which implies that changes in prevalence of overweight and obesity did not explain the increased stress levels (paper IV). Possible explanations for the increased stress levels might be found in lifestyle-related, environmental, and other societal changes. However, a comparison between lifestyle and socioeconomic factors between the birth cohorts could not be made as these data were not collected in the Grow Up 1974 cohort.

Increased stress levels in adolescents over the past decades have been reported in several other studies, both in Sweden (106-109) and in Europe (110). One Swedish study reported high stress levels, including those above the cut-off for chronic stress, among secondary school students, especially girls (111). One factor that has been suggested as an important source of perceived stress is the school environment (108, 110). There are studies demonstrating an association between school stressors (e.g. school-work pressure, harassment by peers and being poorly treated by teachers) and psychosomatic symptoms (112). Both a Swedish study and a study of European adolescents identified aspects of the school environment to be associated with perceived stress (107, 110). The HELENA study of European adolescents in 2006 also showed that uncertainty and concerns about the future were associated with perceived stress (110). Other factors predicting variation in stress levels were high performance demands, low self-esteem, low social support and eating habits (111).

Stress factors may be closely related to sleep habits, which were also analysed in Paper I and V. Only a minority of the adolescents slept 8 hours or

more (Paper V). Correlations have previously been reported between sleep problems and psychosomatic symptoms (such as anxiety and depression), respectively, and perceived stress (107, 111). It is well known that stress has a negative impact on sleep, and less sleep may also increase stress, leading to a vicious cycle (113).

There have been substantial changes in the environment of adolescents in recent decades. Examples are the increased availability to media such as internet and television through the use of cell phones and portable computers, which may influence for instance sleeping habits. Other areas of change are dietary habits, public transport (114) and pollution. Many of these factors are likely to have affected perceived stress levels, but studies establishing causal relationships are needed to be able to draw firm conclusions.

5.3.3 Factors related to well-being in the 1990 cohort

The lack of a relationship between objectively measured height and well-being contrasts with finding from studies conducted in adults (115), but concurs with results from studies in adolescents (116). It is conceivable that height becomes more important after adolescence.

In contrast to height, weight status was related to well-being, but differently so in boys and girls. In boys, the observed higher well-being in overweight and obese, compared to normal weight individuals, was mainly driven by the dimensions *self-esteem* and *stress-balance*. This is in contrast with previous findings showing lower self-esteem in obese children and adolescents (117). Underweight, compared to normal weight, was related to lower scores in the dimension *physical condition*, possibly because this dimension reflects, for example, feelings of being strong and physically fit. In girls, overweight was related to lower well-being, compared to normal weight, and this was driven mainly by the dimensions *mood*, *energy* and *self-esteem*. Lower *self-esteem* among overweight girls has been reported previously (118). Even though weight status was related to well-being in both boys and girls, it only explained a small part of the variation in well-being.

Being aware of the observed relationships between objectively measured weight status and well-being, a further step was to investigate the effect of satisfaction with height and body size on well-being. Being dissatisfied with one's body size was related to lower well-being in both boys and girls. Our results confirmed the reported relationship between positive body image and higher health-related quality of life observed among Norwegian children and adolescents (93). Interestingly, among adolescents in the *Project EAT*, the

association between obesity and impairment in well-being was no longer observed after body dissatisfaction was accounted for (119). Moreover, higher levels of body dissatisfaction were associated with lower levels of psychological well-being both in adult men and women (120).

Other factors associated with well-being were also explored. About 35% of adolescents in our study slept less than 7 hours on nights before schooldays, which is considerably lower than the recommended levels of 8 – 10 hours per night (121). Sleeping few hours was negatively related to lower well-being. Similar results have been obtained when predictors of well-being in college students were investigated (122), where the strongest predictor of lower well-being was poor sleep quality. In addition, a study in Swedish children and adolescents reported on the association between short sleep duration (defined as <7-8 hours) and an increased risk for academic failure (123).

Our findings on physical activity and well-being are consistent with previous studies showing higher well-being in physically active children and adolescents (124, 125). In a systematic review, Eime and co-workers (126) investigated the psychological and social benefits of participating in sports for children and adolescents. Some of the benefits reported were improved self-esteem, social interaction and fewer depressive symptoms. Participating in physical activity as an extracurricular activity was associated with improved youth development, evaluated as academic ability, confidence, talking with friends, character and caring (127). Our finding of the relationship between physical activity and well-being (Paper V) also agrees with a study in a sample of European adolescents concerning the association of physical activity and well-being (128). The authors found a positive relationship between more frequent physical activity and higher well-being. In addition, more frequent physical activity was associated with lower levels of depression and anxiety.

The observed relationship between resilience and well-being in the Grow Up 1990 cohort confirms some previous findings in adults and in adolescents. A study in adults investigated the relationship between coping, resilience and well-being (129). The two concepts, coping and resilience, enhanced the ability of individuals to adopt to adverse situations and, by doing so, achieve well-being. The authors found that resilience was significantly related to all dimensions of well-being. Similarly, a study in high school students, found that resilient individuals experienced higher well-being (130). Furthermore, a study examining adolescent stress and anxiety in relation to resilience suggested that improvements in resilience among adolescents might be a

possible way to decrease negative effects from stress and thereby lessen anxiety and depressive symptoms (131).

In the Grow Up 1990 cohort, girls scored lower than boys in all dimensions of well-being, especially *stress balance* (paper IV). This is in agreement with previous studies, e.g. one showing more psychological symptoms in girls than in boys in Swedish grade nine adolescents (132). That study found that sexual harassment at school was associated with high degree of psychological symptoms in girls, and concluded that the psychosocial school environment may be an important factor to explain why girls report more psychological symptoms than boys.

5.4 General discussion of the results

The childhood BMI classification systems had relatively high specificity meaning that most of the children that were not overweight or obese at 18 years were correctly classified at age ten years. However, to be able to identify as many children as possible at risk of becoming overweight or obese, a system with high sensitivity is preferable, although children that will not become overweight or obese might be incorrectly classified as at risk. If the classification systems are used for prevalence estimation at a population level this is of less importance but at an individual level a misclassification might create unnecessary stigmatization and concerns both for the child and for the parents. However, present results indicate that the objectively measured weight status was less important for the adolescents' well-being than their subjective satisfaction with their body size.

Significantly higher prevalence of both overweight and obesity was observed among the boys, compared to the boys in the population studied 16 years earlier in the same region. On the other hand, girls in the 1990 birth cohort had a higher prevalence of underweight (81). Body dissatisfaction was higher among girls and especially in the overweight and obese girls. Together with the higher prevalence of underweight, this raises concerns about increasing numbers of girls attempting to lose weight in order to fulfil cultural and societal female body ideals. If boys underestimate their weight status and simultaneously have a positive body image even if they are overweight, this might imply that different health promotion approaches are needed for girls and boys.

In this context, it is likely that early-life factors, such as parental socio-economic position and country of birth might have affected gender differences early in life and could also affect lifestyle and opportunities later

in childhood and adolescence, with important implication for gender equality. For a deeper understating of the gender aspect within the areas of weight status, a socio-cultural perspective is important. For example, advantaged socioeconomic conditions are likely to increase the possibility for a healthier diet and a healthy lifestyle while at the same time might increase the pressure for a perfect body in both boys and girls.

Overall well-being was lower in girls compared to boys, suggesting that adolescence may be a more difficult period for girls than for boys, possibly due to social pressure. On the other hand, we found that self-esteem in girls had increased, compared to the cohort born 16 years earlier. This might indicate that girls feel more empowered than previously. Moreover, our results imply that there are similarities in which factors are related to well-being in boys and girls although the relationship may be due to different mechanisms.

The present results highlight the importance of resilience as an explanatory factor in experienced well-being in adolescents. Further studies in adolescent populations investigating this relationship would be valuable in order to better understand how interventions aiming at increasing well-being in this population could be developed. Suggestions have been made to improve well-being by promoting resilience in school-based settings (31, 133-135). One way of building resilience in school settings is to teach children to develop social competence, for example problem solving, effective communication, resisting peer pressure and to develop personal relationships (135). In addition school personnel could be trained in paying attention to each student, encouraging class participation, listening to the student, and having high expectations for student success (135).

The relationship between satisfaction with body size and adolescents' well-being was also confirmed by the present study as were the importance of sleep duration and physical activity.

Others have suggested interventions to support more positive body images to be an important objective to improve subjective health in adolescents. One way to support adolescents and promote a positive body image in order to prevent body dissatisfaction could be through school-based programs (136). However, the most effective programs have been conducted among younger adolescents, including activities focusing on improving understanding of media messages, self-esteem, and the influence of peers.

5.5 Methodological considerations

5.5.1 Study design and samples

The Grow Up 1990 study was partly a replication of the Grow Up 1974 study. The aim of the Grow Up 1974 study was to collect growth data from birth to adult height in order to produce Swedish growth reference values based on longitudinal data (70). Within the Swedish school health care, height and weight are monitored and therefore a school-based sample was deemed appropriate. At the time of data collection (1992) in the Grow Up 1974 study, approximately 98% of children in Sweden remained within the school system (137) and a similar proportion (98%) of children continued to high school in 2008/2009 (138). In view of these findings, and assuming that participation rates in a non-school based cohort having left high-school would be low and induce selection bias, a school-based cohort study was preferable.

However it must be pointed out that the participation rates differed between the studies. This was mainly due to a larger proportion of students being absent on the day when the study team visited the school, 32% in the 1990 cohort compared to 9% in the 1974 cohorts. In addition, about 5% in the 1990 cohort actively declined participation compared to 3% in the 1974 cohort. Declining participation rates are a well-known phenomenon (139), possibly due to increasing numbers of surveys being done. Furthermore, if an individual cannot see any personal gain from participating, he/she might be more inclined not to participate. In a participation analysis of the Grow Up 1990 cohort, it was shown that girls who did not subsequently participate in the study had significantly higher BMI SD score (SE_{2001}) at a younger age compared to girls who later participated in the study (Paper I). This might suggest a hesitancy to participate in height and weight measurements if overweight or obese. As a result, the true prevalence of overweight and obesity among girls may have been underestimated.

Except for the longitudinal measurements included in Paper II, the analyses presented here were based on cross-sectional data in each cohort. Therefore, it was not possible to infer any causal relationship between the studied factors. Another limitation when comparing well-being between the two birth cohorts is the lack of lifestyle data in the 1974 birth cohort. This would have added valuable information in the comparisons made. Another concern could be that the identical well-being questionnaires used in the two studies may still not be fully comparable. In the time span of 16 years, societal and

cultural changes will occur and identical items in the questionnaire may have different meaning over time.

5.5.2 Statistical methods

The factor analysis computation that was used to derive well-being subscales required complete data for all items (Paper III). If an item is missing the options are either to impute a value or omit the participant from data analysis. Imputations are done using different methods, for example mean substitution when a score is assigned to the missing data that is the mean of the person's completed items. However, the assumption is either that the individual omitted the item at random or that it would have been answered with a score consistent with the scores of the other items. However, such assumptions are not possible to test in this type of survey (140). Omitting the observation with missing data is a common approach (141) but if items have been omitted by a significant proportion, the removal of these individuals could lead to a significant decrease in sample size or representativeness. Our sample included less than 3% who had one or more missing values in the well-being data, and were therefore omitted.

In our analysis of the GWBa, it was possible to assess scale reliability using the Cronbach's alpha. Other types of reliability such as test-retest reliability were not possible with the available data. Moreover, although we evaluated the factor structure, it would be valuable to validate the GWBa against other well-being instruments. Therefore, further investigation and validation of the GWBa is needed.

Backward stepwise regression was used for exploring factors related to well-being (Paper V). This approach is useful if many factors are believed to be potentially important explanatory variables. The procedure removes unimportant variables one at a time until all those remaining in the model contribute significantly to explained variability in the outcome. As stepwise procedures for model selection are automated, it is useful to consider whether the selected factors are relevant and whether the relevant factors are selected. This can be done by inspecting changes in explained variance after their removal and inclusion. For these reasons, although stepwise procedures can be informative, their validity has been questioned and they should be used cautiously (142).

6 CONCLUSIONS

In investigating well-being, body perception and weight status in Swedish adolescents, the following conclusions were made:

About three-quarters of the adolescents participating in the Grow Up 1990 cohort study were of normal weight. Prevalence of underweight was higher in girls than in boys, whereas boys had a higher prevalence of overweight and obesity than girls. Despite this, boys had a more positive body image than girls in all weight status categories except in the underweight category, where boys and girls were equally satisfied.

The choice of childhood BMI classification system for predicting overweight and obesity should be based on the purpose, and should be made with care. If the intention of use is to a have a system with high sensitivity, identifying as many at-risk as possible, the WHO_{2007} and SE_{2001} may be preferable, especially in the Swedish context. On the other hand, to have fewer false positives, the $IOTF_{2012}$ should be used. Use of any of the systems requires knowledge and understanding of the differences between the systems.

The development of the GWBa scale resulted in five dimensions (*mood*, *self-esteem*, *physical condition*, *energy* and *stress balance*) and a total score. The adopted scale is of manageable length and has a range of relevant dimensions, and may thus be useful in future studies in adolescents.

Using this scale, we observed that overall well-being had declined in the 1990 birth cohort, compared to a cohort born 16 years earlier, and stress levels in particular were higher. In both cohorts, boys scored higher well-being than girls. In boys, scores in all dimensions were lower in the later-born cohort, while self-esteem was higher in the later-born girls. The differences between the cohorts were not explained by the shift in weight status.

Objectively measured height and weight status explained little of the variation in well-being. However, being satisfied with one's body size explained much more. Considering multiple factors related to well-being, engaging in regular physical activity was positively related to well-being. In contrast, few hours of sleep and dissatisfaction with body size were negatively related to well-being. Additionally, having experienced a happy or sad event during the last years was also related to well-being, and resilience explained more than 26% of the variation in well-being.

The overall conclusion was that objective weight status was related to body satisfaction, which in turn was related to well-being, whereas weight status per se was less consistently associated with well-being. Moreover, the differences in well-being between the two cohorts (born 1990 vs 1974) were not explained by the shift in weight status.

7 FUTURE PERSPECTIVES

Much research has been done on factors that can influence adolescents' well-being, and obesity, lifestyle, body satisfaction and resilience are some examples of previously studied factors. However, most research does not encompass multiple factors at the same time, which makes it difficult to find the most important contributors and to investigate the complex interrelationships. Moreover, there is a limited amount of longitudinal research and evaluation of long-term effects.

For future studies, it would be of interest to follow the Grow Up 1990 cohort longitudinally, with a follow-up study as this cohort is approaching midlife. With such a follow-up, it would be possible to study the impact of well-being in adolescence on later well-being. In addition, also other factors known to be associated with well-being such as education, work, health (both physical and psychological) and social situation could be used for evaluation of the effect of adolescent well-being in adult life. Moreover, weight status in adolescence may be used to investigate the association with adult weight status and health, both physical and psychological. Furthermore, it would be of interest to investigate if and how body dissatisfaction in adolescence relates to later body satisfaction and well-being. Finally, analysis could be made to investigate whether similar factors are associated to well-being in adulthood as in adolescence.

Based on the results of this thesis, it would be of particular relevance to assess the effects of promoting sound sleep habits, physical activity, and to evaluate school-based interventions aiming to improve well-being of adolescents. Moreover, implementing modernized school-based surveillance systems, and monitoring childhood weight status on a population level would increase the possibilities to follow weight status over time and increase the awareness of important secular trends. Correspondingly, monitoring of adolescents' well-being would be equally important as research has shown that it has future effects both on an individual level but also on a societal level. In a rapidly changing society with increasing social and economic turbulence worldwide, it will be of importance for policy makers, community leaders, teachers and parents to become aware of trends in declining well-being among this important part of the population.

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