

Summary

The present thesis is part of the Netherlands Heart Foundation “Netherlands Research programme weight Gain prevention” (NHF-NRG). The focus of this programme was to study determinants of weight gain, and to develop, carry out and evaluate comprehensive weight gain prevention programmes for three different target groups: adolescents, young adults and recently retired people. In all studies within this programme, both food intake and physical activity behaviours were integrated, rather than focusing on a single behaviour. The present thesis focuses on life-style predictors of weight gain. An introduction and outline of this thesis is described in *chapter 1*.

The main objectives of this thesis were 1) to identify and describe groups at high-risk of weight gain and 2) to describe modifiable determinants of weight gain within the selected age groups (adolescents, young adults and recently retired persons). High-risk groups were identified based on personal circumstances (such as household composition/work etc.), life events or life transition, and on anthropometric indices. Modifiable determinants of weight gain that we studied were (changes in) the main energy balance related behaviours, i.e. total dietary intake and physical activity level, or components of these two main behaviours, e.g. energy density of the food, portion size and eating frequency, and intensity, duration and frequency of physical activities.

In the Netherlands, only a few studies exist in which persons’ body weight, body height, and waist circumference are measured over a longer period of time, combined with information on their energy intake and physical activity. Such cohorts are crucial to study lifestyle determinants of weight gain in a real life setting. In this thesis we have used data of two Dutch cohort studies containing both objective measures of body weight, body height and waist circumference as well as self-reported lifestyle measures: i.e. the Amsterdam Growth and Health Longitudinal Study (AGAHLS, adolescents and young adults; 13 years old at baseline followed for 24 years) and the Doetinchem Cohort Study (DCS, adults in general, including young adults and recently retired subjects; 20-59 years old at baseline followed for 11 years).

Adolescence appears to be a critical period for the development of obesity. Until now, little is known about the identification of adolescents who are at increased risk of becoming overweight or obese at an adult age, and it is uncertain which measures should be used to identify adolescents at high risk of adult obesity. In a longitudinal study (*chapter 2*) using data from the AGAHLS, we observed that adults with high body fatness (measured with dual-energy X-ray absorptiometry) had a significant higher body mass index (BMI) and sum of four skinfolds (S4SF) values during adolescence than adults with lower body fatness. In addition, adults with high body fatness had increased more in BMI and S4SF from adolescence into adulthood, than adults with lower body fatness. We showed that high adult body fatness is better predicted by adolescent skinfold thickness than by adolescent BMI. Skinfold thickness should therefore be used as the preferred screening tool to determine which adolescents are at increased risk of

becoming adults with high body fatness. Weight-gain prevention programs should focus on adolescents with large skinfold thicknesses.

In a longitudinal study using data from the DCS, we evaluated age, period and cohort effects on BMI (*chapter 3*). One of the main findings of this study was that the apparent decline in BMI with ageing in the oldest group of men as seen in cross-sectional analyses appeared to be an artefact due to a cohort effect. Our longitudinal data showed that BMI also increased in the oldest age group, in both men and women. Furthermore, increase in BMI was largest in the youngest age group, and the BMI of younger cohorts was higher than that of older birth cohorts at any given age between 30 and 60 years. Although the mean BMI of higher educated persons was lower than the mean BMI of lower educated persons, their increase in BMI with ageing was (in general) similar. This implies that prevention of weight gain should follow a population-wide, life-course approach.

Lifestyle behaviours are subject to change between adolescence and adulthood. Changes in dietary intake and physical activity (PA) are likely to result in changes in body weight and body fatness. In *chapter 4* we evaluated the associations between the developments of energy intake (EI) and PA from adolescence into adulthood, based on multiple measurements of the AGAHLs, in relation to body composition at age 36 years. Based on the concept of energy balance, it was assumed that especially a high baseline or increase in total EI and/or a low baseline or decrease in PA from adolescence into adulthood would be associated with a higher percentage of body fat at adult age. Results, however, showed only sparse associations of EI and PA with obesity and offer strong presumptions that longitudinal observational data based on self-report do not fit the theory of energy balance. Probably, a mixture of measurement error, reporting error, time between measurements and difficulties related to reporting habitual lifestyles makes it very difficult to associate self-reported lifestyle behaviours to weight gain (and resulting body fatness). Therefore, we believe that findings of relations between energy balance related behaviours and weight gain based on self-reported data (that might seem cause-effect relationships) should be interpreted with serious caution.

In *chapter 5*, we investigated the impact of four life events (leaving the parental home, starting to work, living together, and parenting children) on body weight, body mass index, skinfold thickness and waist circumference, using data from the AGAHLs. If effects were observed, we investigated the underlying changes in lifestyles (i.e. total energy intake and physical activity level).

Largest increases in body weight and S4SF between age 16 to 27 years were observed in men who had started to work before age 21 years, while they were still living with their parents. Smallest increases were observed among men and women who left the parental home and

started to work before age 21 years. Between age 27 and 36 years, women who lived alone had a larger increase in body weight and body fat than women who lived with a partner. This difference was not accompanied by significant differences in the changes in lifestyles. Parenting children was associated with larger increases in body weight and waist circumference in both men and women. Women who were parenting children at age 36 years showed a significant increase in total energy intake between age 27 and 36 years. Unexpectedly, some other significant changes in behaviours observed were contradictory to observed changes in anthropometry: a decrease in energy intake was associated with an increase in BMI and maintaining the physical activity level was associated with an increase in body weight. In conclusion, life transitions seem to affect body weight and body fatness. Especially men starting to work while living with their parents and young men and women planning a family seem important target groups for intervention programs to prevent (excessive) weight gain.

The aim of the study presented in *chapter 6* was to identify modifiable determinants of weight gain among young adults. Within the analyses, we studied the development of lifestyle behaviours in young adults over time, and the association between weight gain and both baseline and changes over time in diet and physical activity. We observed that several energy balance related behaviours changed over time in young adults. In men, weight gain was associated with changes in diet and physical activity over follow-up, but not with baseline diet and physical activity. In women, weight gain was associated with both baseline levels and changes in diet and physical activity. However, some baseline levels of behaviour and their changes were associated with weight gain in opposite directions. Different lifestyles were associated with weight gain in men compared to women. Among men, a decrease in using breakfast, an increase in juice consumption and a decrease in time spent on biking were associated with weight gain. Among women, an increase in sweet snack consumption was associated with weight gain. In conclusion, several aspects of energy balance related behaviour are not stable over time in young adults. Furthermore it seems pertinent to study changes in behaviour, rather than only baseline behaviour, in order to study determinants of weight gain.

In *chapter 7* we evaluated the impact of retirement on diet, physical activity, body mass index and waist circumference, over a five-year follow-up period in a population-based cohort. We hypothesised that a sudden reduction in work-related physical activity of moderate intensity may lead to unfavourable changes in energy balance and thereby lead to an increase in body weight and waist circumference. Results showed that retirement was associated with an increase in weight and waist circumference among those with former active jobs, but not among those with former sedentary jobs. Weight gain and increase in waist circumference were associated with a decrease in fruit consumption and fibre-density of the diet, with an increase in eating breakfast and in the consumption of sugar sweetened soft drinks, and with a decrease in

several leisure time physical activities. In conclusion, men who retired from physically active jobs were more prone to gain weight and increase in waist circumference compared to men who retired from sedentary jobs. Since retirement may bring opportunities for healthy changes in diet and physical activity, it seems warranted to develop health promotion programs aimed at prevention of overweight in men who are eligible for retirement, particularly in those who have physically demanding jobs.

In the general discussion (*chapter 8*), we discussed the methodology used in the presented studies and results are integrated into overall conclusions, implications for (clinical) practice and suggestions for future research. Based on results of the present thesis, it can be concluded that there is a need for weight gain prevention. Weight gain is of all ages, both genders and all levels of education. Therefore a population wide, life-course approach of weight gain prevention should be implemented. In addition, we could identify several subgroups that gained even more weight than their peers. Targeted weight gain prevention could be implemented, specifically directed to these subgroups. When studying associations between (changes in) lifestyle and weight gain, several methodological limitations came around. Taking into account these limitations, it seems hard to draw firm conclusions on lifestyle determinants of weight gain. However, when associations between changes in lifestyle factors and weight gain are biologically plausible (in line with the concept of energy balance), there is no problem to address such lifestyle factors in weight gain prevention programs.