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ORIGINAL RESEARCH

Patterns of weight loss and their determinants in a sample of adults with overweight and obesity intending to lose weight

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Abstract

Aim: Weight loss success is highly variable among individuals. Cluster analysis contributes to future intervention development by recognising this individual variability and identifying different weight loss patterns. Identifying determinants that differentiate between these patterns would explain the source of variability. Thus, we aimed to identify weight loss patterns and their determinants in adults with overweight and obesity.

Methods: The present study is a secondary analysis of data from the PortionControl@HOME study. The weight of 175 adults was measured at 0, 3 and 12 months and potential determinants were self-reported using validated questionnaires at 0 and 3 months. Weight loss patterns were identified based on percent weight change during Phase 1 (0–3 months) and Phase 2 (3–12 months) using cluster analysis. Determinants were assessed using multinomial logistic regression.

Results: We identified three weight loss patterns: (i) low success, demonstrating low weight loss achievement, (ii) moderate success, demonstrating successful weight loss in Phase 1 followed by partial regain in Phase 2 and (iii) high success, demonstrating weight loss in Phase 1 followed by continued weight loss in Phase 2. Compared to the moderate success pattern, the low success pattern was negatively associated with power of food at baseline (i.e. the appetitive drive to consume highly palatable food) (odds ratio, OR = 0.42, 95% CI = 0.21–0.86) and change in portion control behaviour (i.e. the use of behavioural strategies to control the amount of food consumed) (OR = 0.28, 95% CI = 0.10–0.78).

Conclusions: Three weight loss patterns were identified in adults with overweight and obesity. Adults with greater power of food and increased portion control behaviour were less likely to exhibit an unsuccessful weight loss pattern.

Key words: cluster analysis, determinants, obesity, overweight, weight loss patterns, weight maintenance.

Introduction

Obesity is one of the major causes of preventable morbidity and mortality.[1] Worldwide, more than 1.9 billion adults are overweight and 600 million are obese.[2] This is equivalent to 39% and 13% of the worldwide population, respectively.[2] Consequently, adults have an increased risk of developing physical diseases such as type 2 diabetes mellitus, cardiovascular diseases, various cancers and arthritis,[3] and mental diseases such as depression and anxiety disorders.[4]

Weight loss results in health benefits.[5,6] It has been reported that weight loss of 10% of initial body weight can lead to a substantial decrease in risk factors for diabetes and heart disease.[5,6] However, maintaining weight loss has proved to be more challenging.[7,8] On average, 30–35% of weight lost is regained in the first year after initial weight loss, and after this year weight regain continues.[9] Promoting weight loss maintenance by preventing regain after loss is crucial to maintain the health benefits.[10] The literature suggests that mild degrees of weight regain can cause plasma lipids, blood pressure, fasting glucose and insulin concentrations to return to baseline.[11] Therefore, weight loss maintenance is considered as important as initial weight loss.

It is well-known that weight loss success is highly variable among individuals.[12] However, most studies with a

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weight loss outcome report group mean weight change at follow up using simple statistical techniques, meaning that individual variability in weight loss success may be overlooked.[12,13] Cluster analysis can contribute to future intervention development by recognising this individual variability. This is because cluster analysis has the potential to distinguish subgroups of individuals who cluster according to a pattern based on individual weight change at multiple time points. Identifying determinants that differentiate between these patterns would explain the source of variability in weight loss success among individuals and thereby allow future interventions to improve weight loss success.[14] For example, insights into these determinants could identify which of the various techniques and delivery formats for self-directed weight loss interventions are effective for which individuals.[15]

On this basis, the present study aimed to identify weight loss patterns and their demographic (sex, age, educational level), biological (body mass index (BMI) at baseline), psychological (impulsivity and power of food at baseline) and behavioural (change in portion control behaviour) determinants in adults with overweight and obesity.

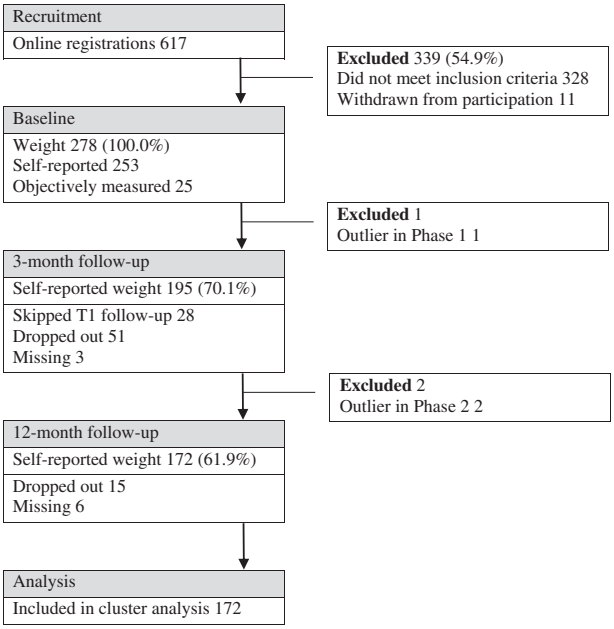

Figure 1 Flow of recruitment and follow up of the study participants.

Methods

The present study conducted secondary data analysis on the PortionControl@HOME dataset. PortionControl@HOME was a randomised controlled trial designed to determine the effectiveness of a multi-component portion size intervention on BMI and portion control behaviour among adults who were intending to lose weight. Details of the study have been described elsewhere.[16] From October to December 2011, participants were recruited from six municipalities between 21 and 45 km from Amsterdam, the Netherlands. Adults willing to participate had to register online by completing an application form on the study website. A total of 617 adults completed the online registration (Figure 1). After exclusion, 278 participants (46.1%) were randomised into either a 3-month intervention program or a wait list control group. After the intervention, all participants were followed-up to survey completion. Measurements were conducted at baseline (T0), 3 months (T1), 6 months (T2) and 12 months (T3) (Figure 1). Only measurements at T0, T1 and T3 were included in the current study. Reasons for dropout were ascertained from a questionnaire completed by approximately 46% of the participants who dropped out and included personal/family reasons, starting another program, health/medical reasons and lack of time. After the exclusion of participants with a missing value on weight at T0, T1 or T3, a total of 175 participants were included in the current study. Dropout and missing data analysis using χ^2 and *t*-tests indicated that sex, age, educational level and BMI at baseline did not significantly differ between participants who did or did not report their weight at T0, T1 and T3 ($P > 0.05$). The original study was conducted in accordance with the Declaration of Helsinki, approved by the Medical Ethics Committee of the VU Medical Center and registered with controlled-trials.com (Registration number, ISRCTN12363482). Written informed consent for participation was obtained prior to baseline measurements. We undertook an observational data analysis and therefore the current study is reported using STROBE.

Dutch adults were included in the original study if they met the following criteria: (i) BMI above 25 kg/m^2, (ii) aged between 18 and 60 years, (iii) residing in or within a distance of 15 km of one of six participating municipalities, (iv) were the nutritional gatekeeper of the family and (v) only one person per address could participate. Participants were excluded if they reported: (i) having or having had one of the comorbidities associated with overweight and obesity (diabetes mellitus, cardiovascular diseases, cancer or clinical depression), (ii) being on a diet, having visited a dietitian or currently having intensive weight loss treatment or within the past 6 months or (iii) being pregnant or planning to become pregnant.

Data were collected on demographics (sex, age and educational level), height and weight, impulsivity, power of food and portion control behaviour. Demographics were self-reported during baseline measurement. Education was based on highest qualification attained and classified into three levels: low (less than secondary school or the higher secondary school certificate), middle (higher secondary school certificate) and high (technical college or university degree). Height was measured by a stadiometer (Seca 214, Germany) to the nearest millimetre. Weight was measured at T0 using professional scales (Marsden MPMS-250 digital scale, UK) and using the participant's scales with the participant wearing light clothing and no shoes. At T1 and T3, participants weighed themselves using their own scales. To be consistent with T1 and T3, self-reported weight

according to the participant's scales was used for weight at T0. If available, missing values at T0 were imputed using the objectively measured weight (n = 25).

Impulsivity was measured at T0 using a translated version of the Barratt Impulsiveness Scale (BIS-11), a validated and widely used measure.[17] The BIS-11 contains 30 items (Cronbach's alpha = 0.75). Items were rated on a 4-point Likert scale ranging from 1 (rarely/never) to 4 (almost always/always).[17] Scores were averaged resulting in a mean score ranging from 1 to 4. Participants with a higher mean score on the BIS-11 were more impulsive.

Power of food was measured at T0 using a translated and shortened version of the Power of Food Scale (PFS). The PFS is a 21-item questionnaire developed to assess the psychological impact of the food environment.[18] The PFS measures the appetitive drive to consume highly palatable food in environments where those foods are constantly available.[19] All items were presented on a 5-point Likert scale ranging from 1 (do not agree at all) to 5 (strongly agree).[18] Validation studies indicated that the PFS is best represented by a 15-item version.[18,19] Therefore, the mean score of the 15 items was used in the present study (Cronbach's alpha = 0.87). A high score indicates greater responsiveness of individuals to the food environment.[18]

Portion control behaviour was defined as the use of behavioural strategies to control the amount of food consumed. It was measured at T0 and T1 by means of a validated 32-item questionnaire regarding the use of strategies incorporated into the PortionControl@HOME intervention program.[20] The use of the strategies was indicated on a 5-point Likert scale ranging from 1 (almost never) to 5 (almost always). The general use of portion control strategies was calculated by the mean score on the 32 items (T0 Cronbach's alpha = 0.78, T1 Cronbach's alpha = 0.85).

Statistical analyses were performed using the software IBM SPSS Statistics 22.0 (Armonk, New York: IBM Corp.). A two-step cluster analysis using the log-likelihood distance measure was conducted to identify weight loss patterns during Phase 1 (T0–T1) and Phase 2 (T1–T3) of the study. Outliers (>3 × SD above or below mean percent weight change in Phase 1 or Phase 2) were excluded (n = 3). Before determining the cluster solution, we investigated whether the assumptions to perform a log-likelihood distance measure were met. Percent weight change was checked for normality using plots and the Pearson correlation coefficient was used to test the independence of both weight change variables.

The number of clusters was determined using the Bayesian Information Criterion, selecting the best fit for the data.[21] In addition, the interpretability of the clusters was considered in the decision on the final cluster solution.[22] Goodness of the cluster solution was tested using the silhouette coefficient for cohesion and separation (≥0.5; good cluster quality).[21] To examine robustness of the final cluster solution, subsequent cluster analyses were performed with the cases arranged in four random orders. Stability of the clusters was further assessed by random division of the study sample into halves, followed by repeated cluster analysis on each half.[23] Cohen's kappa coefficients (0.81–1.00; almost perfect) were used to examine agreement between the original cluster solution and the clusters formed by the methods used to check for robustness and stability.[24,25]

Following cluster analysis, descriptive statistics were used to characterise the sample. Differences between the weight loss patterns were tested using χ^2 and univariable multinomial logistic regression analyses. A multivariable multinomial logistic regression model with all the factors entered simultaneously was produced to identify all the determinants. Portion control behaviour was incorporated as change between T0 and T1, because the literature suggests that changes in behavioural factors are more significant predictors of weight loss success than baseline levels.[26] The psychological factors were regarded as traits and therefore incorporated as baseline factors.[17,19]

Participants in the intervention and control groups were analysed as one sample. These groups did not significantly differ in percent weight change between T0 and T3, and in percent weight change during Phase 2. However, the intervention group lost more weight than the control group during Phase 1. Although chi-square analysis showed that participants in the weight loss patterns did not significantly differ in treatment condition, the condition was added to the multivariable multinomial logistic regression model in order to rule out that the intervention influenced the results.

Multivariable linear regression procedures were used to assess multicollinearity. We accepted a maximum variance inflation factor of 5. Odds ratios (ORs), 95% CIs and *P*-values were estimated for each factor. Values of $P < 0.05$ were considered statistically significant.

Results

The characteristics of the participants are summarised in Table 1. On an average, the participants were 46.5 years old (SD = 9.4), the majority were female (85.5%) and 45.9% had a high level of education.

The two-step cluster analysis revealed three weight loss patterns (Figure 2). The 'low success' pattern comprised 60.5% of the participants (n = 104) and exhibited a mean percent weight change of −1.08 (SD = 2.08) during Phase 1 and +0.41 (SD = 2.07) during Phase 2. The 'moderate success' pattern comprised 19.2% of the participants (n = 33) and exhibited a mean percent weight change of −7.45 (SD = 2.56) during Phase 1 and +3.86 (SD = 3.38) during Phase 2. The 'high success' pattern comprised 20.3% of the participants (n = 35) and exhibited a mean percent weight change of −3.36 (SD = 4.70) during Phase 1 and −6.00 (SD = 2.14) during Phase 2. The moderate success pattern was used as the reference category in the regression because it enabled us to investigate determinants of weight loss initiation (low *vs* moderate) as well as maintenance (high *vs* moderate). The silhouette coefficient demonstrated good cluster quality. Subsequent cluster analyses demonstrated robustness against four random case orders

Table 1 Descriptive statistics of participants

	Overall	*Low success*[(a)]	*Moderate success*[(a)]	*High success*[(a)]
Sample size	172	104	33	35
Age (years)	46.5 (9.4)	47.3 (9.1)[ns]	45.9 (8.5)[ns]	44.7 (10.8)[ns]
Sex, n (%)[(b)]				
Female	147 (85.5)	87 (83.7)	30 (90.9)	30 (85.7)
Male	25 (14.5)	17 (16.3)	3 (9.1)	5 (14.3)
Educational level, n (%)[(b)]				
Low	34 (20.0)	20 (19.6)	9 (27.3)	5 (14.3)
Middle	58 (34.1)	31 (30.4)	13 (39.4)	14 (40.0)
High	78 (45.9)	51 (50.0)	11 (33.3)	16 (45.7)
Body mass index at baseline	31.8 (4.8)	31.9 (4.6)[ns]	31.5 (3.9)[ns]	31.9 (6.1)[ns]
Impulsivity[(c)]	2.03 (0.28)	2.04 (0.27)[ns]	2.06 (0.27)[ns]	1.95 (0.32)[ns]
Power of food[(d)]	3.20 (0.72)	3.11 (0.70)[ns]	3.37 (0.77)[ns]	3.30 (0.67)[ns]
Change in portion control behaviour[(e)]	0.29 (0.43)	0.24 (0.44)[a]	0.45 (0.44)[b]	0.29 (0.38)[ab]

Mean (SD) unless otherwise stated. The presence of different superscript letters denotes statistically significant differences ($P < 0.05$), ns means no statistically significant differences.
[(a)] Weight loss patterns based on percent weight change during Phase 1 and Phase 2.
[(b)] Chi-square analyses revealed no statistically significant differences between weight loss patterns.
[(c)] Impulsivity at baseline measured by 30 items (4-point Likert scale), Barratt Impulsiveness Scale.
[(d)] Power of food at baseline measured by 15 items (5-point Likert scale), Power of Food Scale.
[(e)] Mean change (T1–T0) in portion control behaviour measured by 32 items (5-point Likert scale).

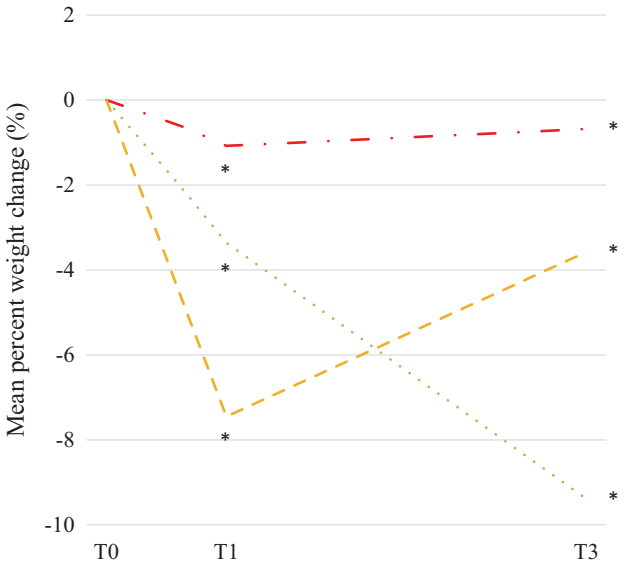

Figure 2 Patterns of weight loss over 12 months identified by cluster analysis. (– · –) Low success pattern; (– – –) moderate success pattern; (· · ·) high success pattern. T0 = baseline measurement; T1 = 3-month follow up; T3 = 12-month follow up. *$P < 0.001$.

($\kappa = 1.00$). Cluster analysis on random halves of the data demonstrated almost perfect stability ($\kappa = 0.91, 0.90$).

Compared to the moderate success pattern, the low success pattern was negatively associated with power of food at baseline (OR = 0.42, 95% CI = 0.21–0.86) and change in portion control behaviour (OR = 0.28, 95% CI = 0.10–0.78) (Table 2). After adjustment for treatment condition, these associations were still evident for power of food at baseline (OR = 0.43, 95% CI = 0.21–0.88) and change in portion control behaviour (OR = 0.32, 95% CI = 0.11–0.95).

Discussion

The present study aimed to identify weight loss patterns and their determinants in adults with overweight and obesity. We identified three weight loss patterns: (i) low success, demonstrating low weight loss achievement, (ii) moderate success, demonstrating successful initial weight loss in Phase 1 followed by partial regain in Phase 2 and (iii) high success, demonstrating initial weight loss in Phase 1 followed by continued weight loss in Phase 2. Compared to the moderate success pattern, the low success pattern was negatively associated with power of food at baseline and change in portion control behaviour.

The patterns identified are consistent with results reported by Laitner *et al*. In their study, participants were clustered based on percent weight change during a 6-month intervention period and a 12-month extended care period. In accordance with our findings, three weight loss patterns were identified, with low, moderate and high rates of weight loss success.[27] Szabo-Reed *et al*. used latent profile analysis to identify profiles for weight change over an 18-month follow up. The profiles were described as 'modest loss-complete regain', 'intermediate loss-minimal regain' and 'substantial loss-minimal regain'.[28] These findings suggest that weight loss patterns can be observed regardless of study population and statistical method used.

We found statistically significant differences between the weight loss patterns. Adults with increased portion control behaviour were less likely to have low success and more likely to exhibit a moderate success weight loss pattern,

Table 2 Multivariable multinomial logistic regression model to determine demographic, biological, psychological and behavioural determinants of weight loss patterns

	Low success[(a)]		*High success*[(a)]	
	OR (95% CI)	P-*value*	*OR (95% CI)*	P-*value*
Age (years)	1.02 (0.97–1.07)	0.48	1.00 (0.94–1.05)	0.89
Sex				
Female	Reference		Reference	
Male	1.61 (0.39–6.58)	0.51	1.12 (0.22–5.80)	0.89
Educational level				
Low	Reference		Reference	
Middle	0.66 (0.18–2.46)	0.53	1.55 (0.28–8.44)	0.61
High	1.62 (0.42–6.30)	0.49	2.32 (0.40–13.40)	0.35
Body mass index at baseline	1.07 (0.96–1.19)	0.23	1.06 (0.94–1.19)	0.39
Impulsivity[(b)]	1.52 (0.28–8.31)	0.63	0.37 (0.05–2.80)	0.34
Power of food[(c)]	0.42 (0.21–0.86)	0.02	0.69 (0.31–1.55)	0.36
Change in portion control behaviour[(d)]	0.28 (0.10–0.78)	0.01	0.45 (0.13–1.53)	0.20

Reference category is the 'moderate success' weight loss pattern.
[(a)] Weight loss patterns based on percent weight change during Phase 1 and Phase 2.
[(b)] Impulsivity at baseline measured by 30 items (4-point Likert scale), Barratt Impulsiveness Scale.
[(c)] Power of food at baseline measured by 15 items (5-point Likert scale), Power of Food Scale.
[(d)] Mean change (T1–T0) in portion control behaviour measured by 32 items (5-point Likert scale).

indicating that portion control behaviour is favourable in initial weight loss. Sciamanna *et al*. reported that portion control behaviour was associated with both initial weight loss and weight loss maintenance.[29]

Another study showed that individuals who maintained their weight loss consumed smaller portion sizes in several high energy-dense food groups than those who regained weight after a weight management program.[30] Our results confirm that increased portion control behaviour is associated with weight loss initiation. However, portion control behaviour did not differentiate between high and moderate success patterns. Therefore, the predictive value of portion control behaviour in weight loss maintenance was not confirmed in the present study.

However, power of food at baseline differentiated between low and moderate success patterns. Adults with greater power of food scores were less likely to have low success compared to moderate success, indicating that power of food is relevant to initial weight loss. Psychological factors may affect weight loss indirectly by influencing weight loss-related behaviours.[31] To date, only one previous study has investigated the relation between power of food and weight loss in a non-clinical sample.[32] In contrast to our findings, no association was found.[32] However, power of food is associated with dieting behaviour and greater risk of perceived overweight.[32,33] While there is an evidence that dieting is effective in initial weight loss, the majority of studies show that dieting is ineffective in weight loss maintenance.[33] This may explain our finding that power of food is negatively associated with the low success pattern, and not positively associated with the high success pattern compared to the moderate success pattern.

No significant associations were found for impulsivity, BMI at baseline or any demographic factors. Previous studies have shown that individuals suffering from obesity are more impulsive than people with a healthy weight.[34] In their review, Guerrieri *et al*. concluded that experimental research on this topic is too scarce to assume that impulsivity causes obesity.[35] In agreement with our findings, other studies showed no or a very small relationship between impulsivity and weight changes.[36] Mixed evidence has been reported on the association between baseline BMI and weight loss.[12] A positive association was particularly observed in studies reporting absolute weight change.[12] In addition, there seems to be a BMI threshold.[12] The weighted average for baseline BMI in studies showing positive associations was ~37 kg/m^2, and for negative or non-significant associations it was ~31 kg/m^2, which may explain the non-significant association found in the present study (mean: 31.8 kg/m^2).

In a review by Williams *et al.*, 10 out of 58 studies observed that men lost significantly more weight than women in the initial phase.[37] Because of greater baseline weight of men, sex differences are less convincing when using relative weight change, as in the current study.[37] Inconsistent results have been found regarding the effect of age on weight loss. While some studies reported older age to be predictive of successful weight loss, others report no significant or negative associations.[38] Moreover, in accordance with our findings, education has been reported not to be a significant determinant of weight loss success.[39,40]

One strength of the present study concerns the identification of weight loss patterns before investigating determinants of weight loss success. Categorical data (e.g. obtained by means of cluster analysis) takes individual variability in weight loss into account and sketches a more accurate picture of reality.[13] Despite the size of the study sample, cluster analysis revealed three almost perfectly stable clusters.

Although the present study provides important knowledge about the determinants of weight loss success, it is

important to note its limitations. Firstly, the amount of missing data because of dropout and non-response may be a limitation. However, there was no ground to assume that these individuals differed from the participating individuals. Secondly, the use of self-reported weight may also be a limitation. However, self-reported weight is regarded as a valid method to measure actual weight, as self-reported and objectively measured weight were found to be highly correlated at T0 ($r = 0.998$; $P < 0.001$). Thirdly, the results of a two-step analysis have been described as poor if cluster variables are of mixed measurement levels.[41] However, when only using continuous cluster variables, as in the current study, other approaches to identify weight loss patterns (e.g. latent class analysis) do not have advantages over clustering.[41] Fourthly, the follow up period was too short to draw any reliable conclusions with regard to long-term weight loss success. Finally, the present study is a secondary analysis of data from the PortionControl@HOME study. Therefore, our results may not be generalisable to all adults with overweight and obesity, as the adults included in the PortionControl@HOME study were willing to participate in the randomised controlled trial and intended to lose weight.

In conclusion, three weight loss patterns were identified in adults with overweight and obesity. Adults with greater power of food and increased portion control behaviour were less likely to have an unsuccessful weight loss pattern, indicating the importance of these factors for future weight loss interventions. However, given that these factors did not differentiate between the high and moderate success patterns, programs should emphasise relapse prevention. Additional research is needed to confirm our results and to enhance the identification of determinants of weight loss patterns across a wider range of populations and disciplinary fields. Moreover, future studies should ascertain how the predictive value of various factors can be implemented in weight loss interventions to improve weight loss outcomes.

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Conflict of interest

ME and MMS declare that they have no competing interests. IHMS and MPP are authors of the educational book that was part of the PortionControl@HOME intervention. IHMS is a co-owner of Brickhouse Academy, a company which aims to translate scientific knowledge into practice. She trains health care professionals based on the PortionControl@HOME intervention.

Authorship

ME conducted the analyses and drafted the manuscript. All authors critically reviewed the manuscript and approved the final version of the manuscript for submission. The authors would like to thank Liesbeth Velema in her support in collecting the data and Emely de Vet for her input on the data that was collected. We state that this manuscript has not been published before and is not under consideration for publication elsewhere.

References

1 Haslam DW, James WP. Obesity. *Lancet* 2005; **366**: 1197–209.
2 World Health Organization. Factsheet obesity and overweight. Geneva: WHO, 2018. (Available from: http://www.who.int/mediacentre/factsheets/fs311/en/, accessed 6 March 2017).
3 Bray GA. Medical consequences of obesity. *J Clin Endocrinol Metab* 2004; **89**: 2583–9.
4 Scott KM, McGee MA, Wells JE, Oakley Browne MA. Obesity and mental disorders in the adult general population. *J Psychosom Res* 2008; **64**: 97–105.
5 Wing RR, Lang W, Wadden TA *et al*. Benefits of modest weight loss in improving cardiovascular risk factors in overweight and obese individuals with type 2 diabetes. *Diabetes Care* 2011; **34**: 1481–6.
6 Blackburn G. Effect of degree of weight loss on health benefits. *Obes Res* 1995; **3**: 211s–6s.
7 Wing RR, Phelan S. Long-term weight loss maintenance. *Am J Clin Nutr* 2005; **82**: 222s–5s.
8 Ulen CG, Huizinga MM, Beech B, Elasy TA. Weight regain prevention. *Clin Diabetes* 2008; **26**: 100–13.
9 Turk MW, Yang K, Hravnak M, Sereika SM, Ewing LJ, Burke LE. Randomized clinical trials of weight loss maintenance: a review. *J Cardiovasc Nurs* 2009; **24**: 58–80.
10 Penn L, White M, Lindstrom J *et al*. Importance of weight loss maintenance and risk prediction in the prevention of type 2 diabetes: analysis of European Diabetes Prevention Study RCT. *PLoS One* 2013; **8**: e57143.
11 Kroeger CM, Hoddy KK, Varady KA. Impact of weight regain on metabolic disease risk: a review of human trials. *J Obes* 2014; **2014**: 1–8.
12 Teixeira PJ, Going SB, Sardinha LB, Lohman TG. A review of psychosocial pre-treatment predictors of weight control. *Obes Rev* 2005; **6**: 43–65.
13 Christian JG, Tsai AG, Bessesen DH. Interpreting weight losses from lifestyle modification trials: using categorical data. *Int J Obes (Lond)* 2010; **34**: 207–9.
14 Teixeira PJ, Carraca EV, Marques MM *et al*. Successful behavior change in obesity interventions in adults: a systematic review of self-regulation mediators. *BMC Med* 2015; **13**: 84.
15 Tang J, Abraham C, Greaves C, Yates T. Self-directed interventions to promote weight loss: a systematic review of reviews. *J Med Internet Res* 2014; **16**: e58.
16 Poelman MP, de Vet E, Velema E, de Boer MR, Seidell JC, Steenhuis IH. PortionControl@HOME: results of a randomized controlled trial evaluating the effect of a multi-component portion size intervention on portion control behavior and body mass index. *Ann Behav Med* 2015; **49**: 18–28.
17 Patton JH, Stanford MS, Barratt ES. Factor structure of the Barratt impulsiveness scale. *J Clin Psychol* 1995; **51**: 768–74.
18 Cappelleri JC, Bushmakin AG, Gerber RA *et al*. Evaluating the power of food scale in obese subjects and a general sample of

individuals: development and measurement properties. *Int J Obes (Lond)* 2009; **33**: 913–22.
19 Lowe MR, Butryn ML, Didie ER *et al*. The power of food scale. A new measure of the psychological influence of the food environment. *Appetite* 2009; **53**: 114–8.
20 Poelman MP, de Vet E, Velema E, Seidell JC, Steenhuis IH. Behavioural strategies to control the amount of food selected and consumed. *Appetite* 2014; **72**: 156–65.
21 Norusis M. *IBM SPSS Statistics 19 Statistical Procedures Companion*. London: Pearson, 2012.
22 Matsuo Y, Ohsawa Y. *Finding the Meaning of Clusters*. Palo Alto: AAAI, 2002.
23 Kos AJ, Psenicka C. Measuring cluster similarity across methods. *Psychol Rep* 2000; **86**: 858–62.
24 Reilly C, Wang C, Rutherford M. A rapid method for the comparison of cluster analysis. *Stat Sin* 2005; **15**: 19–33.
25 McHugh ML. Interrater reliability: the kappa statistic. *Biochem Med (Zagreb)* 2012; **22**: 276–82.
26 Byrne S, Barry D, Petry NM. Predictors of weight loss success. Exercise vs. dietary self-efficacy and treatment attendance. *Appetite* 2012; **58**: 695–8.
27 Laitner MH, Minski SA, Perri MG. The role of self-monitoring in the maintenance of weight loss success. *Eat Behav* 2016; **21**: 193–7.
28 Szabo-Reed AN, Lee J, Ptomey L *et al*. Longitudinal weight loss patterns and their behavioral and demographic associations. *Ann Behav Med* 2016; **50**: 147–56.
29 Sciamanna CN, Kiernan M, Rolls BJ *et al*. Practices associated with weight loss versus weight-loss maintenance results of a national survey. *Am J Prev Med* 2011; **41**: 159–66.
30 Greene LF, Malpede CZ, Henson CS, Hubbert KA, Heimburger DC, Ard JD. Weight maintenance 2 years after participation in a weight loss program promoting low-energy density foods. *Obesity (Silver Spring)* 2006; **14**: 1795–801.
31 Montesi L, El Ghoch M, Brodosi L, Calugi S, Marchesini G, Dalle Grave R. Long-term weight loss maintenance for obesity: a multidisciplinary approach. *Diabetes Metab Syndr Obes* 2016; **9**: 37–46.
32 Lipsky LM, Nansel TR, Haynie DL, Liu D, Eisenberg MH, Simons-Morton B. Power of food scale in association with weight outcomes and dieting in a nationally representative cohort of U.S. young adults. *Appetite* 2016; **105**: 385–91.
33 de Ridder D, Adriaanse M, Evers C, Verhoeven A. Who diets? Most people and especially when they worry about food. *Appetite* 2014; **80**: 103–8.
34 Nederkoorn C, Jansen E, Mulkens S, Jansen A. Impulsivity predicts treatment outcome in obese children. *Behav Res Ther* 2007; **45**: 1071–5.
35 Guerrieri R, Nederkoorn C, Jansen A. The effect of an impulsive personality on overeating and obesity: current state of affairs. *Psychol Topics* 2008; **17**: 265–86.
36 Meule A, Blechert J. Trait impulsivity and body mass index: a cross-sectional investigation in 3073 individuals reveals positive, but very small relationships. *Health Psychol Open* 2016; **3**: 1–6.
37 Williams RL, Wood LG, Collins CE, Callister R. Effectiveness of weight loss interventions—is there a difference between men and women: a systematic review. *Obes Rev* 2015; **16**: 171–86.
38 Svetkey LP, Clark JM, Funk K *et al*. Greater weight loss with increasing age in the weight loss maintenance trial. *Obesity (Silver Spring)* 2014; **22**: 39–44.
39 Jiang L, Huang H, Johnson A *et al*. Special Diabetes Program for Indians Diabetes Prevention Demonstration Project. Socioeconomic disparities in weight and behavioral outcomes among American Indian and Alaska native participants of a translational lifestyle intervention project. *Diabetes Care* 2015; **38**: 2090–9.
40 Ball K, Crawford D. Socioeconomic status and weight change in adults: a review. *Soc Sci Med* 2005; **60**: 1987–2010.
41 Bacher J, Wenzig K, Vogler M. *SPSS TwoStep Cluster—A First Evaluation*. Nürnberg: Universität Erlangen-Nürnberg, 2004.