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Identifying weight management clusters and examining differences in
eating behaviour and psychological traits

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Abstract

Previous research has suggested that differences in psychological traits and eating behaviours may characterise groups of individuals with similar weight management profiles, for example, individuals who have maintained a significant weight loss compared to those who have not. However, no study has looked at differences in traits across a sample with natural variation in bodyweight and its management. Across two studies, we sought to identify and validate weight management profiles using a clustering approach, and to examine differences across groups in terms of various traits. Data were collected using online questionnaires (Study 1: secondary data analysis; Study 2: primary data analysis allowing for cluster validation). Cluster analysis was implemented with BMI, diet history, weight suppression (difference between highest and current weight) as primary grouping variables, and age and gender as covariates. Differences in psychological and eating behaviour traits (e.g., restraint) were explored across clusters. In study 1, 423 participants (27.21 ± 9.90 years) were grouped into 5 clusters: 'lean men', 'lean young women', 'lean middle-aged women', 'successful' and 'unsuccessful dieters'. The cluster structure was broadly replicated in study 2 with 368 participants (34.41 ± 13.63 years). In both studies, unsuccessful dieters had higher restrained and emotional eating scores than lean individuals, and in study 1, they also had higher food addiction scores than successful dieters. Individuals could be grouped in terms of their weight management profiles and differences in psychological and eating behaviour traits were evident across these groups. The identified natural clusters confirmed the pre-defined groups used in previous research (i.e., lean individuals with little need to diet, successful and unsuccessful dieters). Additionally, the results strengthened the importance of gender and age when comparing weight management groupings.

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44 Keywords: weight management; psychological traits; eating behavior traits

Despite the overall upward trend in overweight and obesity that is prevalent within many countries globally (NCD Risk Factor Collaboration, 2016), there remain individuals who seem to 'buck the trend'. For example, they may have remained lean across their lifetime (Yacamán-Méndez, et al., 2021) or they may have successfully lost weight (Bray & Ryan, 2021) and maintained it over a significant time period (Paixão, et al., 2020). One possibility is that those individuals who have had relative success managing their bodyweight, possess advantageous psychological and eating style traits.

Indeed, a number of studies have examined such traits across participant groups characterised by particular weight trajectories. For example, Gold, et al. (2020) found that weight loss maintainers had higher levels of the personality trait of conscientiousness compared to weight re-gainers. While Neumann, et al. (2018) found that weight loss maintainers with an unstable weight trajectory across 2 years were characterised by higher emotional and external eating scores compared to those with a stable weight trajectory, and both of these groups had higher restrained eating scores compared to a general population sample.

However, there has yet to be a study that has examined psychological and eating style traits across a sample with natural variation in bodyweight and its management (i.e., as opposed to focussing on a particular group such as weight loss maintainers with a comparison group). The benefit of this approach is threefold: 1) Multiple groupings characterised by different bodyweights and weight management profiles can be compared in one model simultaneously; 2) Groupings may be identified which have previously been overlooked; 3)

Groupings which have been used in previous research and pre-defined by researchers can be confirmed. Therefore, across two studies, we sought to find natural groupings of individuals based on bodyweight and its management using cluster analysis, and to compare these groupings on a range of relevant psychological and eating style traits.

In order to operationalise ideas around bodyweight management, we drew on Lowe's (1993) seminal and still pertinent 'Three Factor Model of Dieting'. This is a framework that identifies three facets of dieting behaviour; (1) frequency of dieting and overeating which speaks to historical cycles of dieting and subsequent overeating, (2) current dieting, and (3) weight suppression which speaks to weight loss. Therefore, in addition to body mass index (BMI: reflecting body weight adjusted for height), dieting history, current dieting status and weight suppression were considered within our approach.

For study 1, a secondary analysis of an existing dataset (Price, Higgs, & Lee, 2015) was conducted, this included widely used psychological and eating style trait measures that are relevant to bodyweight/ BMI. Questionnaires such as the Power of Foods Scale (Lowe, et al., 2009), the Dutch Eating Behaviour questionnaire (Van Strien, Frijters, Bergers, & Defares, 1986), and the Yale Food Addiction Scale (Gearhardt, Corbin, & Brownell, 2009) were included (a comprehensive list of all measures is included in the methods section). To identify natural groupings of BMI and weight management (these groups are hereafter called 'weight management profiles'), cluster analysis was used, which also allows for the consideration of other factors which might influence weight and weight loss such as age and gender (e.g., Li, et al., 2021; Lifestyles Team & NHS Digital, 2019; Svetkey, et al., 2014). The

benefit of taking a secondary data analysis approach is that it can provide a ‘bird’s eye view’ on a new research question before refining an approach for a future original study (Smith, et al., 2011). Indeed, here, study 2 was original research that sought to refine and validate the findings of the first study.

Study 1

The aims and methodology for Study 1 were pre-registered at the Open Science Framework (OSF; <https://osf.io/g4stb/>). A tentative hypothesis was pre-registered which predicted that amongst clusters, a grouping characterised by a lean bodyweight and low weight suppression would emerge and contrast with a grouping characterised by a lean bodyweight and high weight suppression as well as one characterised by a high bodyweight and low weight suppression. Otherwise, an exploratory approach was taken with respect to the comparison of psychological and eating behaviour traits across clusters, therefore no specific hypotheses were pre-registered. Nevertheless, based on previous literature, we broadly predicted that ‘obesogenic’ traits (e.g., disinhibited or emotional eating) would be higher amongst clusters characterised by a higher BMI combined with a lower weight suppression.

Methods of study 1

1.1. Participants

Participants were recruited by Price, et al. (2015) from the student population at both Swansea University and the University of Birmingham, as well as from the wider community ($N = 496$). Of those, 423 participants’ data were available for secondary data analysis (40 individuals had missing demographic data and 33 individuals were either missing weight or

weight suppression values, or they were ‘improbable’, e.g., a BMI < 14kg/m²). Sample size calculation was not undertaken due to a lack of a rule-of-thumb or standardised approach for cluster analyses (see also Siddiqui, 2013).

Participants were mostly female (77.54%), had an average age of 27.21 years, a BMI in the healthy range and were non-dieters, while most of the individuals who dieted in order to lose weight, had done so 1 – 3 times in the last three years (for all demographics see Table 1).

Table 1. *Baseline demographic characteristics of sample.*

	Value
Total N	423
Gender [female] ¹	328 (77.54)
Dieting status [are currently dieting] ¹	86 (20.33)
Dieting score (possible range: 0-4) ²	1.09 (1.18)
Age [years] ²	27.21 (9.90)
BMI [kg/m ²] ²	24.23 (4.88)
Underweight ¹	22 (5.20)
“Healthy” weight ¹	264 (62.41)
Overweight ¹	98 (23.17)
Obesity ¹	39 (9.22)

¹ Results are presented as N (%); ² Results are presented as M(SD).

The original study was granted departmental ethical approval by the Swansea University, Department of Psychology Research Ethics committee.

1.2. Materials of study 1

Participants were presented with the Dutch Eating Behaviour Questionnaire (Van Strien, et al., 1986), the short Three Factor Eating Questionnaire (Karlsson, Persson, Sjostrom, & Sullivan, 2000), Power of Food Scale (Lowe, et al., 2009), Emotional Eating Scale (Arnow, Kenardy, & Agras, 1995), Barratt Impulsiveness Scale (Patton, Stanford, & Barratt, 1995), and Yale Food Addiction Scale (Gearhardt, et al., 2009). Descriptions of these validated questionnaires can be found in supplemental data 1 and Cronbach's alpha levels of all questionnaires in Table 2.

Table 2. Cronbach's alpha values for all questionnaires used according to Price, et al. (2015).

Measure	Cronbach's alpha
DEBQ Dietary Restraint	.93
DEBQ External Eating	.85
DEBQ Emotional Eating	.92
TFEQ Cognitive Restraint	.81
TFEQ Uncontrolled Eating	.85
TFEQ Emotional Eating	.75
PFS Available	.89
PFS Present	.84
PFS Tasted	.79
EES Anger/frustration	.87
EES Anxiety	.78
EES Depression	.74
YFAS Symptom count	.62
BIS Motor	.70
BIS Attention	.68
BIS Nonplanning	.74
BIS Total	.84

DEBQ: Dutch Eating Behaviour Questionnaire, TFEQ: Three Factor Eating Questionnaire, PFS: Power of Food Scale, EES: Emotional Eating Scale, YFAS: Yale Food Addiction Scale, BIS: Barratt Impulsiveness Scale.

138

139 1.3. Procedure for *Price, et al. (2015)*

140 All questions were presented using Survey Monkey (Palo Alto, California, USA).

141 Students attended the lab to fill in the questionnaires, while community volunteers accessed
142 them remotely. After the participant information and the written consent form, subjects
143 were asked about their demographics such as gender, age, height, and weight. Next
144 psychological and eating behaviour traits were assessed, followed by a debrief.

145

146 1.4. Secondary analyses of existing data

147 The dataset is openly accessible at the OSF (XXX).

148

149 Weight and height were self-reported for some participants and for others measured in the
150 lab. BMI based on self-reported and measured weight and height were combined for further
151 analysis (details about the calculation and reasoning for the combination can be found in the
152 supplemental data 2).

153

154 A dieting score was created by combining scores for two questions (if the participant had
155 ever dieted and if so, how often they dieted on separate occasions in the last 3 years), with
156 '0' indicating that an individual had never dieted to lose weight, if they had dieted 1 – 3
157 times in the last three years it was scored '1', for 4 – 6 times '2', for 7 – 10 times '3' and for
158 11 times or more '4'.

159

Weight suppression was calculated as the difference between the current and highest weight excluding pregnancy. Additionally, a percentage change score was calculated for ease of comparability with current weight as denominator. Some differences between highest and current weight were negative, meaning that the current weight was higher than the highest reported weight. When participants with negative weight suppression were excluded, the same clusters were identified. Therefore, in order to retain participants who might have confused question about their highest and current weight ($n = 44$), the absolute weight difference (only the value without the sign) was utilized for further calculations.

Analyses used a significance threshold of .05 and were conducted using IBM SPSS Statistics (Version 22.0.0.1).

A hierarchical cluster analysis (CA) was performed with current BMI, dieting score, and weight suppression (in percentage and kg) as standardised z-scores, as well as gender and age as covariates. Squared Euclidean distance and Ward's method were used. Combining information from the dendrogram and the agglomeration schedule, five clusters seemed to be the optimal number. ANOVA/chi-square and post-hoc analyses, i.e., Games-Howell, were applied to assess differences between the clusters regarding current dieting and the variables which were used for the CA (for categorical variables Bonferroni corrections were applied).

Next, differences in psychological traits between the clusters were identified using MANOVA and post-hoc analyses (with Games-Howell for between-clusters and False Discovery Rate according to Benjamini-Hochberg (Genovese, Lazar, & Nichols, 2002) for between-variable

differences) entering all traits at once ¹. Where responses to validated questionnaire measures were not normally distributed, logarithmic transformation was conducted. However, no difference in results before and after transformation could be found and therefore the original results (without transformation) are presented.

Results of study 1

2.1. Participant characteristics and cohort-level means

Cohort-level means for key measures can be found in

Table 3.

Table 3. *Participants' characteristics.*

	Value
Current weight [kg]	67.84 (15.57)
Highest weight [kg]	72.21 (17.08)
Absolute weight suppression [kg] ¹	4.88 (5.89)
Absolute weight suppression [%] ¹	7.28 (8.36)
EES	
Anger/Frustration (possible: 11-55)	21.14 (7.83)
Anxiety (possible: 8-40)	17.77 (6.09)
Depression (possible: 6-30)	14.86 (4.52)
Total (possible: 25-125)	53.77 (16.33)
PFS (possible: 1-5)	
Food available	2.48 (1.10)
Food present	3.12 (1.05)
Food tasted	2.88 (0.88)
Total	2.80 (0.89)

¹ A deviation between the pre-registered analysis plan is noted, a MANOVA rather than ANOVA was used to examine the difference in psychological and eating behaviour traits across clusters.

	Value
TFEQ (possible: 1-4)	
Restrained eating	2.57 (0.77)
Uncontrolled eating	2.31 (0.59)
Emotional eating	2.32 (0.74)
DEBQ (possible: 1-5)	
Cognitive restraint	2.84 (0.98)
Emotional eating	2.52 (0.84)
External eating	3.11 (0.69)
BIS11	
Motor impulsiveness (possible: 11-44)	23.49 (4.83)
Attentional impulsiveness (possible: 8-32)	17.59 (3.74)
Non-planning impulsiveness (possible: 11-44)	24.84 (5.22)
Total (possible: 30-120)	65.92 (11.10)
YFAS (possible: 0-7)	1.95 (1.46)

All results are presented as M(SD); ¹ Absolute weight suppression is the absolute value of weight suppression (meaning the values themselves without the signs); EES: Emotional Eating Scale, PFS: Power of Food Scale; TFEQ: Three Factor Eating Questionnaire; DEBQ: Dutch Eating Behaviour Questionnaire; BIS11: Barratt Impulsiveness Scale; YFAS: Yale Food Addiction Scale.

2.2. Weight management clusters

In total, five clusters were identified.

Two clusters emerged that represented 'lean men' and 'lean young women'. They combined low diet score – therefore low diet frequency – and low weight suppression with a low percentage of participants who currently diet (men: 6.8% and women: 12.1%) and a BMI in a 'healthy' range. This indicates that individuals within these clusters manage to stay lean with little or no need for dieting. There were differences in dieting score and BMI which might be

205 due to gender and age (men: 28 years versus women: 21 years). Cluster 3 was labelled 'lean
206 middle-aged women' with similar dieting scores and BMI as lean men and young women.

207

208 'Successful dieters' were the fourth cluster and comprised of men and women. This cluster
209 was characterised by a high dieting frequency and a higher percentage of individuals who
210 currently diet (34.0%) compared to the lean groups (Clusters 1, 2 and 3) along with higher
211 weight suppression. This group of participants seem to be dieters who are successful in their
212 efforts to lose weight. The final cluster can be described as 'unsuccessful dieters' (dieting is
213 often attempted but efforts are not successful), as they had a high dieting frequency (diet
214 score) and a high BMI but low weight suppression. Of all the clusters, the 'unsuccessful
215 dieters' had the highest percentage of individuals who were currently dieting (46.3%).

216

217 Values for key characteristics can be found in supplemental data 3 and a graphical
218 representation in Figure 1.

219

Figure 1. Graphical representation of the main characteristics of the clusters. The size of the circles represents the diet score of each cluster. The number represents the number of the cluster: 1. 'lean men' (n=73), 2. 'lean young women' (n=165), 3. 'lean middle-aged women' (n=58), 4. 'successful dieters' (n=47), and 5. 'unsuccessful dieters' (n=80).

2.3. Comparison of psychological and eating behaviour traits between clusters

Across clusters, 'unsuccessful dieters' had the highest scores for all psychological and eating behaviour traits except for cognitive restraint (DEBQ and TFEQ), external eating and non-planning impulsiveness. Notably, 'unsuccessful dieters' differed significantly from 'successful dieters' in the present subscale of the PFS and food addiction only. In addition, the 'unsuccessful dieters' cluster differed from the 'lean men' and 'lean middle-aged women's' clusters across a number of different measures; there were significant differences between 'unsuccessful dieters' and 'lean middle-aged women' on most traits (except for PFS tasted, TFEQ-restrained eating and BIS-11 non-planning impulsiveness). For the 'lean male' cluster compared to the 'unsuccessful dieters', there were significant differences for motor impulsiveness, restraint, emotional eating due to anger/frustration and depression (and the subscales of the TFEQ and DEBQ), and PFS.

238

239 'Successful dieters' had the highest score in both restraint scales (TFEQ and DEBQ); for the
240 restraint scale from the TFEQ, this was significantly higher for 'successful dieters' than for all
241 three of the lean clusters. For the restraint scale from the DEBQ this was significantly higher
242 for 'successful dieters' than for 'lean men' and 'lean young women'.

243

244 Amongst the lean clusters, some differences were found, in particular between 'lean young
245 women' and 'lean middle-aged women'. 'Lean young women' were more likely than 'lean
246 middle-aged women' to eat due to anxiety or general negative emotions (TFEQ and DEBQ),
247 due to hedonic or external cues, and had higher scores in uncontrolled eating, attentional
248 impulsiveness, and food addiction. In addition, compared to 'lean men', 'lean young women'
249 ate more due to depressive mood, the presence of hedonistic cues and had higher non-
250 planning and total impulsiveness. With respect to 'lean men', they had significantly higher
251 scores in uncontrolled eating and lower scores in cognitive restraint (TFEQ and DEBQ) than
252 'lean middle-aged women'.

253

254 The main results are presented graphically in Figure 2 and a table of all traits can be found in
255 supplemental data 4.

256

Figure 2. Comparison of psychological and eating behaviour traits between the five clusters: A) emotional eating (EES), B) total hedonic hunger (PFS) and cognitive restraint (DEBQ), and C) food addiction (YFAS). The error bars represent the standard deviation. The numbers above the bars indicate a significant difference to the clusters with this number, e.g., the anger and frustration score of 'lean men' is significantly different to cluster 5 ('unsuccessful dieters').

Interim discussion of study 1

Participants were clustered to identify natural groupings of individuals based on bodyweight and its management, and these clusters were then compared across a range of psychological traits including eating behaviours. In total five clusters were identified: 1) 'lean men', 2) 'lean young women', 3) 'lean middle-aged women', 4) 'successful dieters', and 5) 'unsuccessful dieters'.

Consistent with our hypothesis, clusters of individuals who are lean with little need for dieting were identified; these were 'lean men', 'lean young women', and 'lean middle-aged women' ($\text{BMI} < 25\text{kg/m}^2$) who had low weight suppression ($<7\%$) and a low dieting score (<1). We also identified two clusters of dieters, successful who had a lean bodyweight and high weight suppression ($>7\%$) and unsuccessful who were overweight with low weight suppression and a high dieting frequency (>1). As expected, 'unsuccessful dieters' showed the highest values in 'obesogenic' traits such as emotional eating and food addiction, with the greatest cluster differences emerging between this group, and the 'lean men' and 'lean middle-aged women'.

When considering results obtained via cluster analysis, it is important to consider their validity, i.e., that the clustering identified is not peculiar to the particular sample. Researchers might consider internal cross-validation, whereby a sample is initially split into two and a clustering solution is tested in one of the sub-samples and validated with the other (e.g. Fu & Perry, 2020). Here, we were concerned not to reduce our sample size by taking this approach and instead sought to validate via replication (e.g. Rovniak, et al., 2010).

This involves collecting an independent second sample in a subsequent study that can be used to validate and confirm the initial cluster analysis. The aim of such an exercise is the consistent replication of the initial cluster structure within the second sample. Therefore, a second study was conducted. In addition, since study 1 was a secondary data analysis using a sample collected to primarily address another research question, a second study allowed for the modest addition of measures pertinent to the current research question.

Study 2

The overarching aim of study 2 was to validate and confirm the primary cluster structure identified in study 1 via replication. In so doing we aimed to address our broader research question of identifying natural groupings of individuals based on their bodyweight and its management. Our secondary aim was to optimise and confirm findings assessing differences in psychological and eating behaviour traits across clusters. Three additional measures were added, time perspective (ZTPI), food craving (FCQ) as well as a questionnaire differentiating between flexible and rigid restraint, whilst other measures were removed, the TFEQ, PFS, YFAS and EES. These additions and removals are discussed in turn below. Study 2 was conducted as part of a larger study but for the sake of brevity only relevant results are presented here. The aims and methodology of the overall study were pre-registered at the OSF (<https://osf.io/4b2ex/>).

The first additional measure was time perspective which describes a person's view of their future, past and present. This was added because there is an increasing interest in the relationship between BMI and time perspective (Adams & Nettle, 2009; Bnard, et al., 2018),

but little research has been conducted in relation to weight loss and maintenance. Secondly, the Food Craving Questionnaire (FCQ) was added as it was shown to distinguish between groups that are analogous to the clusters identified in Study 1 (individuals with little need to diet, successful and unsuccessful dieters), offering an opportunity to further validate our approach (Meule, Lutz, Vögele, & Kübler, 2012). Thirdly, measures of flexible and rigid restraint were added as this two-factor structure (Westenhoefer, Stunkard, & Pudel, 1999) may offer better understanding of the relationship between cognitive restraint, and BMI and weight management, which has at times been contested (Hawks, Madanat, & Christley, 2008; Westenhoefer, 1991; Westenhoefer, et al., 1999). Indeed, rigid restraint is positively, and flexible restraint negatively related to intake (Hawks, et al., 2008).

Lastly, in order to avoid repetition where possible, the TFEQ was removed because of the inclusion of flexible and rigid restraint which is a measure based on the TFEQ. Therefore, overall restraint was measured using the DEBQ only. The DEBQ also assesses emotional eating and external eating and therefore facilitated the removal of the EES and the PFS. Finally, considering overall questionnaire length and the relative controversy regarding its conceptual origins in food addiction (e.g., Fletcher & Kenny, 2018), we also removed the YFAS.

Methods of study 2

3.1. Participants

Recruitment of participants was UK-wide, utilising social media, websites aimed at participant recruitment (e.g., www.callforparticipants.com), as well as Swansea University

online staff community boards and distribution channels via other universities. Prospective participants were excluded if they met the following criteria: under 18 years old, pregnant or breastfeeding, taking medication or being diagnosed with a condition influencing appetite, having a history of or current diagnosis of an eating disorder, and low proficiency in English.

According to Siddiqui (2013) there is no rule-of-thumb or standardised sample size calculation for cluster analysis, which is the primary analysis used. Therefore, the aim was to recruit a similar number of participants as in study 1 ($N=423$). Due to the poor quality in responding, the current data fell slightly short of this goal. In total data for 675 people were collected. Data for 128 individuals were excluded because respondents did not confirm consent, 161 individuals did not complete the survey, 9 individuals skipped eligibility questions, and 9 individuals reported a BMI < 18kg/m² (to minimise the risk of including individuals with possible eating disorders). Therefore, data for 368 participants was available for analyses.

The majority of participants were female (76.9%), white (78.3%), and non-smokers (92.4%), with an average age of 34.41 years (SD=13.63 years) (for demographics see Table 4).

Table 4. *Baseline demographic characteristics of sample.*

	Value
Total N	368
Gender ¹	
Male	83 (22.6)
Female	283 (76.9)
Other	2 (0.5)
Gender identity ¹	

The same as at birth	367 (99.7)
Different to birth	1 (0.3)
Dieting status [are currently dieting] ¹	85 (23.1)
Age [years] ²	34.41 (13.63)
BMI [m/kg ²] ²	25.06 (5.03)
Dieting score (possible range: 0-4) ²	0.58 (0.58)

¹ Results are presented as N(%); ² Results are presented as M(SD).

Participants were entered into a prize raffle for Amazon e-vouchers of 2 x £25 if they completed the study. The study was approved by the Research Ethics Committee of the Department for Psychology, Swansea University.

3.2. Materials

External, emotional and restrained eating were measured using the Dutch Eating Behaviour Questionnaire (DEBQ; Van Strien, et al., 1986) and impulsiveness was assessed using the Barratt Impulsiveness Scale (BIS-11; Patton, et al., 1995). Additionally, time perspective (ZTPI), food craving (FCQ-T-r), flexible and rigid restraint were assessed. Descriptions of the questionnaires can be found in the supplemental data 5 and Cronbach's alpha values for all questionnaires are presented in Table 5.

Table 5. Cronbach's alpha values for all questionnaires used in study 2.

	Cronbach's alpha
DEBQ (possible: 1-5)	
Cognitive restraint	.88
Emotional eating	.94
External eating	.83
Flexible restraint (possible: 1-12)	.79
Rigid restraint (possible: 1-16)	.75

	Cronbach's alpha
BIS-11	
Attentional impulsiveness	.70
(possible: 8-32)	
Motor impulsiveness	.63
(possible: 11-44)	
Non-planning impulsiveness	.74
(possible: 11-44)	
Total (possible: 30-120)	.83
ZTPI (possible: 1-5)	
Past negative	.86
Present hedonistic	.83
Future	.78
Past positive	.80
Present fatalistic	.80
DBTP	
FCQ-T (possible: 15-90)	.95

365

366 3.3. Procedure

367 All questionnaires were designed and presented using the online survey platform Qualtrics,
368 www.qualtrics.com (Provo, Utah, USA).

369

370 After confirming written consent, participants completed demographic questions and
371 provided further background information such as smoking and dieting status. Participants
372 responded to a battery of measures of psychological and eating behaviour traits which were

kept in the same order for each participant: DEBQ, flexible and rigid restraint, BIS-11, ZTPI and FCQ-T-r. Participants were asked to provide their email address which was used to inform the participant if they had had been successful in the prize draw. Participants were either debriefed immediately or at a later time and thanked for their participation at the end of the main questionnaire.

3.4. Analyses

All analyses were performed in IBM SPSS statistics 23. The data are deposited at OSF (XXX).

To assess the influence of time perspective, the Deviation from the Balanced Time Perspective (DBTP) was calculated (Stolarski, Bitner, & Zimbardo, 2011; Zhang, Howell, & Stolarski, 2013). An explanation of the calculation is presented in supplemental data 6. Otherwise, the procedures as described in study 1 were followed.

Results of study 2

4.1. Participant characteristics and cohort-level means

An overview of the participant characteristics can be found in Table 6 and Table 7. Notably, about half of the sample (45.7%) had never dieted while most of the dieters (49.2%) had done so about one to three times in the last three years.

Table 6. *Categorical participants' characteristics.*

	N (%)
Ethnicity	

	N (%)
White	288 (78.3)
Mixed, multiple ethnic groups	8 (2.2)
Asian, Asian British	62 (16.8)
Black, African, Caribbean, black British	3 (0.8)
Other ethnic groups	6 (1.6)
Prefer not to say	1 (0.3)
Occupation	
Student	155 (42.1)
Full-time employment	123 (33.4)
Part-time employment	42 (11.4)
Self-employment	20 (5.4)
Parent, carer, unemployed	27 (7.3)
Missing	1 (0.3)
Living situation	
Alone	48 (13.0)
Shared flat	102 (27.7)
With partner	99 (26.9)
With family	118 (32.1)
Missing	1 (0.3)
If ever on diet	
No	168 (45.7)
Yes	200 (54.3)
Bariatric surgery	
No	338 (99.7)
Yes	1 (0.3)
Dieting Score	
Never dieted	168 (45.7)
Dieted 1-3 times in last 3 years	181 (49.2)
Dieted 4-6 times in last 3 years	16 (4.3)
Missing	3 (0.8)

	M (SD)
Weight [kg]	70.38 (16.78)
Highest weight [kg] ¹	76.24 (19.34)
Height [cm]	167.04 (8.99)
Weight suppression [kg]	6.10 (7.81)
Weight suppression [%]	8.76 (11.63)
Exercise [min per week]	
Light activities	204.57 (192.41)
Moderate activities	31.24 (73.72)
Vigorous activities	53.22 (101.42)
Strength workout	57.54 (97.18)
Exercise score	542.44 (515.81)
Mean exercise score	67.80 (64.48)
DEBQ (possible: 1-5)	
Cognitive restraint	2.77 (0.81)
Emotional eating	2.70 (0.93)
External eating	3.16 (0.63)
Flexible restraint (possible: 1-12)	5.76 (3.13)
Rigid restraint (possible: 1-16)	6.34 (3.47)
BIS-11	
Attentional impulsiveness (possible: 8-32)	16.38 (3.74)
Motor impulsiveness (possible: 11-44)	21.89 (4.05)
Non-planning impulsiveness (possible: 11-44)	23.73 (4.99)
Total (possible: 30-120)	61.99 (10.32)
ZTPI (possible: 1-5)	

	M (SD)
Past negative	3.02 (0.79)
Present hedonistic	3.18 (0.56)
Future	3.54 (0.56)
Past positive	3.49 (0.69)
Present fatalistic	2.58 (0.68)
DBTP	2.20 (0.61)
FCQ-T (possible: 15-90)	44.29 (15.48)

BMI: Body Mass Index, WIMD: Wales Index of Multiple Deprivation, DEBQ: Dutch Eating Behaviour Questionnaire, BIS-11: Barratt Impulsiveness Scale, ZTPI: Zimbardo Time Perspective Inventory, DBTP: Deviation from the Balanced Time Perspective, FCQ T: Food Craving Questionnaire – Trait. * This is the highest weight an individual has had since their current height excluding pregnancy.

4.2. Weight management clusters

In total seven clusters were identified (basic characteristics of each cluster in Figure 3 and supplemental data 7).

Clusters 1 to 4 represented all lean participants with a ‘healthy’ BMI combined with a low diet score. Clusters 1 and 3 had the lowest dieting scores, with cluster 1 comprised of ‘lean men’ with a very low dieting score and cluster 3 comprised of ‘lean women without dieting’ who reported never dieting. Amongst clusters comprised of women (2, 3 and 4), differentiation was based firstly on dieting score with the ‘lean young women’ (cluster 2) dieting the most, followed by the ‘lean middle-aged women’ (cluster 4) and then the ‘lean women without dieting’. Secondly, BMI was similar for the ‘lean young women’ and ‘lean middle-aged women’ but was significantly lower for the ‘lean women without dieting’. Thirdly, weight suppression for the ‘lean women without dieting’ and the ‘lean young

women' was lower than for the 'lean middle-aged women'. Finally, 'lean middle-aged women' were older (56.2 ± 7.7 years) than the other two lean clusters comprised of women ('lean young women' = 25.4 ± 4.7 years and 'lean women without dieting' = 26.7 ± 6.5 years).

Clusters 5 ('young successful dieters') and 6 ('very successful dieters') comprised participants with a 'healthy' or slightly overweight BMI with high weight suppression. Cluster 7 ('unsuccessful dieters') was characterised by obesity and low weight suppression. The diet scores and number of individuals who currently diet were not significantly different between the groups of dieters.

Figure 3. Graphical representation of the main characteristics of the clusters. The size of the circles represents the diet score of each cluster. The number represents the number of the cluster: 1. 'lean men' ($n=68$), 2. 'lean young women' ($n=65$), 3. 'lean young women without dieting' ($n=81$), 4. 'lean middle-aged women' ($n=43$), 5. 'young successful dieters' ($n=40$), 6. 'very successful dieters' ($n=4$), and 7. 'unsuccessful dieters' ($n=38$).

428

429 4.3. Comparison of psychological and eating behaviour traits 430 between clusters

431 ‘Unsuccessful dieters’ did not differ in any of the psychological traits from the two successful
432 dieters’ clusters. However, the restrained and emotional eating scores for the ‘unsuccessful
433 dieters’ were significantly higher than the scores for the lean men and women who do not
434 need to diet. ‘Unsuccessful dieters’ also scored higher in food addiction and emotional
435 eating compared to the lean middle-aged women’s cluster. There was only a significant
436 difference in the present fatalistic time perspective between ‘unsuccessful dieters’ and ‘lean
437 young women’.

438

439 The ‘young successful dieters’ had the highest scores in the sub-scales of the DEBQ (except
440 emotional eating), rigid and flexible restraint, as well as in food craving. The restrained
441 eating (DEBQ, rigid and flexible) and food craving scores were significantly different to the
442 ‘lean men’ and ‘lean women without dieting’ clusters. Additionally, emotional eating was
443 higher for ‘young successful dieters’ than for ‘lean men’ and food craving higher than ‘lean
444 middle-aged women’. The ‘very successful dieters’ cluster did not show significant
445 differences to any of the other clusters.

446

447 Across the lean clusters, the greatest number of differences were found by comparison to
448 the lean men’s cluster. ‘Lean men’ had lower scores than ‘lean young women’ in restrained
449 (DEBQ, flexible and rigid) and emotional eating, future time perspective and food craving,
450 but higher scores in present fatalistic time perspective. Restraint and future time perspective

451 were also lower for 'lean men' than 'lean middle-aged women'. In contrast, attentional and
452 total impulsiveness as well as past negative time perspective were higher in the lean men's
453 cluster compared to the lean middle-aged women's cluster. Compared to the 'lean women
454 without dieting', 'lean men' had lower future time perspective. 'Lean young women' and
455 'lean women without dieting' differed in restrained eating (DEBQ, rigid and flexible) and
456 food craving. However, 'lean women without dieting' and 'lean middle-aged women'
457 contrast only in restraint (DEBQ, rigid and flexible), but not in food craving. Differences
458 between 'lean middle-aged women' and 'lean young women' can be found in emotional
459 eating and food craving.

460
461 The main results are presented graphically in Figure 4 and a table of all traits can be found in
462 supplemental data 8.

Figure 4. Comparison of psychological and eating behaviour traits between the seven clusters: A) restrained, emotional, and external eating (DEBQ), B) Food craving (FCQ-T). The error bars represent the standard deviation. The numbers above the bars indicate a significant difference to the clusters with this number, e.g., the food craving score of lean men is significantly different to clusters 2 ('lean young women') and 5 ('young successful dieters').

Overall discussion

The overarching aim of these studies was to identify natural groupings across a broad sample based on bodyweight and its management. In line with our hypothesis and in support of Lowe's three factor model of dieting, three types of clusters emerged across the

two studies similarly to the groupings used in previous literature: lean individuals with little or no need to diet historically or currently, successful dieters who were currently lean but had a history of dieting and had previously had a higher body weight, and unsuccessful dieters who had overweight and little difference to their highest weight despite current and history of dieting. Individual clusters within these categories, were also characterised further by age and gender, which was considered less in previous research. Notably, whilst these broad categories were replicated across Studies 1 and 2, there were some differences in the structure of individual clusters within these categories that are discussed further below.

The secondary and exploratory aim was to compare the weight management clusters regarding their psychological and eating behaviour traits. In line with our overarching prediction, we found that traits that are often regarded as obesogenic were associated with our clusters characterised by higher BMI combined with a lower weight suppression, labelled 'unsuccessful dieters'. Indeed, most differences in traits were observed between the 'unsuccessful dieters' and clusters with lean individuals, supporting previous literature. In study 1, 'unsuccessful dieters' had higher scores in restraint, emotional and hedonic eating, and food addiction than lean men and women as well as in external eating than middle-aged women. This is in line with the weight management literature in which participants with unstable weight showed higher scores in restrained compared to general population and additionally higher external and emotional eating scores than individuals with stable weight (Neumann, et al., 2018). Also, higher emotional eating was related to weight regain (Grief & Miranda, 2010), indicating influences of these psychological factors on weight loss and maintenance. The results of study 1 were partially supported by study 2, which showed

higher (rigid) restrained and emotional eating compared to the 'lean men' and 'lean young women'.

'Unsuccessful dieters' not only had significantly higher food addiction scores than participants in the lean groups, but also compared to the successful dieters group. Additionally, hedonic hunger of present foods was higher than 'successful dieters'. Notably, these two traits are the variables with the highest compulsiveness on the uncontrolled eating continuum proposed by Vainik, García-García, and Dagher (2019), and might indicate an important factor responsible for the success of weight loss maintenance. The theory proposes placing psychological traits which assess either the reason for overeating or loss of control over eating on a continuum based on an increase of severity and compulsiveness of uncontrolled eating. The continuum ranges from "passive overeating" (occasional impulsive overeating), over emotional and disinhibited eating to binge eating and can lead to food addiction (assessed by the YFAS). Factors of this uncontrolled eating phenotype were related to BMI and some of the constructs, such as disinhibition, also to intake (Price, et al., 2015; Vainik, et al., 2019; Vainik, Neseliler, Konstabel, Fellows, & Dagher, 2015). Since hedonic hunger and food addiction have the highest severity of uncontrolled eating, it is harder for individuals with higher scores in these traits to manage their intake leading to a higher BMI and a higher probability to struggle losing weight or to regain weight after weight loss.

Our results also provide further support for the non-linear relationship between BMI categories and food addiction suggested by Meule (2012), which might explain the inconsistent results in previous literature which had assumed a linear relationship. In Figure

5, the BMI categories of the clusters as well as of the whole sample were mapped on the curve reported by Meule (2012) and show a similar line. It also provides a visual representation of a higher food addiction score of the ‘unsuccessful dieters’ (cluster 5 in study 1 and cluster 7 in study 2) compared to the other clusters with a lower BMI (also discussed in the paragraph above).

Figure 5. Relationship between the mean YFAS symptom count and BMI category of overall sample (grey squares) and the clusters (grey x) in presented study as well as of the sample presented by Meule (2012) (black). Curved lines represent third order polynomial trend lines (overall sample of presented study = dashed line ($R^2 = .940$) and sample by Meule (2012) = dotted line ($R^2 = .095$)). Cluster 1 = Lean men, Cluster 2 = Lean young women, Cluster 3 = Lean middle-aged women, Cluster 4 = Successful dieters, Cluster 5 = Unsuccessful dieters.

Notably, in both studies, there was one cluster with only men, while there were two or three clusters with only women. This may be because the overall sample included more women than men (study 1: $n=77.5\%$ women; study 2: $n=76.9\%$ women) and therefore the men were limited in diversity on our clustering measures. Another possibility is that it may indicate that it is only at the leaner end of the spectrum that gender is a meaningful differentiator. The

all-male clusters were lean and had the lowest scores in restrained eating, emotional eating, food addiction, future time perspective and craving. This supports the current literature about gender differences in such traits (Cepeda-Benito, Fernandez, & Moreno, 2003; Provencher, Drapeau, Tremblay, Després, & Lemieux, 2003).

Lean clusters were also differentiated by age, and these young and middle-aged clusters varied in psychological traits. In study 1, middle-aged lean women had lower values than the young lean women in most psychological and eating behaviour traits, such as in emotional, uncontrolled, and external eating, power of food and total impulsiveness. Since lower scores in these traits are related to lower BMI (Meule & Blechert, 2017; Price, et al., 2015), these traits may have helped participants to maintain their healthy weight into their forties. However, in study 2, reversed relationships were observed with middle-aged women showing higher scores in emotional and restrained eating (assessed by DEBQ, flexible and rigid restraint) compared to the younger women. This may be explained by differential weight suppression across studies with the 'lean middle-aged women' having a weight suppression of 4% compared to 12% in Study 2. In the weight loss maintenance literature, weight loss and maintenance were related to higher restraint, which might explain the differences in scores (Grief & Miranda, 2010; Neumann, et al., 2018).

Considering dieting history in addition to weight suppression, gave a better picture of dieting behaviour and weight fluctuations, in particular for lean participants. The lowest weight suppressions were around 5%, which is considered clinically relevant weight loss (Ryan & Yockey, 2017), yet these individuals did not report dieting. This suggests that they do not use

diets to keep a 'healthy' weight and that a moderate weight suppression of 5% might be a 'normal' state for many individuals. One possible explanation why these lean groups might not need to diet is that they use strategies to maintain their weight but do not label these as dieting to lose weight. This is consistent with a study by Gatzemeier, Price, Wilkinson, and Lee (2019). They found a wide range of strategies which were used to manage intake of tempting foods in the day-to-day life amongst participants who did not identify themselves as dieting and were lean.

A future study utilising this approach might consider recording length of dieting episodes and periods of time at a particular weight (e.g., current weight and highest weight) and/ or the inclusions of a measure such as the 'Dieting and Weight History Questionnaire' (Witt, Katterman, & Lowe, 2013). This would be helpful in identifying whether our 'successful dieters' in both studies could be considered weight loss maintainers due to a maintained reduced bodyweight over particular time periods (e.g., one year). These additional measures would also be helpful in further characterising the 'very successful dieters cluster' which emerged in study 2. These individuals lost on average 84% of their highest bodyweight but did not indicate that they underwent bariatric surgery, had a low dieting frequency (<1) and a 'healthy' BMI ($M=22.7\pm2.2$ kg/m²). There might be a range of explanations for this strong weight loss. These participants may have attended a commercial diet program for many years and lost weight over the time. Further information would also help to eliminate the possibility that this cluster is due to methodological issue, for example, these participants were outliers and mistyped their highest weight.

5.1. Strengths and limitations

Firstly, cluster analysis is an exploratory tool to group a sample based on researcher-chosen variables. To identify the number of clusters, the dendrogram and agglomeration schedule were used, which are somewhat subjective. In order to improve validity, the results of study 1 were replicated in study 2 with a separate sample (as suggested by Fu & Perry, 2020; Rovniak, et al., 2010) and the methods pre-registered. Secondly, the majority of measurements were 'self-report' in nature. With respect to BMI, though self-reported height and weight can be under- and overreported, respectively, as discussed earlier, there is a strong relationship between self-reported and researcher-measured BMI. As such, self-reported BMI is widely used in the scientific literature (Celis-Morales, et al., 2015; Pursey, Burrows, Stanwell, & Collins, 2014). Hence, a strength of the current study was the inclusion of researcher-measured BMI (60%) in Study 1. Thirdly, the studies were cross-sectional and therefore no conclusion about the causal relationship between the traits and clusters can be made. Understanding the direction in a longitudinal context might help to design more successful weight loss and maintenance programs either by trying to change the psychological traits first or choosing the program based on the traits of the individual.

5.2. Conclusion

In both studies, clusters of individuals who are lean with little or no need for dieting, successful and unsuccessful dieters were identified using the diet history and weight suppression factors in line with the Three-Factor Model of Dieting (Lowe, 1993). This supports the groupings of successful and unsuccessful weight loss used in previous research. However, additionally, lean individuals were differentiated according to gender, age and if

609 they had never or only rarely dieted, which should be considered in future research and
610 weight management advice. These clusters varied in their psychological traits, with
611 'unsuccessful dieters' showing higher restrained and emotional eating scores compared to
612 lean individuals (in both studies). Study 1 also supported the uncontrolled eating continuum
613 (Vainik, et al., 2015) and the non-linear relationship between BMI and food addiction
614 (Meule, 2012), with significant differences between successful and unsuccessful dieters in
615 hedonic hunger and food addiction. More research about the directionality of the
616 relationship between the traits and weight management is needed to personalise weight
617 loss and maintenance programs by changing the psychological traits of the individual or
618 choosing the program depending on the traits.

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Author contributions

All authors contributed to conceptualisation, methodology, and writing – review&editing. JG was responsible for data curation, formal analysis, investigation, project administration, visualisation, and original draft preparation. LLW, MP and MDL were supervising. All authors approved the final article.

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Declarations of interest

None

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758

Supplemental data

Study 1

Supplemental data 1. *Description of psychological and eating behaviour traits.*

Power of Food Scale (PFS; Lowe, et al., 2009)

The PFS is a measure of the influence of the food environment and contains 15 items. It has 3 sub-scales: assessment of appetite if the food is 1) available (e.g., “It seems like I have food on my mind a lot”), 2) present (e.g., “If I see or smell a food I like, I get powerful urge to have some”), and 3) tasted (e.g., “When I eat delicious food I focus a lot on how food it tastes”). Ratings are from ‘don’t agree at all’ to ‘strongly agree’ on a 5-point scale. The average is used for each sub-scale, with a higher score indicating greater appetite for palatable food.

Emotional Eating Scale (EES; Arnow, et al., 1995)

The EES is used to measure over-eating in response to emotional stimuli. It is a 25-item adjective checklist that asks participants to rate, on a 5-point scale, the degree to which each mood state generates a desire to overeat, has no effect, or a desire to under eat. It has three sub-scales; anger/frustration (e.g., resentful, discouraged, irritated), anxiety (e.g., shaky, uneasy, on edge) and depression (e.g., sad, worn out, bored). A total sum-score for each sub-scale and the total is then calculated with higher scores indicating greater tendencies to eat in response to negative emotions.

Three Factor Eating Questionnaire – short (TFEQ-18R; Karlsson, et al., 2000)

The TFEQ-18R – a short version of the original TFEQ (Stunkard & Messick, 1985) – measures cognitive and behavioural components of eating and has three sub-scales. The cognitive restraint sub-scale is designed to measure the tendency to restrict dietary intake to control weight and has six items (e.g., “I deliberately take small helpings as a means of controlling my weight”). The uncontrolled eating sub-scale measures the extent of control over one’s eating behaviour (e.g., “Sometimes when I start eating, I just can't seem to stop”) and has nine items. The emotional eating sub-scale assesses the tendency to eat in response to negative emotions (e.g., “When I feel blue, I often overeat”) and has three items. The average of each sub-scale was calculated, and higher scores suggest higher restrained, uncontrolled, and emotional eating, respectively.

Dutch Eating Behaviour Questionnaire (DEBQ; Van Strien, et al., 1986)

The DEBQ measure has 33 items in total and is comprised of three sub-scales. The dietary restraint sub-scale has ten items relating to restrained eating (e.g., “When you have put on weight, do you eat less than you usually do?”). The external eating sub-scale has ten items relating to the presence of food cues in the environment (e.g., “If you see others eat do you have the desire to eat?”). The emotional eating sub-scale has thirteen items and relates to the tendency to eat in response to negative emotions (e.g., “Do you have the desire to eat when someone lets you down?”). A score is obtained for each sub-scale by obtaining an average from the sum-scores, with higher scores indicating greater tendencies to restrain, eat in response to external cues or when in a negative mood, respectively.

Barratt Impulsiveness Scale (BIS-11; Patton, et al., 1995)

The BIS-11 is a 30-items questionnaire that is widely used to measure trait impulsiveness and is structured to assess long-term patterns of behaviour. It is comprised of three second order (attention, motor, and non-planning impulsivity) sub-scales to measure different facets of impulsiveness. Motor impulsiveness (11 items) measures the tendency to act without thinking (e.g., “I do things without thinking”), the 8 item sub-scale attentional impulsiveness is defined as an inability to focus attention or concentrate (e.g., “I have racing thoughts”) and non-planning impulsiveness (11 items) is defined as a lack of ‘futuring’ or forethought (e.g., “I am more interested in the present than the future”). A sum-score for each sub-scale and an overall total is then calculated with higher scores indicating greater impulsiveness.

Yale Food Addiction Scale (YFAS; Gearhardt, et al., 2009)

The YFAS is a 25-item eating behaviour measure and can return a continuous variable score for the number of diagnostic criteria met, with higher scores indicating a greater tendency to lose control over ones eating behaviour. Depending on cut-off values for each question, a 0 or 1 is given and then a sum-score for the seven substance dependence criteria is taken (excluding the criterion ‘clinical significance’). For example, “I find that when certain foods are not available, I will go out of my way to obtain them. For example, I will drive to the store to purchase certain foods even though I have other options available to me at home”.

Supplemental data 2. *Calculation of BMI.*

BMI for each participant was calculated using the standard formula (kg/m^2) based on self-reported (37.6%) or measured weight and height (62.4%). Self-reported BMI is found to be highly correlated with measured BMI in young (Pursey, et al., 2014), middle age and elderly groups (Ng, et al., 2011). Nevertheless, weight can be overestimated and height underestimated (Ng, et al., 2011). Hence, for example, Price, et al. (2015) created a dichotomous variable of measurement (self-reported or recorded) and used this new variable as covariate in the analyses. As there was no influence of measurement on the results, the findings of the combined sample were reported (similarly in Wilkinson, Rowe, & Millings, 2020).

Supplemental data 3. *Differences in demographics and weight management between the five clusters.*

Factors	1. Lean men (n=73)		2. Lean young women (n=165)		3. Lean middle- aged women (n=58)		4. Successful dieters (n=47)		5. Unsuccessful dieters (n=80)		<i>p</i> *
	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD	
Gender [m/f]	73/0 ^{2,3,4,5}		0/165 ^{1,4,5}		0/58 ^{1,4,5}		9/38 ^{1,2,3}		13/67 ^{1,2,3}		<.001
Age [y]	28.0 ^{2,3}	10.2	21.4 ^{1,3,4,5}	2.9	42.6 ^{1,2,4,5}	7.3	24.8 ^{2,3}	7.5	28.9 ^{2,3}	9.5	<.001
Diet score	0.38 ^{2,4,5}	0.57	0.75 ^{1,4,5}	0.79	0.59 ^{4,5}	0.65	1.57 ^{1,2,3,5}	1.08	2.50 ^{1,2,3,4}	1.35	<.001
BMI [kg/m ²]	23.5 ^{2,5}	3.3	22.1 ^{1,5}	2.6	23.4 ⁵	3.5	23.5 ⁵	4.1	30.4 ^{1,2,3,4}	6.0	<.001
Weight suppression [%]	5.9 ^{2,4}	5.1	4.0 ^{1,3,4}	3.5	7.1 ^{2,4}	4.8	24.8 ^{1,2,3,5}	11.4	5.1 ³	4.6	<.001
Weight suppression [kg]	4.5 ^{2,4}	3.9	2.4 ^{1,3,4,5}	2.0	4.4 ^{2,4}	3.1	16.6 ^{1,2,3,5}	9.1	3.9 ^{2,4}	3.4	<.001
Current dieting [yes N(%)]	5 (6.8) ^{4,5}		20 (12.1) ^{4,5}		8 (13.8) ⁵		16 (34.0) ^{1,2}		37 (46.3) ^{1,2,3}		<.001

* *p*-values indicate the results of the ANOVA or chi-squared test of each variable across all five clusters. The superscribed number indicates a significant difference to the clusters with this number, e.g., for age: lean men have an average age of 28.0 years, and this is significantly different to clusters 2 (lean young women) and 4 (lean middle-aged women).

Supplemental data 4. *Psychological and eating behaviour traits for each cluster.*

Factors	1. Lean men (n=73)		2. Lean young women (n=165)		3. Lean middle- aged women (n=58)		4. Successful dieters (n=47)		5. Unsuccessful dieters (n=80)		<i>p</i> *	R ²
	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD		
EES												
Anger and frustration	19.8 ⁵	7.7	21.2	7.1	19.4 ⁵	7.8	20.8	8.0	23.6 ^{1,3}	8.7	0.011	0.031
Anxiety	17.8	6.7	18.4 ³	5.9	15.5 ^{2,5}	5.7	17.1	5.3	18.4 ³	6.3	0.023	0.027
Depression	13.4 ^{2,5}	4.1	15.3 ¹	4.3	13.5 ⁵	5.0	15.0	4.4	16.1 ^{1,3}	4.6	<.001	0.049
Total	50.9	16.9	55.0	15.1	48.4 ⁵	16.3	52.0	16.1	58.0 ³	17.2	0.004	0.036
PFS												
Available	2.2 ⁵	1.0	2.6 ³	1.0	2.0 ^{2,5}	1.0	2.5	1.1	2.9 ^{1,3}	1.2	<.001	0.068
Present	2.8 ^{2,5}	1.1	3.3 ^{1,3}	1.0	2.7 ^{2,5}	1.0	2.9 ⁵	1.1	3.5 ^{1,3,4}	1.0	<.001	0.066
Tasted	2.8	0.8	2.9	0.8	2.8	0.9	2.8	0.9	3.0	1.0	0.380	0.010
Total	2.6 ⁵	0.9	2.9 ³	0.8	2.5 ^{2,5}	0.8	2.7	0.9	3.1 ^{1,3}	1.0	<.001	0.054
TFEQ												
Restrained eating	2.2 ^{3,4,5}	0.8	2.5 ^{4,5}	0.8	2.6 ^{1,4}	0.6	3.0 ^{1,2,3}	0.7	2.8 ^{1,2}	0.7	<.001	0.097
Uncontrolled eating	2.3 ³	0.6	2.4 ³	0.6	2.0 ^{1,2,5}	0.5	2.2	0.6	2.5 ³	0.6	<.001	0.069
Emotional eating	2.2 ⁵	0.7	2.4 ³	0.7	2.0 ^{2,5}	0.7	2.3	0.7	2.5 ^{1,3}	0.8	<.001	0.048
DEBQ												
Cognitive restraint	2.4 ^{3,4,5}	1.0	2.7 ^{4,5}	1.0	2.9 ^{1,5}	0.8	3.3 ^{1,2}	1.0	3.3 ^{1,2,3}	0.8	<.001	0.111
External eating	3.1	0.7	3.2 ³	0.6	2.8 ^{2,5}	0.7	3.0	0.6	3.2 ³	0.7	<.001	0.048
Emotional eating	2.2 ^{2,5}	0.7	2.6 ^{1,3}	0.8	2.2 ^{2,5}	0.8	2.6	0.9	2.8 ^{1,3}	0.9	<.001	0.065
BIS11												
Attentional impulsiveness	17.0	3.5	18.0 ³	3.5	16.6 ^{2,5}	3.1	16.9	3.8	18.5 ³	4.4	0.008	0.032

Factors	1. Lean men (n=73)		2. Lean young women (n=165)		3. Lean middle- aged women (n=58)		4. Successful dieters (n=47)		5. Unsuccessful dieters (n=80)		<i>p</i> *	R ²
	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD		
Motor impulsiveness	22.8 ⁵	3.8	23.5	4.4	22.0 ⁵	3.9	22.9	4.8	25.5 ^{1,3}	6.4	<.001	0.050
Nonplanning impulsiveness	23.3 ²	4.4	25.9 ¹	5.2	24.2	4.6	23.9	5.4	25.1	5.8	0.004	0.036
Total	63.2 ^{2,5}	9.0	67.3 ^{1,3}	10.4	62.7 ^{2,5}	9.3	63.8	11.0	69.1 ^{1,3}	14.0	<.001	0.048
YFAS - symptom count	1.7 ⁵	1.2	1.8 ^{3,5}	1.3	1.3 ^{2,4,5}	1.1	2.0 ^{3,5}	1.4	2.9 ^{1,2,3,4}	1.8	<.001	0.121

* *p*-values indicate the results of the post-hoc analysis of the MANOVA of each trait with its respective adjusted R². The superscribed number indicates a significant difference to the clusters with this number, e.g., EES-Anger and frustration for lean men has a score of 19.77, which is significantly different to cluster 5 (Unsuccessful dieters). EES: Emotional Eating Scale, PFS: Power of Food Scale; TFEQ: Three Factor Eating Questionnaire; DEBQ: Dutch Eating Behaviour Questionnaire; BIS11: Barratt Impulsiveness Scale; YFAS: Yale Food Addiction Scale.

Study 2

Supplemental data 5. *Description of psychological and eating behaviour traits.*

Zimbardo Time Perspective Inventory (ZTPI; Zimbardo & Boyd, 1999)

The 56-item ZTPI scale is used to measure time perspective and is comprised of five sub-scales (Past Negative, Present Hedonistic, Future, Past Positive and Present Fatalistic). The 10 item Past-Negative (PN) sub-scale describes a generally negative view of the past (“Painful past experiences keep being replayed in my mind”). The Present-Hedonistic (PH) sub-scale consists of 15 items and is characterised by a focus on the present enjoyment and pleasure (e.g., “I try to live my life as fully as possible, one day at a time”). The 13 item Future (F) sub-scale describe an attitude of future planning (e.g., “I am able to resist temptations when I know that there is work to be done”). The Past-Positive (PP) sub-scale is defined as a sentimental attitude towards the past and has 9 items (“It gives me pleasure to think about my past”). The Present-Fatalistic (PF) sub-scale comprises also 9 items and describes fatalistic and hopeless attitude towards the future and life (“My life path is controlled by forces I cannot influence”). The average of the sum-score for each sub-scale is calculated (scores therefore ranging from 1 to 5) with higher score indicating a higher tendency to think about the past in a negative way, “live in the moment”, to plan ahead, to think about the past in a positive way or about the present and future in a hopeless way, respectively.

The Food Craving Questionnaire – Trait - reduced (FCQ-T-r; Meule, Hermann, & Kubler, 2014)

The 15 item FCQ-T-r assesses the habitual craving for a range of foods (e.g., “If I eat what I am craving, I often lose control and eat too much”). The ratings for each item ranges from

'Never' (1) to 'Always' (6). A sum-score is obtained with a higher score meaning higher tendency for food craving.

The flexible and rigid control (*Westenhoefer, et al., 1999*)

The Flexible Control sub-scale has 12 items and assesses the flexibility of the attitude to eating, dieting and weight (e.g., "If I eat a little bit more on one day, I make up for it the next day"). The Rigid Control sub-scale consists of 16 items and relates to a rigid, black-and-white approach to eating, dieting and weight (e.g., "Do feelings of guilt about overeating help you to control your food intake?"). The average from the sum-scores of each sub-scale is calculated with a higher score represents a more flexible or more rigid approach, respectively.

Supplemental data 6. *Calculation of the Deviation from the Balanced Time Perspective (DBTP) according to Stolarski, et al. (2011).*

To calculate the DBTP, the five sub-scales of the ZTPI – past negative (PN), present hedonistic (PH), future (F), past positive (PP) and present fatalistic (PF) – were used in following equation:

$$DBTP = \sqrt{(oP - ePN)^2 + (oPP - ePP)^2 + (oPF - ePF)^2 + (oPH - ePH)^2 + (oF - eF)^2}$$

oPN is the optimal time perspective (in this case past negative) and ePN the empirical time perspective (in this case past negative). For the optimal values the proposal by Zimbardo and Boyd (2014) was followed: a ‘high’ score on PP is defined as 3.67, a ‘moderately high’ score on PH as 4.33 and F as 3.69, and a ‘low’ score on PN and PF as 2.10 and 1.67, respectively. A DBTP of close to zero stands for an almost perfectly balanced time perspective with higher values indicate stronger deviation from the optimal Balanced Time Perspective.

Supplemental data 7. *Characteristics of the seven weight management clusters.*

Factors	1. Lean men (n=68)		2. Lean young women (n=65)		3. Lean women without dieting (n=81)		4. Lean middle-aged women (n=43)		5. Young successful dieters (n=40)		6. Very successful dieters (n=4)		7. Unsuccessful dieters (n=38)		<i>p</i> *
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
Gender [m/f/n]	68/0/0		0/65/0		0/81/0		0/43/0		2/37/1		1/3/0		0/37/1		<.001
Age [y]	33.2 2,3,4,7	13.7	25.4 1,4,5,7	4.7	26.7 1,4,5,7	6.5	56.2 1,2,3,5,7	7.7	33.8 2,3,4,7	8.4	45.9	16.6	42.2 1,2,3,4,5	11.5	<.001
Diet score	0.32 2,3,4,5,7	0.47	1.06 1,3,4	0.24	0.00 1,2,4,5,7	0.00	0.63 1,2,3,5	0.54	1.10 1,3,4	0.38	0.75	0.50	0.97 1,3	0.55	<.001
BMI [kg/m ²]	25.3 3,7	3.9	24.1 3,7	3.3	21.7 1,2,4,5,7	2.2	24.2 3,7	3.1	26.2 3,7	5.4	22.7 7	2.2	34.0 1,2,3,4,5,6	5.2	<.001
Weight suppression [%]	6.6 4,5,6,7	6.1	4.8 4,5,6	4.2	5.0 4,5,6	5.0	11.8 1,2,3,5,6,7	8.3	21.9 1,2,3,4,6,7	10.2	84.0 1,2,3,4,5,7	17.9	3.6 1,4,5,6	2.6	<.001
Weight suppression [kg]	5.4 2,3,5,6	5.1	3.0 1,4,5,6	2.6	2.9 1,4,5,6	3.0	7.7 2,3,5,6,7	5.4	15.8 1,2,3,4,6,7	7.1	53.6 1,2,3,4,5,7	7.7	3.3 4,5,6	2.4	<.001
Current dieting [yes N(%)]	9 (13.2) ^{3,5,7}		23 (35.4) ³		0 (0.0) ^{1,2,4,5,6,7}		12 (27.9) ³		20 (50.0) ^{1,3}		1 (25.0) ³		17 (44.7) ^{1,3}		<.001

* *p*-values indicate the results of the ANOVA or chi-squared test of each variable across all seven clusters. The superscribed number indicates a significant difference to the clusters with this number, e.g., for age: lean men have an average age of 33.2 years, and this is significantly different to clusters 2 (lean young women), 3 (lean women without dieting), 4 (lean middle-aged women) and 7 (unsuccessful dieters).

Supplemental data 8. *Psychological and eating behaviour traits for the seven weight management clusters.*

Traits	1. Lean men (n=58)		2. Lean young women (n=58)		3. Lean women without dieting (n=69)		4. Lean middle-aged women (n=30)		5. Young successful dieters (n=33)		6. Very successful dieters (n=4)		7. Unsuccessful dieters (n=35)		<i>p</i> *	R ²
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD		
DEBQ																
Rest-eat	2.47 _{2,4,5}	0.85	3.08 _{1,3}	0.68	2.31 _{2,4,5,7}	0.72	3.14 _{1,3}	0.75	3.25 _{1,3}	0.75	2.80	1.01	2.93 ₃	0.77	0.000	0.194
Emo-eat	2.30 _{2,5,7}	0.75	2.99 _{1,4}	0.84	2.54 ₇	0.86	2.39 _{2,7}	0.73	2.94 ₁	0.97	3.29	0.77	3.12 _{1,3,4}	0.87	0.000	0.126
Ext-eat	3.04	0.64	3.25	0.63	3.22	0.59	2.91	0.63	3.21	0.62	3.03	0.43	3.34	0.73	0.070	0.040
Flexible restraint	5.02 _{2,5}	3.25	6.76 _{1,3}	2.94	4.44 _{2,4,5}	2.49	6.83 ₃	3.07	7.06 _{1,3}	2.86	7.00	3.65	5.06	3.44	0.000	0.115
Rigid restraint	5.29 _{2,5,7}	3.31	7.97 _{1,3}	2.92	4.10 _{2,4,5,7}	2.57	6.60 ₃	3.39	8.64 _{1,3}	3.14	5.25	2.75	7.63 _{1,3}	3.32	0.000	0.235
BIS11																
Attent-Impuls	17.57 ₄	3.59	16.62	4.40	15.84	3.24	14.13 ₁	3.46	16.36	3.60	19.25	5.19	16.74	3.62	0.002	0.071
Motor-Impuls	23.05	4.42	22.10	4.16	21.51	3.99	20.43	3.90	20.97	3.14	22.25	3.59	21.74	3.26	0.072	0.040
Nonplan-Impuls	24.83	5.00	23.21	5.25	23.45	4.80	22.07	5.28	23.15	5.46	23.75	4.11	23.86	3.90	0.308	0.025
Total	65.45 ₄	10.84	61.93	11.46	60.80	9.33	56.63 ₁	10.84	60.49	8.69	65.25	11.59	62.34	8.00	0.010	0.058
ZTPI																
PN	3.23 ₄	0.71	2.98	0.75	2.95	0.82	2.58 ₁	0.84	3.21	0.90	2.90	0.63	3.11	0.78	0.012	0.056
PH	3.30	0.60	3.19	0.49	3.21	0.57	2.91	0.61	3.24	0.56	3.27	0.60	3.17	0.51	0.113	0.036

Traits	1. Lean men (n=58)		2. Lean young women (n=58)		3. Lean women without dieting (n=69)		4. Lean middle-aged women (n=30)		5. Young successful dieters (n=33)		6. Very successful dieters (n=4)		7. Unsuccessful dieters (n=35)		<i>p</i> *	<i>R</i> ²
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD		
F	3.29 _{2,3,4}	0.50	3.70 ₁	0.59	3.59 ₁	0.55	3.73 ₁	0.63	3.59	0.58	3.54	0.24	3.55	0.51	0.003	0.068
PP	3.42	0.66	3.55	0.63	3.65	0.68	3.49	0.72	3.37	0.71	3.44	0.57	3.38	0.78	0.374	0.023
PF	2.86 ₂	0.71	2.34 _{1,7}	0.69	2.50	0.69	2.44	0.61	2.50	0.63	2.72	0.39	2.79 ₂	0.66	0.001	0.079
DBTP	2.37	0.64	2.05	0.56	2.14	0.57	2.18	0.66	2.26	0.64	1.98	0.16	2.31	0.70	0.118	0.035
FCQ-T	40.14 _{2,5}	13.03	50.33 _{1,3,4}	16.79	41.36 _{2,5}	12.64	34.93 _{2,5,7}	12.27	51.64 _{1,3,4}	13.15	41.75	8.85	50.00 ₄	17.79	0.000	0.139

* *p*-values indicate the results of the ANOVA or chi-squared test of each variable across all seven clusters. The superscribed number indicates a significant difference to the clusters with this number, e.g., for restrained eating: cluster 1 (lean men) have a score of 2.47 which is significantly different to clusters 2 (lean young women), 4 (lean middle-aged women) and 5 (young successful dieters).

DEBQ: Dutch Eating Behaviour Questionnaire, Rest-eat: Restrained Eating (adj. *R*²=.177), Emo-Eat: Emotional Eating (adj. *R*²=.108), Ext-Eat: External Eating (adj. *R*²=.020), flexible restraint (adj. *R*²=.096), rigid restraint (adj. *R*²=.219), BIS11: Barratt Impulsiveness Scale, Attent-Impuls: Attentional Impulsiveness (adj. *R*²=.051), Motor-Impuls: Motor Impulsiveness (adj. *R*²=.020), Nonplan-Impuls: Non-planning Impulsiveness (adj. *R*²=.004), Total (adj. *R*²=.038), ZTPI: Zimbardo Time Perspective Inventory, PN: Past Negative (adj. *R*²=.036), PH: Present Hedonistic (adj. *R*²=.015), F: Future (adj. *R*²=.048), PP: Past Positive (adj. *R*²=.002), PF: Present Fatalistic (adj. *R*²=.059), DBTP: Deviation from the Balanced Time Perspective (adj. *R*²=.015), FCQ-T: Food Craving Questionnaire – Trait (adj. *R*²=.120).

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