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Abstract

Background: Does food reward increase or decrease during weight management attempts? Excessive food intake is the main behavioural determinant of obesity; therefore, a better understanding of food reward and its relationship with food intake and weight outcomes could contribute to more effective weight management solutions.

Methods: This systematic review assessed the role of changes in food reward (directly or indirectly measured) during weight management interventions. Four databases were searched for articles published until April 2018 involving weight management interventions (all types and designs) in healthy adults with overweight or obesity.

Results: Of 239 full-text articles assessed, 17 longitudinal studies were included. Twelve studies reported a significant change in food reward over time. When compared to control interventions, dietary, pharmacological, behavioural and cognitive interventions were effective in decreasing liking and/or wanting for high-energy food using a range of methodologies to assess food reward. Three studies reported that decreased food reward was associated with improved weight management outcomes.

Conclusion: Food reward appears to decrease rather than increase during weight management interventions. Future studies specifically targeting the hedonic aspects of food intake (liking/wanting) are needed to gain a better understanding of how to uncouple the obesogenic relationship between food reward and overeating.

PROSPERO Registration number: CRD42017081209

Abbreviations

BMI: body mass index, fMRI: functional magnetic resonance imaging, VAS: visual analogue scale, LFPQ: Leeds food preference questionnaire, FPQ: food preference questionnaire, MIIT: moderate intensity interval training, MICT: moderate-intensity continuous training, HIIT: high intensity interval training, RCT: randomised controlled trial, BIS: bio impedance spectroscopy, ADP: Air displacement plethysmography, DXA: dual-energy X-ray absorptiometry, TFEQ: three factor eating questionnaire

Introduction

Increasing obesity rates have necessitated a multidimensional approach to the investigation of weight management (1, 2). Control over energy intake is a central component of weight management and is influenced by the cross-talk between homeostatic and hedonic systems in the brain (3, 4). In the current obesogenic environment, characterised by an abundance of highly palatable food, hedonic influences tend to determine food choices, which frequently leads to excessive energy intake (5, 6). Hereafter, food intake refers to all examples of eating especially when qualitative aspects are being measured, while energy intake is reserved for occasions where energy is actually measured (kcal). The susceptibility to overeat when given access to palatable food varies among people according to their eating behaviour traits such as disinhibition (7) or binge eating (8). Food reward can be defined as a mechanism that guides eating behaviour and represents "the momentary value of a food to the individual at the time of ingestion" (9; p.2). Food reward comprises sub-components (e.g. liking and wanting) and these are likely to play a role in weight management (10). Liking is described as the pleasure of eating a food and wanting as the drive to eat triggered by a food cue (8). Both can be assessed implicitly or explicitly, but the most used measures are explicit liking, the hedonic experience (11), implicit wanting the automatic motivation to eat a specific food (12) and explicit wanting, the cognitive desire (12). These psychological processes have a major influence on food intake but seem to function differently (4, 13). Preferences for energy-dense and highly palatable foods are related to excess energy intake in free-living settings (14, 15). However, liking accounts only for a small proportion of the variance in intake, and liking alone may not explain the whole picture of reward-induced food intake (15, 16). Processes of wanting may increase the reactivity to palatable food (compared to non-eating activities) in women with obesity (17). In daily life, wanting triggered by environmental cues (such as food advertising) may be more important to motivate food intake (18). Few studies have investigated the relationship between food reward and physiological factors. Some showed a positive association between preferences for high-fat foods and fat mass (19), independent of genetic background (20). However, the relationship between food reward and body mass index (BMI) may not be linear, as the sensitivity to reward in people ranging in body weight status has been suggested to follow an 'inverted-U' relationship (21).

Given that behaviour accounts for 100% of energy intake (22), identifying interventions that modulate the hedonic aspects of food intake (23) may provide a novel approach to tackle obesity and improve weight management. Currently, weight management interventions tend to be based on comprehensive multidisciplinary lifestyle modification including dietary, exercise, cognitive and behavioural components. However, food reward seems not to have been systematically examined as a target for improving weight outcomes. A systematic review of the literature is therefore warranted to investigate the role of food reward in the context of weight management interventions.

Objectives

The aim of this systematic review was to evaluate whether components of food reward are amenable to change after weight loss and whether observed changes are related to weight management outcomes. The population targeted was healthy adults with overweight or obesity. Weight management interventions (≥4 weeks) that attempted to target or measure a change in components of food reward were assessed. Weight management included all interventions (e.g. weight loss, weight maintenance) that aimed to improve weight outcomes. The primary outcome was food reward (i.e. liking, wanting or overall palatability) measured directly or indirectly and secondary outcomes included food intake and weight outcomes (e.g. body weight, fat mass, waist circumference). All methods to measure food intake (e.g. diary, 24-h recall) and weight outcomes (e.g. calibrated scales) were included. All primary and secondary outcomes had to be measured pre and post weight management intervention. All interventional study designs were included. The primary research question was: Do components of food reward change after weight loss? Secondary questions were: Which interventions are effective in changing components of food reward and what is the associated effect on weight management outcomes?

Methods

This systematic review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines (24) (see Table S2 for the PRISMA checklist) and the protocol is registered in the PROSPERO database (registration number: CRD42017081209).

Literature search strategy

Four electronic bibliographic databases were searched: MEDLINE (Ovid), EMBASE (Ovid), PsycINFO (EBSCOHost) and Cochrane Library. The search strategy (see supporting information) was organised in two key blocks of terms: interventions (aiming at improving weight management outcomes) and food reward (all terms related to liking and wanting for food). The specific keywords used are listed in Table S1. Previous reviews were screened to identify adequate keywords. The search terms were a combination of medical subject headings (MESH terms) and text-words (title and abstract) and were adapted for use in each database. Searches were supplemented by reading the reference lists of eligible studies and systematic reviews. Limits were set to include all papers published in English or French after 1990, in healthy human adults. The last search was run in April 2018.

Inclusion and exclusion criteria

Articles were included if they involved longitudinal measures (≥4 weeks (25)) taken pre and post weight management intervention in healthy adults with overweight or obesity. All types and design of intervention were included and all comparator treatments were considered. Articles were excluded if they involved animals, children, adolescents or elderly, and participants with pregnancy, disease, an eating disorder or who smoke. Interventions were excluded if they only measured food reward through functional magnetic resonance imaging (fMRI) without a supplementary psychometric assessment of food reward. Indeed, all psychometric measures of food reward either direct (e.g. ratings or pleasantness or desire to eat) or indirect (e.g. measure of the willingness to work to obtain a food or reaction time) were included. Trait measurements of food reward were not included.

Data extraction and synthesis

Search results from each database were exported to Endnote and duplicates were removed. Study selection was undertaken using Covidence (26). Titles and abstracts were screened twice by the main reviewer and 10 % were screened independently by a second reviewer. Full-texts of retained studies were accessed and further screened according to the eligibility criteria by 3 reviewers (one reviewer screened all and the other two screened half). Any disagreements over the eligibility of particular studies was resolved through discussion with a third reviewer. One author extracted the following information into an Excel spreadsheet: study information (e.g. authors, years, and title), baseline characteristics of participants (sample size, age, sex, BMI, weight), details of the intervention (intervention type, control conditions, study methodology, study completion rates, design), outcome measures and methods (food reward, food intake and physiological measures), information for assessment of the risk of bias.

Outcome measures

Risk of bias was assessed by two reviewers using the Cochrane Collaboration's tool (27). Disagreements were discussed with a third reviewer. Seven criteria were assessed: random sequence generation, allocation concealment, blinding of participants and personnel, blinding of outcomes data, incomplete outcome data, selective reporting and other bias.

Only significant changes in food reward, food intake or weight outcomes were reported as an increase or decrease, otherwise no change over time was stated. Psychological outcomes were reported if they contributed in explaining the change in outcomes. Differences between arms of interventions (i.e. intervention effect) were also reported. As the methods to report food reward components were not consistent across studies, the results are presented with a qualitative synthesis. The magnitude of the change over time was reported in % pre to post intervention in order to compare studies, except when data were not available.

Results

Study selection

Out of 239 studies full-text assessed, 14 originally met the inclusion criteria (see Figure 1 for the flow diagram). The last update of the search led to a total of 17 longitudinal studies. Eighty studies among the 136 excluded for being acute interventions will be reported in another review to assess the role of food reward in acute weight management outcomes.

Figure 1 here

Risk of bias

The selection bias (i.e. sequence generation and allocation concealment) was judged to be low risk in 59% (n=10) and 18% (n=3) of the studies, respectively. The performance bias (i.e. blinding participants and personnel) was judged high risk in 53% (n=9) of the studies and 71% (n=12) of the studies were judged high risk as they did not blind assessors about outcomes. Attrition bias (i.e. incomplete data) was unclear in 65% (n=11) of the studies and reporting bias (i.e. selective outcome) was unclear in 88% (n=15) of the studies. Other biases were judged low risk in 59% (n=10) of the studies. See Figure 2 for the details of each study and Fig.S1 for the summary of risk of bias across all the studies

Figure 2 here

Food reward definition and measurements

In this review, we considered psychometric assessments of food reward as they have been shown to have an impact on eating behaviour. The first finding was the diversity of the measurements of food reward assessed in the studies. Therefore, measures were grouped in categories - liking, wanting and overall palatability - to enable comparisons between studies. Two main higher-order constructs were outlined: liking and wanting. “Liking” was the most reported (16 out of 17 studies) and covered two different notions “overall palatability” (28-32) and “liking for a specific food at this moment” (30, 31, 33-43). For the latter notion, “liking” measures were labelled as such in 6 studies (30, 31, 33, 36, 38, 40) but also included different terms such as “tastiness” (35) “food preferences” (34, 37, 39), “pleasantness” (41, 42) and “palatability” (43). “Specific food” referred to different food labelling such as low/high-fat (34, 39, 40, 44), low/high fat and sweet/savoury (30, 33, 36, 38, 41), healthy/unhealthy (35), low/high-carbohydrate (34, 37, 39), energy dense (31, 41, 42), and low/high-calorie food (43). These different labels were grouped in this review as low-energy food or high-energy food. Given that they all referred to the hedonic value of the taste of a specific food at a given time (ingestion or viewing), these terms were reported as “liking” in this review. In contrast, overall palatability refers to evaluation of the taste of the diet as a whole and does not refer specifically to a particular food or food type. This category will therefore be reported separately from liking. Wanting, the motivational drive to eat, was measured in 7 out of 17 studies and included implicit wanting (30, 31, 33, 36, 38) and explicit wanting, also termed “desire to eat” (43, 44).

Two different methods were used to measure liking: visual analogue scales (VAS) (31, 41, 42) such as the Leeds Food Preferences Questionnaire (8) (LFPQ) (30, 33, 36, 38), and Likert scale (35, 40, 43) such as the food preferences questionnaire from Geiselman et al. (45) (FPQ) (37, 39). Two VAS were of 100mm scale (41, 42) and one was 150mm (31) and performed under a similar design that consisted in rating liking just after tasting a snack food. One difference was the hunger state before the VAS. In Raynor et al.’s study (42) a preload was given before tasting the snack to account for homeostatic drive whereas in Cameron et al. (31) and Raynor et al. (41) participants were in a hungry state. LFPQ measured liking by VAS in response to viewing food images of high or low-fat content and sweet or savoury taste. The Likert scales used were 5, 9 or 10-point scales and the ratings were based either on low or high-fat food tasting (40) or viewing of food pictures (35, 37, 39, 43). All these methods measured the same concept (i.e. liking for a specific food). Implicit wanting was measured indirectly by a forced choice reaction time paradigm (i.e. LFPQ) (30, 33, 36, 38), and via a progressive ratio computer task (31). Explicit wanting was assessed through a 5-point scale assessing the desire to eat low, medium or high-fat food over the last 7 days (44) and by the willingness to pay for a food (43).

Study characteristics

Five types of intervention emerged from this systematic review: dietary (28, 31, 32, 34, 37, 39, 40), exercise (33, 36, 38), pharmacological (29, 30) cognitive (43) and behavioural/multidisciplinary (35, 41, 42, 44). Dietary interventions included nutritional manipulations such as the macronutrient content of the diet (low or high-fat, high-protein, low or medium-carbohydrate) or energy restriction. Behavioural interventions incorporated a combination of dietary, exercise, behavioural therapy or food variety interventions and not a single intervention. Exercise studies included moderate intensity interval training (MIIT), moderate-intensity continuous training (MICT), high intensity interval training (HIIT), or aerobic exercise. The pharmacological studies included nutraceutical (C. fimbriata extract) (29) or pharmaceutical (semaglutide) (30) compounds, as both interventions followed a pharmacological approach to deliver the treatment (e.g. refined and encapsulated or injected). The cognitive study consisted of a food response and attention training intervention. With regard to the study design, 10 studies were randomised controlled trial (RCT) (28-30, 32, 37, 38, 40-43), and 5 had no control condition (31, 34-36, 44) and were embedded in either RCT or in a pre-post design. The intervention duration ranged from 4 weeks to 2 years with a median of 12 weeks and study duration ranged from 6 weeks to 2 years. The main outcomes assessed were changes in food reward and the methods are reported above. The secondary outcomes assessed were changes in food intake-related measures (12 out of 17 studies) which are eating behaviour assessments such as food intake (qualitative assessment of eating behaviour) (44), energy intake (in kcal) (28-30, 32, 33, 36, 38, 40, 42) and energy intake from fat (in kcal) (29, 33), and/or weight outcomes (15 out of 17 studies) such as waist circumference (29), fat mass (30, 33, 36, 43) and body weight (28-32, 35-42, 46). However, the methods used to measure each outcome varied remarkably across studies. Food intake-related measures were assessed by food diaries (28, 29, 32, 38, 40, 41), ad libitum test meal (30, 33, 36), food frequency questionnaires (40, 42), 24-h recall (42), or a 48-item questionnaire (44). Body weight was measured by weighing scale (28, 29, 31, 32, 40-42), fat mass by bio impedance spectroscopy (BIS) (33), air displacement plethysmography (ADP) (30, 36, 43) or dual-energy X-ray absorptiometry (DXA) (31), and waist circumference by a measuring tape above the umbilicus (29).

Participant characteristics

All studies (n=17) included individuals with obesity and some also included people who were either overweight or obese (29, 33, 34, 36, 43). Participants' median (range) BMI and age were 33.7 kg/m^2 (30.5-38.5) and 44.6 years (29.0-56.5), respectively. Two studies were only in men (32, 33). The median percentage of women was 68%. The number of participants in the intervention ranged from 10 to 136 with a median of 27 and the total number of participants across all studies was 1312.

Study results

All results from the weight management interventions (n = 17) are summarised in Table 1.

Table 1 here

Changes in food reward

Twelve studies reported a significant change in a component of food reward (liking, implicit or explicit wanting, or overall palatability) over time. Liking changed in 9 out of 13 studies (30, 31, 34, 35, 37, 39, 41-43). Overall palatability changed in 2 out of 5 studies (28, 29). Wanting changed in 3 out of 7 studies (30, 43, 44).

Concerning the direction and magnitude of the change: liking for high-energy food (high-fat, high-carbohydrate, high-calorie, high-energy-dense, and unhealthy food) decreased significantly in 8 studies (30, 34, 35, 37, 39, 41-43). The same trend was reported in Alkahtani et al. (33) but was not significant. However, one study reported an increase in liking for a favourite high-energy food snack (31). When data were available, percentages of change pre to post weight loss were calculated. The median decrease in liking for high-energy food was 16% (34, 35, 39, 41) and the increase was 9% (31). Liking for low-energy food was reported in 10 studies. It decreased in 3 studies (34, 37, 39) with a median of 5.9% and increased in one study (35) by 5%. Wanting for high-energy food decreased in 3 out of 7 studies (30, 43, 44) and 2 out of 6 studies (30, 44) reported an increase in wanting for low-energy food. The magnitude of the decrease in wanting pre to post intervention in percentage was not calculated due to data not being available.

A further question is whether there was an effect of intervention type on the change in food reward. Five out of 12 interventions reported a decrease in liking for high-energy food with a difference between conditions (30, 37, 41-43) showing that different types of interventions (i.e. pharmacological, dietary, behavioural, cognitive) can all be effective in reducing liking for high-energy food. Of the 3 studies (34, 37, 39) that decreased both liking for low and high-energy food, only one intervention (37) reported a condition effect for decreasing both low and high-energy food. For overall palatability, only one study out of the 5 showed a difference between conditions with an effect of the nutraceutical on the decrease of overall palatability (29). Two out of 7 interventions showed reduction in wanting for high-energy food compared to control (30, 43) and one of the pharmacological interventions (30) found reduced wanting for high-energy food and increased wanting for low-energy food. Two out of 6 interventions (30, 43) found a decrease in both liking and implicit wanting for high-energy food.

Association between changes in food reward and food intake

One study measured the intake of low and high-fat food (44) and reported a significant decrease in intake of high-fat food and an increase in intake of low-fat food after a behavioural intervention. There was a strong positive association between change in desire to eat and change in consumption of these foods. Two studies measured energy intake from fat (29, 33), one of which reported a significant decrease in energy intake from fat (46%) in the nutraceutical condition compared to the control (29). The correlation between change in overall palatability and change in energy intake from fat was not assessed. Eight studies measured total daily energy intake (28-30, 32, 36, 38, 40, 42) and 3 studies (28, 30, 32) reported an effect of the intervention on decreasing energy intake. Only Johnstone et al. (32) assessed the correlation between change in overall palatability and change in total daily energy intake but they were not associated. Three studies measured energy intake for high-energy food specifically (30, 41, 42); 2 studies (30, 42) reported a significant decrease in the intervention arm. Only Raynor et al. (42) analysed the association between change in liking and energy intake from this food but found no correlation. To conclude, few studies reported a significant effect of the intervention on food intake. Even fewer studies analysed the relationship between change in food reward and change in food intake-related measures.

Association between changes in food reward and weight outcomes

The 14 studies that measured body weight all reported a decrease ranging from 2% to 10% with a median weight loss of 5% (29-32, 34-37, 40, 42). Three studies (30, 32, 39) showed a difference between intervention arms. Only McVay et al. (39) assessed the association between changes in body weight with changes in food reward and showed that an increase in liking for low-energy (diet-congruent) foods was associated with greater weight loss. However, this was only significant for 1 out of 4 time points where liking was measured. Four studies measured fat mass (30, 33, 36, 43), and 2 studies (30, 43) reported a decrease in fat mass in the intervention arm compared to the control. Only Stice et al. (43) assessed the relationship between food reward and fat mass, and reported a marginal positive correlation between pre to post fat mass and decrease in palatability ratings for high-calorie foods. This association between liking and fat mass was also reported in Hopkins et al. (36). To conclude, 5 studies (28, 31, 37, 39, 43) assessed the relationship between changes in food reward and changes in weight outcomes: 2 studies (39, 43) showed an association between decreased liking for high-energy food and reductions in fat mass or body weight; one study (31) found an increase in liking was not correlated with changes in fat or fat-free mass; one study (37) found no correlation between a decrease in liking with weight loss; and in one study (28) there was no relationship between change in overall palatability and weight loss.

Association between changes in food reward and psychological measures

One study (31) reported a moderating effect of trait disinhibition on wanting pre to post weight loss. Individuals with obesity who scored high in disinhibition (measured by the Three Factor Eating Questionnaire (TFEQ)) tended to work harder to earn snacks post weight loss.

Discussion

Main findings

The aim of this systematic review was to assess whether components of food reward change during weight management interventions and whether any changes were related to weight management outcomes. The results showed that food reward does change during most types of weight management intervention and the majority of studies showed that food reward decreases after weight loss. Both liking and wanting for high-energy food decreased post-intervention. Wanting for low-energy food increased and liking for low-energy food increased in one behavioural intervention and decreased in dietary interventions. A range of intervention types - dietary, behavioural, cognitive and pharmacological - seemed to be effective in decreasing liking and/or wanting for high-energy food. However, the relationship between changes in food reward and change in weight management outcomes was less clear. Only a few studies assessed this relationship and showed that a decrease in liking for high-energy food was associated with a decrease in body weight or fat mass. Changes in wanting appeared to be more related to changes in food intake. However, these associations need to be confirmed.

Methodological considerations

It is commonly agreed that food reward influences what and how much is eaten (4, 9, 12). However, the definition and measurement of food reward can be confusing as shown in this and previous reviews (11). The complexity of defining and measuring components of food reward rests on their logical status as intervening variables (i.e. liking and wanting cannot be directly observed) (47). There is no consensus on the definition of the components of food reward. However, authors (9, 12, 13) agree on the fact that food reward translates the momentary pleasure and motivation to eat a food that is seen or tasted. That is why in this review all measures of liking for a specific food were grouped together and overall palatability of the meal was not considered as a measure of liking. Moreover, trait measures of reward such as sensitivity to reward, or general food craving were not considered as food reward in this review as they don't measure the pleasure or motivation to eat a specific food at the time of viewing or ingestion. Definitions of liking across studies were consistent but some studies explicitly defined liking as the "pleasantness of the taste of the food", whereas others only used the word "liking" or "palatability" without giving more information, which may add some flaws in the comparison of studies. Other potential bias across studies could be the time of day of the measurement and the state of hunger. The hedonic value of food may differ between morning, noon and evening, or when fasted compared to fed (48). More standardised measurements (e.g. at the same time point) are needed in future research to analyse this potential confound. Food reward may also change across the lifespan and differ in children or the elderly and for this reason we focused on adults only. Furthermore, smokers were excluded as they may not have the same sensibility to palatable food due to changes in sensory perception or reward function (49).

A variety of methods were reported to measure liking and wanting, raising the question of whether measures can be compared. For liking measurements, the main differences were whether participants rated liking after having seen pictures of food or eaten food, and whether they were rating a small or large set of food items covering different aspects of the diet (fat, carbohydrate, low or high-energy content). Firstly, seeing a food picture instead of tasting/consuming reflects more the expected pleasantness than the hedonic experience of liking (11). Secondly examining changes in liking on a limited set of foods may not accurately represent changes in high-energy or low-energy foods and consequently this could explain some of the discrepancies in the results. VAS ratings are seen as accurate to report changes in subjective sensations of appetite (50), but use of Likert scales compared to VAS may not have the same sensitivity to detect an impact on the change of liking. In this review, one measure of explicit wanting was quite remote as it measured the desire to eat a specific food but over the past 7 days and not at the moment of ingestion (or viewing). Measurements of food reward should ideally target a specific food at a given time and consistent methodology should be used to yield more accurate and comparable measures (e.g. broad set of foods, same wording and definition of liking and wanting). To be more discriminating, measures of food reward should allow the distinction between liking and wanting. Also, indirect measures of implicit wanting (e.g. willingness to exert an effort to obtain a food or reaction time of responses to a food) should be used more often as they are more representative of implicit motivational process.

Role of food reward in weight management

It is frequently assumed by researchers that weight loss will lead to compensatory increases in homeostatic responses that drive up food intake to protect energy stores. This has led some to hypothesise that food reward will also increase after weight loss. Indeed, studies have shown that acute food deprivation increases food reward (31, 51). Furthermore, a dietary intervention leading to 10% weight loss resulted in increased neural activation (BOLD signal) in response to images of food (52). However, the present systematic review demonstrates that most studies actually find a decrease in food reward in the context of weight management. How can these contradictory views be resolved?

Methodological differences might explain some of the discrepancy in findings. Firstly, there are contradictory findings in fMRI studies with studies reporting increased and decreased brain responses to food (53). Furthermore, studies reporting an increase in BOLD signal may not translate into cognitive or behavioural hedonic responses. More studies are needed to validate the brain responses to food cues in relation to food reward measured by psychometric methodologies. Another explanation could be due to the extent of the induced calorie deficit between studies, where a larger deficit could lead to greater reductions in food reward compared to a smaller deficit. However, the data from this review do not allow this question to be quantitatively examined. Finally, the duration of exposure and strength of the energy deficit should be taken into account. It has been shown that short-term (a day or less) nutrient depletion increases liking and wanting for specific foods (54, 55) and that acute (3-day) fasting increases liking and wanting for high-energy foods (56). In Rosenbaum et al.'s study (52) the weight loss duration lasted from 5 to 8 weeks, whereas in this review dietary interventions ranged from 8 weeks to 2 years. It could be hypothesised that short-term food deprivation may enhance food reward whereas longer term deprivation will attenuate it. Is there a minimum time needed to observe a decline in food reward? The shift in reward for low and high-energy foods may occur as weight loss goals become internalised and more automatic, representing an alignment between cognitions and eating behaviour. For instance, dietary interventions (34, 37, 39) from this review that showed reduced intake of high-energy food during weight loss also reported a decrease in liking for high-energy food.

In this review, only one study (31) found an increase in liking for palatable food after weight loss. This result needs to be considered carefully as the study had a high risk of bias. Inconsistencies in the design of this study and especially in the assessment of food reward may account for this contrary finding. Firstly, this study was a secondary analysis with no control condition and consequently difficult to attribute changes in liking to the weight loss intervention per se. Secondly, in other studies (34, 37, 39) liking was assessed for different types of food categorised as low or high-energy whereas in this study (31) liking was measured only for one specific high-energy food (i.e. the participant's preferred palatable snack). It is not clear whether this very specific intervention can be generalized to different types of interventions or high-energy foods that were not specifically preferred.

Another question concerns the discrepancies found in changes in liking for low-fat food. Three dietary interventions (34, 37, 39) reported a decrease and one behavioural intervention found an increase (35). What differed between these studies was the assessment of liking. The discrepant study (35) measured the tastiness for perceived unhealthy or healthy snacks and this latter categorisation of food may not correspond exactly to high/low-energy foods which may weaken the comparison. With regards to wanting measures, all the interventions from this review that reported a change in wanting showed a decrease for high-energy food and/or an increase for low-energy food. All together these results suggest that reductions in wanting and liking for food are generally achieved following weight management interventions.

Implications for weight management

All the studies reported here were not acute studies (i.e. ≥4 weeks) giving more clinical relevance to the food reward changes. However, only a few studies assessed the relationship between food reward changes and weight management outcomes, and one was at high risk of bias (44) therefore implications for weight management need to be confirmed. Interventions included individuals with overweight and/or obesity but data were not available to analyse the role of food reward by subgroups of BMI classification.

Can conclusions be drawn on which type of intervention is most effective to change food reward? Dietary interventions seem effective as 4 out of 5 studies reported a change in liking for high or low-energy food. Newman et al. (40) reported no change in liking for low or regular-fat products, only liking for low-fat cream cheese increased over time. The measure of liking appeared quite strong as they assessed liking just after tasting each food item, however they only assessed liking for a limited set of food that did seem to have been screened for acceptability, palatability and macronutrient content. A broader and more controlled set of foods would throw light on this question.

All the behavioural, pharmacological and cognitive interventions reported a change in food reward. However, none of the exercise studies reported changes in food reward. All these studies used the same methodology to measure liking and wanting (i.e. LFPQ) which is a robust method for detecting changes in food reward in different settings (8). Furthermore, acute exercise has been shown to have different effects on food reward (measured by LFPQ) depending on the population (57) or the dose of exercise (58, 59). Several hypotheses can be proposed to explain the null findings in the longitudinal exercise studies from this review. The main reason might be that measures of food reward were not consistent across studies (regarding time and hunger state). Indeed they all used LFPQ, but food reward was measured before and after the acute exercise (33), or in a fasted state before lunch (36) or pre and post breakfast (38). Besides, one study (36) had no control condition and the others (33, 38) were based on a limited sample (i.e. n < 14) questioning whether the lack of changes could really be attributed to the intervention and not to lack of power. In sum, more consistency in the design, duration, and energy deficit is required to be able to determine which type of intervention is the most effective to reduce food reward while improving weight management outcomes.

Limitations and strengths

The main limitation encountered by this review was the complexity in the definition and measurement of food reward, which may lead to confusion when grouping and synthesising outcomes. Changes in food reward were reported qualitatively due to lack of available data. In future, given more studies, a meta-analysis of the changes in liking and wanting would provide a more powerful analysis. Also, only a few studies measured implicit or explicit wanting which weakens the ability to compare changes in liking versus wanting in response to weight management, which would be theoretically and clinically relevant (13). The studies were mainly on women (median of 68%) which limits the generalization of results to men. Five papers had a high risk of bias but these were not impacting the main results. Only 17 interventions were included, but this review used high methodological standards that assured quality. It is important to consider drop-out rates in weight management interventions and in this review the median attrition rate was 19% which is not unusual. However, no studies adjusted for this in their analyses (e.g. BOCF). Finally, only peer-reviewed studies were considered for inclusion in this review and future updates could include grey literature.

Conclusion

This review used a systematic approach to examine changes in food reward during weight management interventions. It revealed that liking and wanting for high-energy food mostly decreased during weight management, and different types of interventions were effective to reduce food reward. The associations between food reward and weight management outcomes need to be confirmed. The synthesised findings may help to elucidate some of the previous uncertainty on whether components of food reward increase as a compensatory response to weight loss. Some of the confusion may arise due to the difficulty in defining the components of food reward and the discrepancies between measures of food reward. Food reward should be measured in a consistent manner in future weight management interventions to allow systematic reviews to quantify its effect on outcomes. Weight loss interventions that facilitate reductions in the reward for high-energy food (or increased liking and wanting for low-energy food) may be beneficial for weight loss maintenance, and it remains to be examined whether hedonic rather than homeostatic mechanisms could be responsible for weight regain after weight loss (60).

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