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Intermittent versus daily calorie restriction: which diet regimen is more effective for weight loss?

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Summary

Dietary restriction is an effective strategy for weight loss in obese individuals. The most common form of dietary restriction implemented is daily calorie restriction (CR), which involves reducing energy by 15–60% of usual caloric intake every day. Another form of dietary restriction employed is intermittent CR, which involves 24 h of *ad libitum* food consumption alternated with 24 h of complete or partial food restriction. Although both diets are effective for weight loss, it remains unknown whether one of these interventions produces superior changes in body weight and body composition when compared to the other. Accordingly, this review examines the effects of daily CR versus intermittent CR on weight loss, fat mass loss and lean mass retention in overweight and obese adults. Results reveal similar weight loss and fat mass loss with 3 to 12 weeks' intermittent CR (4–8%, 11–16%, respectively) and daily CR (5–8%, 10–20%, respectively). In contrast, less fat free mass was lost in response to intermittent CR versus daily CR. These findings suggest that these diets are equally as effective in decreasing body weight and fat mass, although intermittent CR may be more effective for the retention of lean mass.

Keywords: Alternate day fasting, body composition, calorie restriction, weight loss.

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Introduction

Overweight and obesity are major global health concerns owing to the predominance of sedentary lifestyles and the abundance of energy-dense foods (1). As the prevalence of overweight and obesity increases, so does the prevalence of certain obesity-related disorders, including coronary heart disease and type 2 diabetes (2). Losing weight by means of dietary restriction has been shown to improve indicators of disease risk (3). The major form of dietary restriction currently implemented is daily calorie restriction (CR). These regimens consist of decreasing energy intake by 15–60% of baseline needs every day. Although daily CR has been shown to be an effective weight loss strategy for certain segments of the obese population, many individuals find it difficult to adhere to these diets (4). As such, *intermittent* CR regimens were created to improve adherence with these protocols, as restriction is only required *every other day*, rather than *every day*, as with daily CR (5). Intermittent CR regimens generally involve a 'feed day', where food is consumed *ad libitum* over a 24-h period, alternated with a 'fast day', where food intake is either completely restricted or partially reduced over 24 h. This form of intermittent CR is also referred to as alternate day fasting. Other forms of intermittent CR, which involve 2 to 4 d of fasting alternated with 2 to 4 d of *ad libitum* feeding, have also been implemented. The ability of these individual interventions, i.e. daily CR and intermittent CR, to facilitate weight loss has been tested in several recent trials (5,6). What has yet to be determined, however, is whether one of these interventions produces superior changes in body weight and body composition parameters when compared to the other.

Accordingly, the objective of this review was to evaluate and compare the effects of daily CR versus intermittent CR on weight loss, fat mass loss, lean mass retention and visceral fat mass reduction, in overweight and obese adults.

Methods

Studies included in this review were subject to the following criteria (i) randomized control trials; (ii) primary endpoint of weight loss and/or body composition changes; (iii) daily CR or intermittent CR as the primary focus of the intervention; (iv) study duration of 4–24 weeks (i.e. short-term and moderate-term trials only); (v) adult populations; (vi) overweight or obese subjects and (vii) non-diabetic patients. A Pubmed search using various combinations of the keywords 'calorie restriction', 'intermittent calorie restriction', 'alternate day fasting', 'body weight', 'weight loss' and 'body composition' limited to Adults, Clinical trials, English and Humans produced 11 daily CR trials (4,7–16), and five intermittent CR trials (17–21) published between 2000 and 2010. Two unpublished trials of intermittent CR from our lab were also included in the analysis (22,23).

Benefits of weight loss

At present, 32% of Americans are categorized as overweight (body mass index [BMI] between 25.0–29.9 kg m^{-2}), while 34% of Americans are categorized as obese (BMI > 30.0 kg m^{-2}) (24). Reducing body weight by decreasing energy intake has been shown to improve biomarkers for disease risk (25). For instance, plasma lipid concentrations (total cholesterol, low-density lipoprotein cholesterol and triglycerides) are lowered once 5% weight loss is achieved (26,27). Blood pressure (systolic and diastolic) is also lowered once an individual reduces their body weight by 5% from baseline (28). Moreover, C-reactive protein, an extremely sensitive marker of inflammation that is positively associated with the occurrence of vascular events, can be lowered in response to 10% weight loss (29). As for insulin and glucose levels, a 5% reduction in body weight can produce potent reductions in these biomarkers of disease risk in both overweight and obese adults (30). Daily CR and intermittent CR are two forms of diet therapy that can help individuals lose weight. The following section compares the efficacy of each of these interventions in modulating body weight in overweight and obese populations.

Daily calorie restriction: effects on body weight

We identified 11 CR trials (4,7–16) that resulted in significant declines in body weight over 4 to 24 weeks in overweight and obese men and women (Table 1). When the studies were ordered according to treatment duration, it was observed that short-term 25–60% CR (4 to 12 weeks) produced a mean weight loss of 5–8% (7–12), while moderate-term 25–60% CR (13 to 24 weeks) resulted in weight loss of 6–19% from baseline (4,13–16). Thus, not surprisingly, longer treatment durations generally demonstrate greater weight loss. It should be noted, however, that even the short-term trials of daily CR (7–12) were able to produce a minimum weight loss of 5% from baseline. As such, even short durations of daily CR may help overweight and obese individuals improve biomarkers of disease risk that respond to 5% weight loss (i.e. low-density lipoprotein cholesterol, triglycerides, blood pressure, insulin and glucose levels). However, in order to improve biomarkers that require a minimum weight loss of 10% (i.e. C-reactive protein concentrations), longer durations of treatment ranging from 13 to 24 weeks may be required. We were also interested in examining whether degree of weight loss varied in overweight versus obese individuals in response to daily CR. In examining the literature, an absolute but not a relative difference in weight loss was observed between these two BMI classifications. For example, overweight men and women in the study by Redman *et al.* (11) lost the same per cent of weight (7% from baseline) as obese men and women in the study by Kirk *et al.* (10) after the same duration of treatment (12 weeks). Another key factor that impacts amount of weight loss is degree of energy restriction. No dose–response relationship between greater degree of energy restriction and larger amounts of weight loss was identified in the trials examined here, however (4,9,11–13,15,16). For instance, similar weight loss (6% from baseline) after 12–13 weeks of treatment was demonstrated with 16% energy restriction (13) and 23% energy restriction (12). Moreover, the trial (4) that reported the greatest degree of energy restriction (63%) only resulted in slightly greater weight loss (16% body weight reduction after 22 weeks of treatment), than a trial (15) that reported 23% energy restriction (13% weight loss after 20 weeks of treatment). The lack of relationship between degree of energy restriction and amount of weight loss may be due to poor dietary intervention control. Although food was provided in some of these trials (4,15), the investigators did not control for extra food items that may have been consumed after the subjects left the research centre. If the subjects did consume extra food items (i.e. in addition to the food provided), this would greatly decrease the degree of energy restriction over the course of the trial.

Intermittent calorie restriction: effects on body weight

Given that intermittent CR is implemented far less frequently than daily CR, only seven human studies (17–23) to date have examined the effect of this diet regimen on weight reduction (Table 2). Findings from these trials reveal that intermittent CR is able to produce significant

Table 1 Daily calorie restriction: effects on body weight and body composition

Reference	Subjects	Trial length	Prescribed CR regimen	Estimated daily CR achieved*	Body weight change (%)	Fat mass change (%)	Fat free mass change (%)	Visceral fat mass change (%)
Norrelund, 2000 (7)	*n* = 15, F Age 36 ± 4 years BMI 40 ± 2	4 weeks	60% CR daily (food provided)	–	↓5%†	↓10%†	↓1%†	–
Haugaard, 2009 (8)	*n* = 9, MF Age 52 ± 3 years BMI 32 ± 1	8 weeks	60% CR daily (food provided)	–	↓8%†	↓14%†	↓5%†	↓6%†
Luscombe, 2006 (9)	*n* = 11, MF Age 50 ± 3 years BMI 34 ± 2	8 weeks	25% CR daily (food provided)	18% (isotope dilution)	↓8%†	↓20%†	↓3%†	↓12%†
Kirk, 2009 (10)	*n* = 22, MF Age 43 ± 4 years BMI 37 ± 1	12 weeks	50% CR daily + LP diet (food provided) 50% CR daily + HP diet (food provided)	– –	↓7%† ↓8%†	↓11%† ↓11%†	↓3%† ↓4%†	↓11%† ↓12%†
Redman, 2007 (11)	*n* = 12, MF Age 39 ± 5 years BMI 28 ± 1	12 weeks	25% CR daily (food provided)	18% (DLW)	↓7%†	↓16%†	↓4%†	↓13%†
Tapsell, 2010 (12)	*n* = 21, MF Age 46 ± 4 years BMI 31 ± 2	12 weeks	25% CR daily (food not provided)	23% (food records)	↓6%†	↓10%†	↓1%	↓10%†
Lee, 2009 (13)	*n* = 67, MF Age 48 ± 4 years BMI 29 ± 3	13 weeks	30% CR daily + LP diet (food not provided) 30% CR daily + HP diet (food not provided)	16% (food records) 20% (food records)	↓6%† ↓7%†	↓12%† ↓11%†	↓4%† ↓2%†	↓7%† ↓7%†
Lantz, 2003 (14)	*n* = 173, MF Age 41 ± 5 years BMI 40 ± 2	16 weeks	60% CR daily (food not provided)	–	↓19%†	↓28%†	↓8%†	–
Nicklas, 2009 (15)	*n* = 29, F Age 58 ± 6 years BMI 34 ± 4	20 weeks	25% CR daily (food provided)	23% (food records)	↓13%†	↓18%†	↓7%†	↓26%†
Del Corral, 2009 (4)	*n* = 34, F Age 35 ± 6 years BMI 28 ± 1	22 weeks	65% CR daily (food provided)	63% (food records)	↓16%†	↓34%†	↓2%†	–
Das, 2007 (16)	*n* = 34, MF Age 35 ± 5 years BMI 28 ± 2	24 weeks	30% CR daily (food provided)	18% (DLW)	↓10%†	↓23%†	↓1%	–

*Estimated daily CR achieved: mean degree of energy restriction achieved throughout the duration of the study (method of assessment appears in parentheses).

†Post-treatment values significantly different ($P < 0.05$) from baseline values within the intervention group.

BMI, body mass index (kg m^{-2}); CR, calorie restriction; DLW, doubly labelled water; F, female; HP, high protein; LP, low protein; M, male.

Table 2 Intermittent calorie restriction: effects on body weight and body composition

Reference	Subjects	Trial length	Prescribed CR regimen	Estimated daily CR achieved*	Body weight change (%)	Fat mass change (%)	Fat free mass change (%)	Visceral fat mass change (%)
Halberg, 2005 (17)	*n* = 8, M Age 25 ± 1 years BMI 26 ± 1	2 weeks	Fast day: 100% CR Feed day: *ad libitum* fed (food not provided)	–	↓1%	↓1%	–	–
Michalsen, 2005 (18)	*n* = 30, M Age 54 ± 9 years BMI 27 ± 5	2 weeks	4 fast days: 85% CR alternated with 4 feed days: 25% CR (food not provided)	–	↓3%†	↓4%†	–	–
Heilbronn, 2005 (19)	*n* = 16, MF Age 32 ± 2 years BMI 26 ± 1	3 weeks	Fast day: 100% CR Feed day: *ad libitum* fed (food not provided)	–	↓4%†	↓5%†	↓4%†	–
Johnson, 2007 (20)	*n* = 10, MF Age not specified BMI 34 ± 2	8 weeks	Fast day: 80% CR Feed day: *ad libitum* fed (food not provided)	–	↓8%†	–	–	–
Varady, 2009 (21)	*n* = 16, MF Age 46 ± 2 years BMI 34 ± 1	8 weeks	Fast day: 75% CR Feed day: *ad libitum* fed (food provided on fast day)	37% (food records)	↓6%†	↓11%†	↓1%	↓4%†
Varady, 2010 (22)	*n* = 14, MF Age 40 ± 2 years BMI 36 ± 1	12 weeks	Fast day: 75% CR Feed day: *ad libitum* fed (food provided on fast day)	38% (food records)	↓8%†	↓16%†	↓2%†	↓10%†
Varady, 2010 (23)	*n* = 11, MF Age 52 ± 2 years BMI 26 ± 1	12 weeks	Fast day: 75% CR Feed day: *ad libitum* fed (food provided on fast day)	35% (food records)	↓7%†	↓14%†	↓2%	↓8%†

*Estimated daily CR achieved: mean degree of energy restriction achieved throughout the duration of the study (data collected on feed and fast days combined). Method of assessment appears in parentheses.

†Post-treatment values significantly different ($P < 0.05$) from baseline values within the intervention group.

BMI, body mass index (kg m^{-2}); CR, calorie restriction; F, female; M, male.

declines in body weight after very short trial durations. More specifically, after only 2 and 3 weeks of diet, overweight men and women lost 3% and 4%, respectively, of their initial body weight (18,19). When treatment duration was extended to 8 to 12 weeks, reductions in body weight became more pronounced (6–8% weight loss) (20–23). Although the evidence is quite limited, these findings indicate that similar degrees of weight loss can be achieved by intermittent CR versus daily CR after short-term intervention periods. Additionally, as 8 to 12 weeks of intermittent CR results in a weight loss that exceeds the 5% threshold required to modulate key biomarkers of disease, this diet may be equally as effective as daily CR in modulating disease risk. Whether weight loss varied according to BMI class was also examined. As with daily CR, intermittent restriction appears to be equally as effective in overweight and obese individuals. For instance, after 12 weeks of diet, similar relative weight loss was observed in overweight men and women (7% from baseline) (23) when compared to obese men and women (8% from baseline) (22). We were also interested in investigating how degree of energy restriction impacts weight loss by intermittent CR. Energy restriction was assessed in three studies (21–23) by collecting food records on feed and fast days throughout the trial. In each of these studies (21–23), the subjects were permitted to consume 25% of energy needs on the fast day, and eat *ad libitum* on the feed day. Results from the food record analysis reveal that on the fast day, subjects consumed 20–30% of energy needs, while on the feed day, subjects consumed 100–110% of energy needs (21–23). When total energy restriction was calculated over a 48-h period (i.e. fast day and feed day combined), it was shown that the majority of subjects achieved 35–38% restriction daily over the course of the trial (21–23). This degree of energy restriction for 8 to 12 weeks produced body weight reductions ranging from 6% to 8% (21–23). These findings for energy restriction differ greatly from what was reported for daily CR. For instance, in the 12-week trials of daily CR that demonstrate weight loss of 6–7% from baseline, energy restriction was estimated to be 18–23% (11,12). The reason for the discrepancy in energy restriction between the two diets may be related to the technique used to measure food intake. In several of daily CR and intermittent CR studies, food records were employed to assess energy restriction. As mentioned previously, food record data are flawed in that it relies upon subject self-reports. In view of this, it is not surprising that the data from different studies varied so greatly.

Benefits of fat mass loss and lean mass retention

Although body weight loss is the primary focus of intervention for overweight and obese individuals, changes in body composition that accompany weight loss are also important to consider. When an individual loses weight by dietary restriction alone, approximately 75% of weight is lost as fat mass, and 25% of weight is lost as fat free mass (31). Fat free mass is an important predictor of basal metabolic rate (32). Thus, dietary interventions that preserve fat free mass at the expense of fat mass may be metabolically advantageous. Whether intermittent CR produces more optimal changes in body composition versus daily CR remains unknown. The following section examines changes in fat mass and fat free mass by daily CR versus intermittent CR.

Daily calorie restriction: effects on body fat and lean mass

Changes in fat mass and fat free mass were assessed in all of the daily CR studies reviewed here (Table 1). Short-term trials (4 to 12 weeks) of daily CR produced mean reductions in body fat of 10–20% (7–12), while moderate-term trials (13 to 24 weeks) resulted in reductions of 11–34% from baseline (4,13–16). As for fat free mass, only minimal reductions in this body composition parameter were noted for short-term (1–4% from baseline) (7–12) and moderate-term trials (2–8% from baseline) (4,13–16). It was also noted that in the majority of these studies, weight loss by daily CR resulted from a 75–80% decrease in fat mass, and a 20–25% decrease in fat free mass (4,7–16). This ratio was held constant for both overweight and obese individuals. Thus, BMI classification does not impact the *relative* amount of fat mass to fat free mass lost during daily CR. However, the *absolute* amount of weight loss for obese individuals would still exceed that of overweight individuals. We were also interested in examining the effects of high protein intake on retention of fat free mass during daily CR. This hypothesis was tested in two of the studies reviewed here. Findings from these trials by Kirk *et al*. (10) and Lee *et al*. (13) reveal no apparent effect of high protein intake (30% kcal from protein, 40% kcal from carbohydrates, 30% kcal from fat) during daily CR on maintenance of lean mass (i.e. ratio of fat mass lost to fat free mass lost was approximately 4 to 1). Thus, although the data are limited, consuming a background diet that is high in protein during daily CR may have no effect on retention of lean mass.

Intermittent calorie restriction: effects on body fat and lean mass

Body composition changes were only assessed in four of the intermittent CR trials included in this review (Table 2) (19,21–23). Similar to what was reported for daily CR, short-term trials (4 to 12 weeks) of intermittent CR decreased fat mass by 11–16%, and fat free mass by

1–4% from baseline (21–23). To date, there are no moderate-term trials (13 to 24 weeks) of intermittent CR, so no comparisons between diets could be made for longer intervention periods. We were also interested in comparing the ratio of fat mass to fat free mass lost with intermittent CR versus daily CR. From the studies reviewed here, it would appear as though a lower proportion of lean mass is lost in response to intermittent CR (90% weight lost as fat, 10% weight loss as fat free mass) (21–23) when compared to daily CR (75% weight lost as fat, 25% weight loss as fat free mass) (4,7–16). Although the reason for this maintenance of lean mass is not clear, these preliminary findings suggest a preferential retention of fat free mass by intermittent restriction regimens when compared to daily restriction protocols. It is important to note, however, that comparing values for fat mass and fat free mass between studies is difficult as different techniques were employed to assess these parameters. More specifically, the majority of daily CR trials implemented dual-energy X-ray absorptiometry (DXA) and magnetic resonance imaging (MRI), while the majority of intermittent CR trials employed bioelectrical impedance analysis. It is well known that DXA and MRI are vastly more accurate techniques for the assessment of fat mass and fat free mass when compared to bioelectrical impedance analysis (33). Thus, the different methods employed could create variability when comparing findings between diets.

Benefits of visceral fat mass loss

Visceral obesity, as determined by increased waist circumference and elevated intra-abdominal fat area, is associated with elevated risk of coronary heart disease and type 2 diabetes (34,35). In contrast, individuals who store comparable amounts of adipose tissue in the subcutaneous gluteo-femoral depots exhibit lower risk of these obesity-related disorders (36). Evidence for the pathogenic role of visceral fat involves the secretion of inflammatory cytokines (i.e. tumour necrosis factor-alpha and interleukin-6) (37). These inflammatory mediators have been shown to augment hepatic gluconeogenesis in turn favouring the development of insulin resistance (37). In view of this, a preferential loss of visceral fat by diet therapies may be considered protective. The ability of daily CR and intermittent CR to reduce visceral fat mass is summarized in the following section.

Daily calorie restriction: effects on visceral fat mass

The effect of daily CR on changes in visceral fat mass was evaluated in seven of the 11 trials reviewed here (Table 1) (8–13,15). For each study, it was observed that as per cent weight loss increased, per cent visceral mass fat loss (assessed by MRI in most trials) was also augmented in a roughly linear fashion. For instance, in the studies that achieved 6–8% weight loss, visceral fat mass was reduced by 6–13% (8–13). In the trial that achieved greater weight loss (13% from baseline), more pronounced decreases in visceral fat mass were noted (26% from baseline) (15). The effects of varying background diets on visceral fat mass reduction were also examined. From the trials reviewed here, it would appear as though alterations in macronutrient distribution do not impact visceral fat mass loss when degree of CR is held constant (10,13). For example, in the trial by Kirk *et al.* (10), similar decreases in visceral fat (11–12%) were observed in response to either a 50% CR high-protein diet or a 50% CR low-protein diet. Similarly, Lee *et al.* (13) demonstrate identical changes in visceral fat mass loss (7%) with either a 30% CR high-protein diet or 30% CR low-protein diet. As for the influence of BMI classification on this parameter, similar relative reductions in visceral fat were noted in overweight and obese individuals undergoing comparable CR protocols (8–13).

Intermittent calorie restriction: effects on visceral fat mass

Three trials (21–23) to date have examined the effects of intermittent CR on regional fat distribution (Table 2). In each of these studies, subjects consumed 25% of their caloric needs over a 24-h period, alternated with a 24-h period of *ad libitum* feeding (21–23). After 8 to 12 weeks of treatment, visceral fat mass was reduced by 4–10% from baseline (21–23). As with daily CR, these decreases in visceral fat were positively associated with body weight loss. For instance, the most potent reduction in visceral fat mass (10%) was attained in the trial that achieved the greatest amount of weight loss (8%) (22), whereas the smallest reduction in visceral fat (4%) was noted for the study with the least amount of weight loss (6%) (21). These changes in visceral fat mass for intermittent CR (21–23) were comparable to those of daily CR (8–13). Thus, both diets appear to be equally as effective for reducing abdominal fat mass. Nonetheless, it should be noted that these studies of intermittent CR (21–23) are limited in that they employed DXA to assess visceral (i.e. trunk) fat mass. DXA is often employed in clinical trials to measure abdominal fat mass because it is cost-effective and relatively easy to perform. However, this technique only provides an estimate of fat contained in the trunk and does not allow for an accurate quantification of visceral fat (38). Thus, in order to assess the true impact of intermittent CR on changes in visceral fat mass, more accurate techniques (i.e. MRI) will need to be employed in future studies (39).

Summary of findings

The present findings indicate that a similar degree of weight loss can be achieved with intermittent CR as with daily CR. More specifically, results from short-term trials (3 to 12 weeks) demonstrate body weight reductions of 4–8% from baseline by intermittent CR (19–23), and 5–8% decreases with daily CR (7–12). As no moderate-term trials (13 to 24 weeks) examining the effect of intermittent CR on body weight have been performed to date, no comparison can be made between diets for this duration of treatment. The degree of weight loss that can be achieved with intermittent CR after longer trial periods will unquestionably be an important focus of future research in this area.

As for fat mass, similar decreases were noted when intermittent CR was compared to daily CR. After 8 to 12 weeks of treatment, 11–16% reductions in fat mass were reported for intermittent restriction (21–23), while 10–20% decreases were demonstrated for daily restriction (8–12). These two diets differed, however, in their effects on lean mass. For instance, a lower proportion of lean mass was lost in response to intermittent CR (90% weight lost as fat, 10% weight loss as fat free mass) (21–23) when compared to daily CR (75% weight lost as fat, 25% weight loss as fat free mass) (4,7–16). Therefore, intermittent CR may be a more effective diet for the retention of lean mass when compared to daily CR.

Reductions in visceral fat mass were also comparable between intermittent CR (4–10% reductions) (21–23) and daily CR protocols (6–13% reductions) (8–13). Then again, it should be pointed out that the technique used to assess abdominal fat mass in the majority of daily CR studies (i.e. MRI) was far superior to that of the intermittent CR trials (i.e. DXA). As a result of this methodological disparity, a true comparison between diets for this body composition parameter cannot be made at present.

Nevertheless, it should be mentioned that the observed differences between daily CR and intermittent CR may be due to factors other than treatment effect. For instance, findings between trials may have varied based on the different populations used for each study. The trials reviewed here differed greatly in terms of subject age range, inclusion of one or both sexes, and BMI classification. Thus, it is possible that the discrepancy in effects observed between studies could be partly due to the subject population employed. Results between studies may have also varied depending on the different feeding protocols utilized. While some studies carefully controlled the dietary intervention by providing all meals to the subjects, other studies only offered brief dietary counselling sessions at baseline. Thus, the different levels of dietary control between studies may have also confounded the treatment effects reported here. Moreover, this review is limited in that comparisons between the two regimens are not based on objective measures or statistical analyses. On this note, as more studies are performed in this area, it will be of interest to compare these two regimens using more robust statistical techniques such as a meta-analysis.

There are several questions that still require investigation in the intermittent CR field. First and foremost, the important issue of long-term weight maintenance with this diet should not be overlooked. It is estimated that 30–35% of the weight a person loses is regained during the first year after diet therapy (40). Thus, diet regimens that help individuals to *maintain* weight loss are of paramount importance in obesity treatment. Although the data are limited, preliminary findings indicate that individuals may find it easier to adhere to intermittent CR when compared to daily CR for short treatment durations (i.e. 12 weeks) (22). Whether or not this improved adherence to intermittent CR can help people with long-term weight maintenance is an important issue that warrants further research. Secondly, the impact of these diets on leptin and energy expenditure also requires examination. Recent findings indicate that the reduction in energy expenditure by CR is not due to a reduction in metabolic rate *per se*, but instead, due to a reduction in activity-related energy expenditure (41). Whether the effect of daily CR on these parameters differs from that of intermittent CR remains unknown, but is of great interest. Thirdly, the impact of background diet (i.e. high-fat versus low-fat) on body weight during intermittent CR has yet to be elucidated. In all previous trials, a low-fat background diet was implemented. This being the case, it is still not clear whether or not a high-fat background diet would differentially affect body weight and body composition during intermittent CR. Fourthly, the effects of combining intermittent CR with exercise on changes in body weight and body composition also warrant exploration. As endurance exercise has been shown to selectively reduce visceral fat mass and aid in the retention of lean mass (42), the combination effects of these two interventions on body weight and body composition could be a fruitful area for future study.

Conclusion

In sum, intermittent CR and daily CR diets appear to be equally as effective in decreasing body weight, fat mass, and potentially, visceral fat mass. However, intermittent restriction regimens may be superior to daily restriction regimens in that they help conserve lean mass at the expense of fat mass. These findings add to the growing body of evidence showing that intermittent CR may be implemented as another viable option for weight loss in overweight and obese populations.

Conflict of Interest Statement

No conflict of interest was declared.

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