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Weight cycling, metabolic rate and eating behaviours in normal weight females.

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Abstract

Background & Objective: Repeated weight loss followed by weight gain may cause women to become metabolically efficient and therefore regain weight after dieting. The aim of this study is to investigate what effect long term weight cycling has on metabolic function and eating behaviour in a normal weight population.

Design: Subjects were matched for body composition and grouped by previous weight fluctuates, (weight cyclers) versus those who have remained weight stable (non-weight cyclers). Indirect calorimetry, 7-day nutritional intake and activity, three-factor eating questionnaire and a DEXA scan were performed.

Outcomes: There were no significant differences in resting metabolism, however the weight cyclers were lower (4.8 ± 1.0 versus 5.0 ± 1.1 MJ/day). Restrained eating and disinhibition were different between non-weight cyclers (3.9 ± 2.9; 5.1 ± 2.2) and weight cyclers (6.7 ± 3.7, p=0.04; 7.8 ± 3.7, p=0.03; respectively).
Self reported daily activity was higher (p=0.03) in the weight cyclers (1.7 ± 0.2) than the non-weight cyclers (1.5 ± 0.2).

Conclusions: Resting metabolic rate did not differ between groups, however will power, resistance to eating cues and daily activity levels did. Therefore, in order for subjects who have dieted to obtain the same body composition they must have compensatory psychological and physical behaviours.

Introduction

Maintaining a normal body weight is an enormous challenge in today's society of convenience foods and inactive lifestyles, leading to a life of dieting. However, it appears that only a small proportion of these females are able to maintain the lower weight [1], suggesting a physiological mechanism to either 1) increase consumption of calories or, 2) reduce the metabolic rate relative to the reduced body weight [2,3].

The purpose of this study is to investigate differences in resting metabolic rates, eating habits, physical activity and attitudes between weight cyclers and non-weight cyclers in normal weight females. Previous studies have used animals, formerly obese or subjects that are still weight cycling [4,5,6]. Therefore what effect has long term weight fluctuations had on metabolic function and eating patterns?

Method

Subjects

57 female subjects recruited via newspaper advertising, completed a questionnaire concerning past dieting. 19 subjects were classified as weight cyclers or non-weight cyclers and matched for weight, lean mass and fat mass. Descriptive characteristics for the two groups of women are presented in Table 1. Laboratory familiarization was completed before beginning.

Table 1 near here.

Physical Activity

The subjects reported their activity in a 7-day diary in 15 minute increments which were then calculated into hours per day of each level. Physical activity was then converted to a daily activity factor using the Australian Nutrition Services spreadsheet and an activity factor was calculated [7].

Resting Metabolic Rate (RMR)

After a 12-hour over night fast RMR was measured by indirect calorimetry on a MetaSoft 2004 v.3.2, Meta-Analyzer using standardized procedures [8]. The coefficient of variation was under 5%.

Body Composition:

Whole body Lunar GE Medical system DEXA machine was used to measure body composition and further analysed for central body composition.

Nutritional Intake and Eating Habits

Macronutrient intake were determined using the New Zealand food database (FoodWorks version 4, Australia) and analysed by a nutritionist.

Eating behaviour was assessed using the Three Factor Eating Questionnaire (TFEQ), a psychometric instrument developed by Stunkard & Messick [9].

Statistical Analysis

Descriptive data are presented as means ± standard deviations (SD). Two tailed *t* tests assuming unequal variances were used to find significant differences between the two groups. Central fat mass was corrected for weight and height.

Results

Resting Metabolic Rate

Mean resting metabolic rate was no different ($p = 0.36$) between non-weight cyclers (5.0 ± 1.1 MJ/day) and weight cyclers (4.8 ± 1.0 MJ/day), see table 2.

Table 2 near here.

Estimated Resting Metabolic Rate

The Schofield equation was used to calculate resting metabolic rate in the order of 6.0 MJ/day [8]. This result is considerably higher than the values actually determined under standard conditions on these individuals.

Body Composition

The body composition differences in fat and lean mass between groups were insignificant. The non-weight

cyclers (169.9cm ± 5.3) were taller than the weight cyclers (165.0 ± 4.5 ; p=0.046).
Central fat mass after adjusting for height differences was higher in the non-weight cyclers (15.3kg ± 0.8) than the weight cyclers (12.5kg ± 0.8), although this result was insignificant. (see Table 1).
Table 3 near here.

Dieting History
The weight cyclers (n=10) reported that they had dieted an average of 12 ± 4 times from the age of 18 years and lost, each time they dieted, on average 6.2 ± 2.6kgs. They were not at their lightest adult weight and last reported diet was 2 ± 1 years ago.
The non-weight cyclers (n=9) reported that they had dieted an average of 0.7 ± 0.3 times from the age of 18 years. Their last reported diet was 6.5 ± 0.3 years ago.

Physical Activity
The non-weight cyclers had an average activity factor of 1.5 ± 0.2 compared to the weight cyclers activity factor of 1.7 ± 0.2, respectively ($p = 0.03$). Total energy expenditure was estimated to be 9.0 MJ/day for non-weight cyclers and 10.2 MJ/day for weight cyclers. [7].

Food Intake
Mean energy ($p = 0.36$) intake was no different between non-weight cyclers (9.0 ± 1.5 MJ/day) and weight cyclers (8.6 ± 2.5 MJ/day), as with fat ($p = 0.40$), carbohydrate ($p = 0.20$) and protein ($p = 0.42$) intake. Macronutrient intake from carbohydrate, fat and protein are reported in Table 2. To minimize variability, only the macronutrients were recorded [11].
Table 3 near here.

Three Factor Eating Questionnaire (TFEQ)
Mean scores restrained eating were significantly different ($p = 0.04$) between non-weight cyclers (3.9 ± 2.9) and weight cyclers (6.7 ± 3.7). Mean scores for disinhibition were significantly different ($p = 0.03$) between non-weight cyclers (5.1 ± 2.2) and weight cyclers (7.8 ±3.7). Mean score for the subjective feeling of hunger were not significantly different ($p = 0.18$) between non- weight cyclers (3.3 ± 1.3) and weight cyclers (4.3 ± 2.9).

Discussion
Results of this study do not support part of the initial hypothesis that weight cycling decreases RMR in a normal weight female population. There was a trend towards a lower metabolic rate in the weight cycling group, however there was typically more variation within the groups than between, suggesting that other factors may act in addition to physiological aspects in weight regain after dietary restriction in this group.
The weight cycling females were found to participate in active lifestyles, and if they had not their metabolic rate may have in fact been significantly lower; as seen in some but not all previous studies [5,12,13]. This may also explain the lack of additional central fat mass in the cyclers, as the exercise may negate the fat accumulation.
These results agree with carefully controlled rat and human studies which found a metabolic efficiency in obese, but not the overweight, suggesting the physiological mechanisms to cope with body mass overload break down once obesity ensues, but not necessarily before [14,15].
The Schofield equation is used by dietitians worldwide to estimate energy requirements for normal weight adults. The present study suggests that this equation overestimates the energy required to maintain weight in this population. Horgan and Stubbs,[16] state that many population groups (especially inactive groups) may not conform to this linear equation [16].
The TFEQ suggests that the weight cyclers have a psychological tendency to diet. Results show that weight cyclers are more likely to restrict caloric intake, resist stimulus control, and are more likely to binge or follow group eating behaviours. This result supports previous findings found in former dieters [13].

Relevance to Practice
At this stage past weight cyclers can be comforted by the knowledge that past dieting efforts should not

significantly reduce metabolic rate. However, the implication that weight cyclers need to somehow over compensate with physical activity to maintain a metabolic rate similar to that of non-weight cyclers may be important for those confronting weight management and health issues and further study is worth investigating. It may be speculated that if the weight-cyclers did not exercise more, they would in fact be either 1) heavier and/or 2) have a lower metabolic rate.

The weight cyclers were more likely to experience psychological stress with food, despite that fact that the food quantities were quite similar to the non-weight cyclers, which warrants further investigation.

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Table 1: Subject characteristics (mean ± SD) for non-weight cyclers and weight cyclers. No significance between any of the characteristics apart from height where the non-weight cyclers were taller (p=0.04).

	Non-weight cyclers (n=9)	**Weight cyclers (n=10)**
Age (years)	35 ± 8	37 ± 8
Weight (kg)	73.6 ± 9.4	73.8 ± 8.2
Height (m)	1.70 ± 0.05	1.65 ± 0.04
BMI	25.4 ± 2.6	27.1 ± 3.3
Fat Free Mass (kg)	43.3 ± 5.4	45.5 ± 4.4
Fat Mass (kg)	27.3 ± 6.1	25.7 ± 7.3
Central Fat Mass (kg) $_{(adjusted)}$	5.3 ± 0.8	12.5 ± 0.8
% Body Fat	38.5 ± 4.9	35.7 ± 7.8
Bone Mineral Content (kg)	3.11 ± 0.41	2. 93 ± 0.37

Table 2: Mean (±SD) resting metabolic rate and percent total body fat of non-weight cyclers and weight cyclers. (Average RMR is 4891 ± 138 kJ/day). Central fat mass (mean kg ± SE) has been adjusted for height. P>0.05 for all parameters.

	Non-weight cyclers (n=9)	**Weight cyclers (n=10)**
Resting Metabolic Rate (MJ/day)	4.980 ± 1.105	4.811 ± 0.910
Total diet energy reported (MJ/day)	8.513 ± 1.391	8.488 ± 2.486
Activity diary energy expenditure (MJ/day)	13.819 ± 2.684	15.570 ± 1.947
% Total Body Fat	38.5 ± 4.9	35.6 ± 8.2

Table 3: Mean (±SD) macronutrient and energy intake expressed as average per day for non-weight cyclers and weight cyclers. P>0.05 for all parameters.

Subject group	Fat intake per day (grams)	Carbohydrate intake per day (grams)	Protein intake per day (grams)	Total kilojoules per day
Weight Cyclers	80 ± 40	240 ± 52	92 ± 29	8617±2472
Non-weight cyclers	76 ± 15	251 ± 55	90 ± 22	8947±1470