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The Effects of the Special K Challenge on Body Composition and Biomarkers of Metabolic Health in Healthy Adults

Shaw P[1], Walton J[2] and Jakeman P[*1]

[1]Human Science Research Group, Faculty of Education and Health Sciences, University of Limerick, Limerick, Ireland
[2]Kellogg's Co. Ltd., Talbot Road, Manchester, M16 0PU, United Kingdom

[*]**Corresponding author:** Jakeman P, Human Science Research Group, Faculty of Education and Health Sciences, University of Limerick, Limerick, Ireland, Email: phil.jakeman@ul.ie

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Abstract

The Special K Challenge is a short term (14 day) partial meal replacement diet designed to reduce body mass and motivate long term reduction in body mass. Our study evaluated the effects of the Special K Challenge on reported energy intake, body mass, body composition and biomarkers of metabolic health in healthy overweight and obese men and women. We found a reduction in total reported energy intake; body mass; fat mass and waist circumference but no changes in plasma total cholesterol or triglycerides in response to the Special K Challenge. The reduction in total reported energy intake facilitated a positive, health-related decrease in body mass, regional fat mass and waist circumference in this small sample size. Our study suggests that the Special K Challenge may act as an effective motivator to long term reduction in body mass.

Keywords: Energy intake; Body composition; Special K Challenge; Biomarkers; Meal replacement

Introduction

Obesity is caused by an energy imbalance between calories consumed and calories expended [1] that poses an increased risk of hyperglycaemia, hypercholesterolemia and insulin resistance. Results from the 2013 Health Survey for England (HSE) estimate that approximately 62.1% of the adult population of the UK and Ireland are overweight or obese [2]. As a recommended strategy in the treatment of overweight and obesity and related disorders, 20-30% of adults use dieting in an effort to reduce body mass [3]. In accordance with the World Health Organization and the National Obesity Observatory an energy deficit of 600kcal per day is recommended to reduce body mass by approximately 0.5-1.0kg per week [4,5]. Whilst diets focus on body mass, body compositional change is of significant clinical importance as a reduction in total and regional fat mass is associated with a reduction in metabolic risk factors and mortality [1,6].

Meal replacement diets have been shown to be effective in achieving a reduction in body mass [7-10] compared to traditional reduced energy diets [11-15]. Furthermore, maintained over a 3 month period, meal replacement diets may also lead to a reduction in biomarkers of metabolic risk (i.e. plasma cholesterol, triglycerides, blood pressure, glucose and insulin) [13].

Promoted as a motivation tool to encourage long term dietary change, and conducted in accordance with the NICE recommendations for body mass reduction, short term (~14 day) proprietary meal replacement diet plans, such as the Special K Challenge, have been reported to achieve an energy deficit approximating to 600kcal per day and a commensurate 2kg reduction in body mass in healthy overweight and obese individuals [7,14]. However, the regional fat loss distribution and the effect of the Special K Challenge on biomarkers of metabolic risk have not previously been evaluated.

Given the association between the compositional change in body mass and metabolic risk, the aim of this study was to investigate whether the Special K Challenge, could achieve a favourable compositional change in body mass and associated changes in biomarkers of metabolic health.

Methodology

Study design

The study was approved by the Faculty of Education and Health Sciences Research Ethics Committee (EHSREC 10-50) and all participants provided informed consent. All screening, data collection and analysis took place at the University of Limerick. An illustration of the study design is provided in Figure 1. The study comprised of 2 consecutive 14 day phases. During the first phase (basal phase) participants followed their usual diet. During the second phase (diet phase) participants engaged in the Special K Challenge. A factorial design with repeated measures was used by which the participants acted as their own control. All statistical analysis was performed using PASW Statistics 18.0 (SPSS, Inc., Chicago, IL). Normality of data was confirmed using a Shapiro-Wilk test and Analysis of Variance (with repeated measures) applied to determine statistically significant ($p < 0.05$) effect.

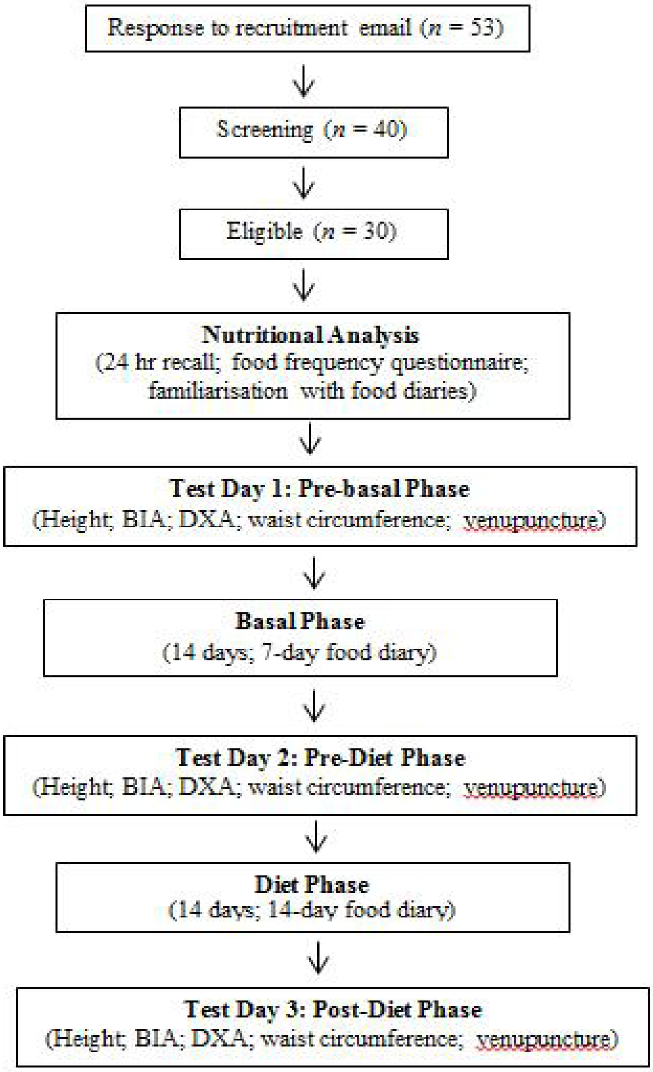

Figure 1: Illustration of recruitment protocol and study design

Participants

All participants were 20-60 years of age, with a mean body mass index (BMI) of 24-35kg/m^2. Participants were excluded if they were pregnant, lactose intolerance, diabetic or coeliac or taking medication affecting cholesterol; blood pressure or glucose regulation.

Intervention

The Special K Challenge is a partial meal replacement diet whereby two main meals of the day are replaced with Special K cereal (Special K, Kellogg's Marketing and Sales Co., UK) for 14 days. Therefore this study evaluated the effects of the Special K Challenge over 14 days only. Each meal substitution consisted of 30g of cereal and 125ml of semi-skimmed milk. Between meals Special K snacks (23g cereal bars) were recommended in addition to fruit or vegetables.

Dietary analysis and compliance

Prior to starting, all participants attended a nutritional analysis interview consisting of a 24hr recall; a 52-item food frequency questionnaire (FFQ) and detailed instructions and familiarisation with the food diaries and Special K Challenge. FFQ's have demonstrated acceptable validity and reproducibility in the estimation of energy and nutrient intake [16]. A portion size booklet was provided to assist the participants in the estimation of their portion sizes [17]. During the basal and diet phases participants were required to keep 7 and 14 day food diaries respectively. The 7 day food diary was used to record the first 7 days of the basal phase, consisting of five weekdays and two weekend days [18]. To assist the participants, the 14 day food diary, used to record the diet phase, included the meal substitutions at breakfast and lunch and therefore participants selected 'yes' or 'no' as appropriate. In addition there was space to record any additions or alterations to the meal substitution, for example tea, coffee, fruit, etc. The use of a 7 day food diary during the basal phase aimed to minimise misreporting as a result of fatigue which may occur following 28 consecutive days of dietary records. The calculation of nutrient intake was performed using WISP Dietary Analysis Software Package (Tinuviel Software, Warrington, UK).

To facilitate dietary compliance, pre-packaged, 30g portion sized boxes of cereal and a selection of Special K snacks were provided *gratis*. Participants were considered noncompliant if on any one occasion they failed to replace two of their main meals, breakfast, lunch or dinner, with the proprietary dietary substitution as per instructions. This was determined by the analysis of the food diaries and a post-diet phase interview.

Anthropometry

Participants arrived at the test centre following an overnight fast and with an empty bladder and were required to abstain from exercise for 12 hours prior to the test. Height was measured to the nearest 0.1cm using a stadiometer (Seca, Birmingham, UK). Waist circumference was measured at the midway point between the ribs and iliac crest.

Bio-electrical impedance analysis (BIA)

A bioelectrical impedance analyser (Tanita MC-180MA Body Composition Analyzer, Tanita UK Ltd) was used to determine total body water content (kg). A 0.4% coefficient of variance for the measurement of total body water by BIA had been established previously [19].

Dual energy x-ray absorptiometry (DXA)

Whole body compositional analysis was measured by dual energy x-ray absorptiometry (Lunar iDXA™ scanner; GE Healthcare, Chalfont St Giles, Bucks., UK with enCORE™ v.14.1 software. The precision for repeated measurement was 0.6% body [20]. Total body mass was reported as reconstituted body mass (kg) (LTM + BFM + bone tissue mass). The enCore™ software provided the segmental analysis into arm, leg and trunk segments. The trunk segment is defined as all tissue distal to the lowest point of the skull, excluding that contained in arms and leg segments. Body fat mass was partitioned into visceral adipose tissue (VAT, kg); abdominal fat mass (kg); trunk fat mass (kg) and android fat mass (kg). Android fat mass, produced automatically by the enCore™ software, is measured approximately from the top of the pelvis to the midpoint of the lumbar spine. Abdominal fat mass was manually defined by the region between upper edges of the first lumbar vertebrae to the lower edge of the fourth lumbar vertebrae (L1-L4) and was measured using the custom region of interest (ROI) analysis procedures [21,22]. Repeated measurements of this procedure have a coefficient of variance of 1.5% [22]. Visceral adipose tissue (VAT, kg) was measured using CoreScan™ (GE Healthcare, Madison, WI) software.

Blood biomarkers

Two 4.5 ml blood samples were obtained by venipuncture of an antecubital vein of the left arm. Serum and plasma were separated by centrifugation and frozen at -78 °C until analysis. The Biochemistry Department of the University Hospital, Limerick, undertook the analysis of plasma cholesterol, triglycerides (TAG), calcium, albumin and urea (UniCel DxC 800 Synchron ® Clinical Systems,Beckman Coulter; UK), glucose and insulin (Elecsys 2010 :Roche Diagnostics; Germany). Leptin (pg/mL) and adiponectin (μg/mL) were analysed by immunoassay (Meso Scale Discovery®, Meso Scale Diagnostics, LLC, Gaithersburg, MD, 20877 USA) at the University of Limerick.

Results

Thirty participants were recruited to the study. Two participants withdrew during the intervention and four were excluded from analysis due to poor compliance. A total of twenty four participants completed both the basal and diet phases and were included in the analysis. Participant characteristics are shown in Table1.

	Total (n = 24)	**Men (n = 12)**	**Women (n = 12)**
Age (years)	37.4 (11.7)	33.6 (10.8)	41.1 (11.9)
Height (m)	1.72 (0.10)	1.80 (0.05)	1.63 (0.07)
BMI (kg/m^2)	28.6 (2.9)	28.4 (3.1)	28.7 (2.9)
Body Mass (kg)	84.3 (12.2)	92.4 (11.3)	76.2 (6.3)
Waist Circumference (cm)	90.9 (9.4)	93.7 (9.1)	88.1 (9.3)
Reported Energy Intake (kcal/day)	2054 (573)	2379 (562)	1728 (372)
Plasma Total Cholesterol (mmol/L)	5.0 (0.5)	4.9 (0.6)	5.0 (0.5)
Plasma HDL Cholesterol (mmol/L)	1.4 (0.4)	1.2 (0.3)	1.5 (0.4)
Plasma LDL Cholesterol (mmol/L)	2.9 (0.6)	3.0 (0.5)	2.8 (0.6)
TAG (mmol/L)	1.2 (0.6)	1.2 (0.7)	1.2 (0.5)
Glucose (mmol/L)	5.1 (0.4)	5.1 (0.4)	5.2 (0.5)
Insulin (pmol/L)	54.2 (35.4)	39.9 (22.4)	68.6 (40.8)
HOMA	1.0 (0.7)	0.8 (0.4)	1.3 (0.8)

Table 1: Demographic and anthropometric characteristics at baseline. Data are mean (SD)

Effect of the diet phase on energy and nutrient intake

The mean (SD) reported energy and nutrient intakes during the basal and diet phases are shown in Table 2. Overall there was a significant reduction in mean reported energy intake and a 50% reduction in total and saturated fat intake. There were also significant reductions in protein, carbohydrate, fibre, sodium and calcium intakes. When expressed as a percentage of baseline, men and women had a similar reduction in reported energy intake (34 (10) *vs.* 28 (9)%; $p = 0.147$).

Intake	Basal phase	Diet phase	Difference	95% CI	P-value	Power	Effect Size
Energy (kcal/day)	2054 (573)	1381 (310)	673 (360)	521 to 825	<0.001	1	0.79
Total Fat (g)	82 (31)	42 (16)	40 (23)	30 to 49	<0.001	1	0.76
Sat[1] Fat (g)	30 (12)	15 (7)	16 (10)	11 to 20	<0.001	1	0.7
Poly[2] Fat (g)	14 (9)	5 (2)	9 (8)	5 to 12	<0.001	0.99	0.55
Mono[3] Fat (g)	24 (10)	12(5)	12 (9)	8 to 15	<0.001	1	0.65
Carbohydrate (g)	235 (66)	188 (40)	47 (43)	30 to 65	<0.001	1	0.57
Protein (g)*	90 (25)	68 (20)*	21 (17)	14 to 28	<0.001	1	0.62
Fibre (g) *	11 (10)*	10 (3)	2 (3)	1 to 4	0.002	0.91	0.34
Sodium (mg)	2946 (819)	1956 (443)	989 (785)	658 to 1351	<0.001	1	0.62
Calcium (mg)	932 (305)	687 (169)	245 (223)	151 to 339	<0.001	0.99	0.6
*Median (IQR); [1]Saturated; [2]Monounsaturated; [3]Polyunsaturated							

Table 2: Effects of the diet phase on reported energy and nutrient intake. Data are mean (SD)

Mean reported energy intake was significantly reduced by 198kcal (95% CI -268 to -127; $p < 0.001$) at breakfast, 287kcal (95% CI -399 to -175; $p < 0.001$) at lunch and 135kcal (95% CI -236 to -34; $p = 0.011$) during snacking (Figure 2). Mean fat intake was significantly reduced by 13g (95% CI 9 to -7.4; $p < 0.001$) at breakfast, 19 (18)g (95% CI -26.4 to -11.0; $p < 0.001$) at lunch and 5g (95% CI -10.7 to 0.1; $p < 0.045$) during snacking (Figure 3).

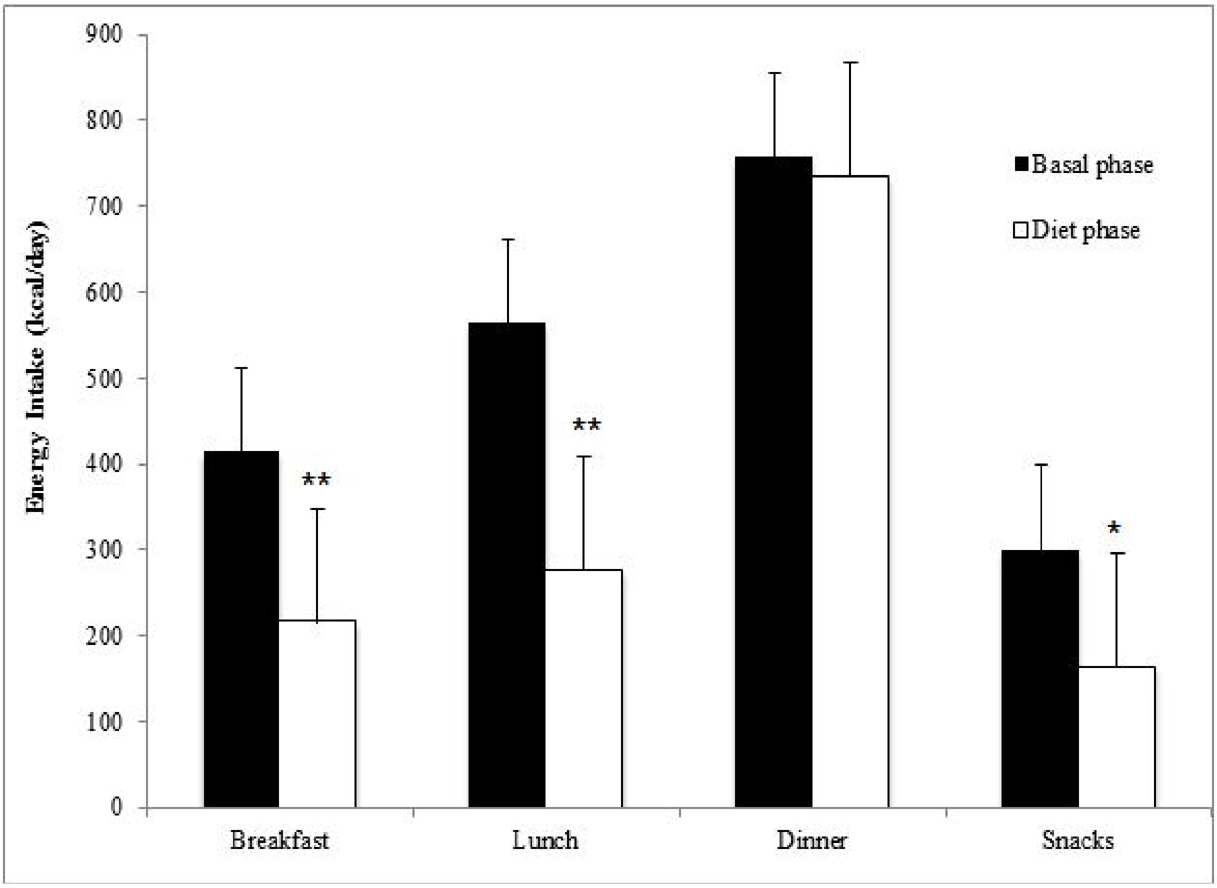

Figure 2: Reported energy intake (kcal) at breakfast, lunch, dinner and snacks during the basal and diet phases. Data are mean (SE). Significantly different from the basal phase: *$p < 0.05$; **$p < 0.001$

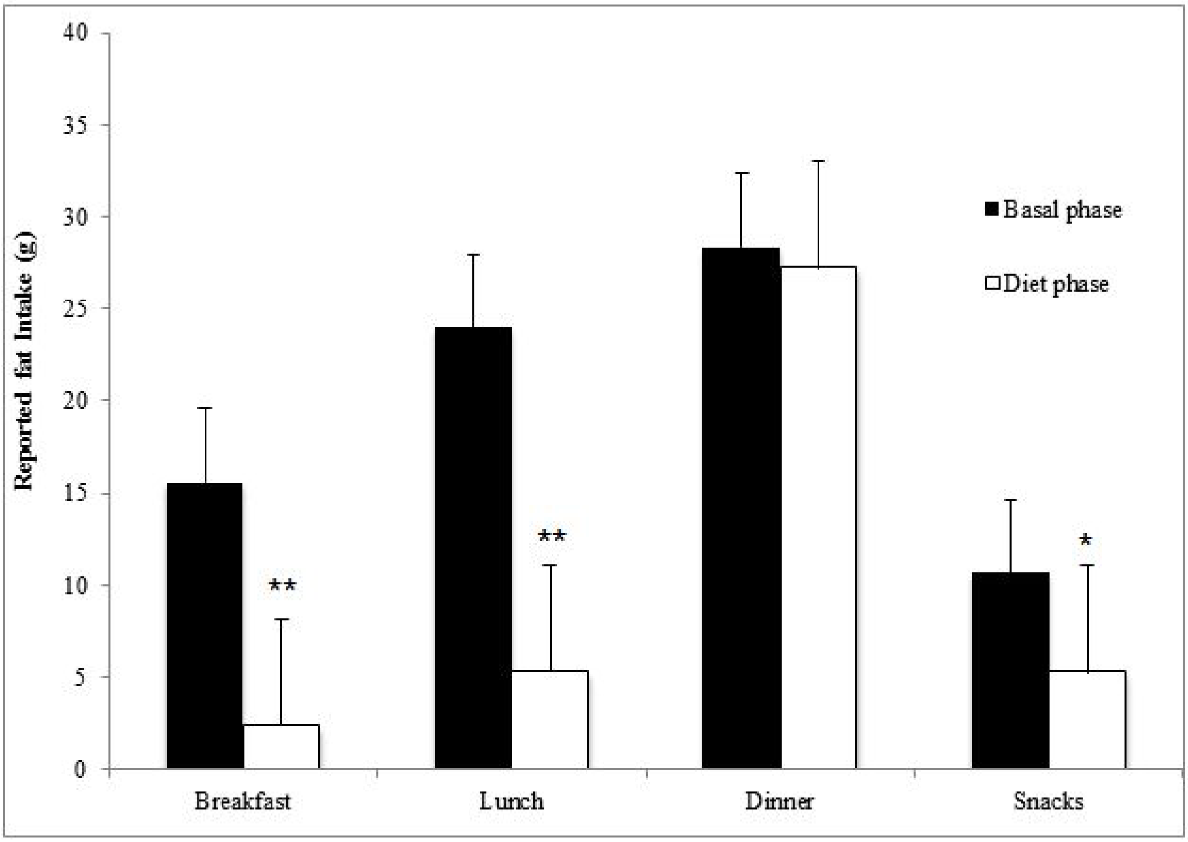

Figure 3: Reported fat intake (g) at breakfast, lunch, dinner and snacks during the basal and diet phases. Data are mean (SE). Significantly different from the basal phase: *$p < 0.05$; **$p < 0.001$

Effect of the Basal and Diet Phases on Body Mass and Body Composition

Men and women had similar total fat mass at baseline ($p = 0.167$) and therefore women had a significantly higher body fat percentage then men (40.7 (4.3) *vs*. 28.8 (7.2)%; $p < 0.001$). Table 3 shows the changes in body mass and body composition during the basal and diet phases of the intervention. There were no statistically significant changes in any of the variables during the basal phase. In response to the diet phase there was a significant reduction in reconstituted body mass, BMI, total and regional fat mass, waist circumference and lean tissue mass. The change in body mass between the basal and diet phases is shown in Figure 4 and 5. Men had a greater reduction in total fat was when compared to women (-1.1 (0.8) *vs*. 0.3 (0.5)kg; $p < 0.005$) however there were no sex-specific changes in lean tissue mass ($p = 0.265$) or total body water ($p = 0.458$).

	Basal phase	95% CI	Diet phase	95% CI	*P*-value	Power	Effect Size
BMI (kg/m^2)	0.0 (0.4)	-0.2 to 0.2	-0.6 (0.4)	-0.8 to -0.3	<0.001	1	0.55
Total Body Mass (kg)	0.2 (1.5)	-0.4 to 0.5	-1.6 (1.4)	-2.3 to -0.9	<0.001	1	0.64
BFM (kg)	-0.3 (0.6)	-0.6 to 0.1	-0.7 (0.8)	-1.1 to -0.3	<0.001	0.98	0.49
VAT (kg)	-0.04 (0.1)	-0.1 to 0.02	-0.07 (0.1)	-0.1 to -0.02	0.002	0.93	0.43
Trunk FM (kg)	-0.3 (0.6)	-0.6 to 0.0	-0.5 (0.5)	-0.7 to 0.2	<0.001	0.99	0.52
Android FM (kg)	-0.04 (0.2)	-0.1 to 0.1	-0.13 (0.2)	-0.2 to -0.1	<0.001	0.95	0.45
L1-L4 FM (kg)	-0.07 (0.2)	-0.1 to 0.2	-0.12 (0.2)	-0.2 to 0.03	0.023	0.71	0.29
LTM (kg)	0.3 (0.8)	-0.1 to 0.7	-0.8 (1.0)	-1.4 to -0.3	0.004	0.89	0.41
TBW (kg)	0.1 (0.9)	-0.6 to 0.4	-0.7 (1.0)	-1.2 to -0.3	0.049	0.94	0.43
Waist (cm)	0.2 (1.5)	-0.6 to 0.1	-1.9 (1.7)	-2.8 to -1.0	<0.001	1	0.59
Waist-to-height ratio	0.00 (0.01)	-0.01 to 0.01	-0.01 (0.01)	-0.02 to -0.01	0.002	1	0.52
BFM: Body Fat Mass; LTM: Lean Tissue Mass; TBW: Total Body Water; FM: Fat Mass							

Table 3: Effects of the basal and diet phases on body mass and body composition. Data are mean (SD)

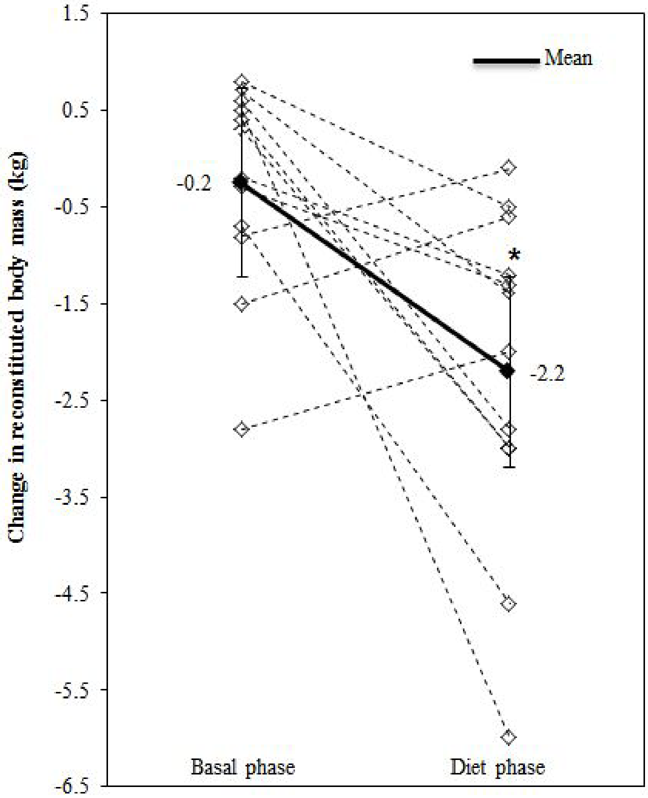

Figure 4: Individual and mean (SE) reconstituted body mass changes (kg) in men in response to the basal and diet phases (n = 12). Significantly different from the basal phase: $*p < 0.001$

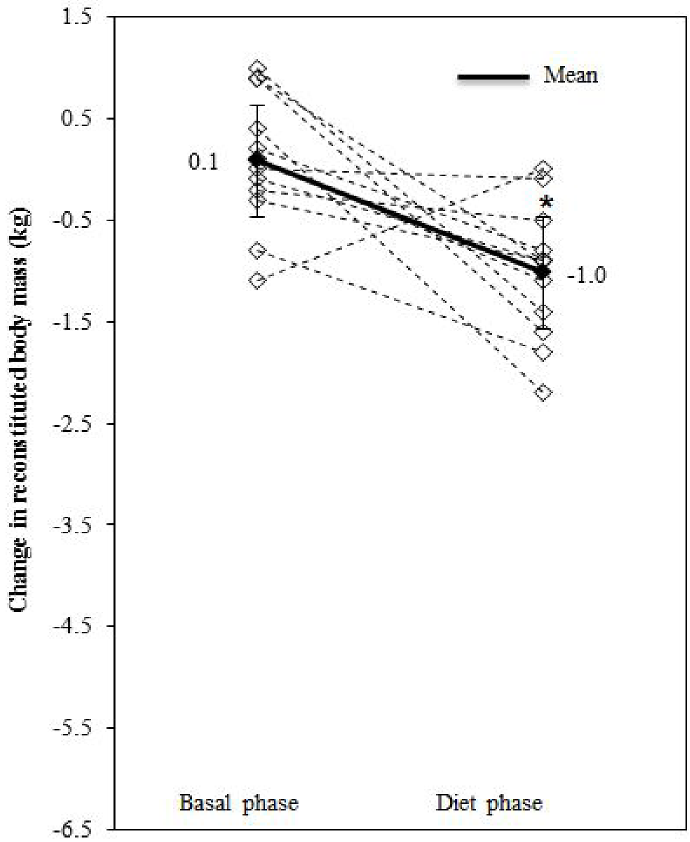

Figure 5: Individual and mean (SE) reconstituted body mass changes (kg) in women in response to the basal and diet phases (n = 12). Significantly different from the basal phase: $*p < 0.001$

Effect of the Basal and Diet Phases on Biomarkers of Metabolic Health

The response of the biomarkers of metabolic health to the diet phase is shown in Table 4.

	Basal phase	95% CI	Diet phase	95% CI	*P*-value	Power	Effect Size
Plasma Total Cholesterol (mmol/L)	-0.2 (0.5)	-0.4 to 0.1	-0.1 (0.5)	-0.4 to 0.2	1.000	0.5	0.22
Plasma HDL Cholesterol (mmol/L)	-0.1 (0.2)	-0.2 to 0.02	-0.1 (0.1)	-0.3 to -0.01	0.215	0.65	0.29
Plasma LDL Cholesterol (mmol/L)	-0.1 (0.4)	-0.3 to 0.1	-0.01 (0.5)	-0.3 to 0.2	1.000	0.14	0.06
Plasma Total: HDL Cholesterol	0.02 (0.4)	-0.2 to 0.3	0.1 (0.5)	-0.2 to 0.4	1.000	0.14	0.06
TAG (mmol/L)	0.1 (0.4)	-0.1 to 0.4	-0.3 (0.7)	-0.7 to 0.1	0.111	0.43	0.19
HOMA	-0.1 (0.4)	-0.3 to 0.1	0.02 (0.6)	-0.3 to 0.3	1.000	0.24	0.1
Leptin (ng/ml)*	0.1 (7.1)	-6.8 to 3.6	-3.7 (8.1)	-10.0 to -1.0	0.020	0.82	0.37
Adiponectin (ng/ml)*	-221 (1871)	-2089 to 619	-738 (1876)	-1836 to 570	0.029	0.63	0.28
Significantly different to the basal phase: *$p < 0.001$							

Table 4: Effects of the basal and diet phases on biomarkers of metabolic health. Data are mean (SD)

During the basal phase there were no statistically significant changes in any of the variables. We did not find significant reductions in plasma total, HDL, LDL cholesterol, TAG or HOMA during the basal or diet phases however during the diet phase there were significant reductions in leptin and adiponectin.

Discussion

The present study aimed to evaluate the effect of the Special K Challenge on reported energy intake; body composition and biomarkers of metabolic risk. We found that the Special K Challenge reduced the total reported energy intake by a mean of 673 (360)kcal/day and therefore achieved the target of 600kcal/d set by the NICE guidelines. This reduction came predominantly from a reduction in fat intake. The low fat content of the cereal and the semi-skimmed milk (0.5g and ~2g per serving respectively) led to a 50% reduction (40g) in the mean total fat intake during the Special K Challenge. To a lesser extent, the reduction in reported energy intake came from a 20 and 23% reduction in carbohydrate and protein intake respectively. The role and significance of a high protein intake during dietary interventions for the maintenance of lean tissue has previously been demonstrated [23] and therefore the reduction in protein intake in the present study may have been a contributing factor to the reduction in lean mass.

During the basal phase of the intervention the mean intake of sodium exceeded the recommended daily allowance (RDA) [24] of 1600mg by approximately 1300mg. Meal replacements have been criticized for their high salt content [5] however the present study found that the Special K Challenge resulted in a 30% reduction in mean sodium intake. There was a less favourable reduction in mean calcium intake which was reduced from 932mg to 687mg, marginally below the UK RNI of 700mg/d for adults [25]. This result was not anticipated as the Special K Challenge requires the daily addition of milk at two meals and is therefore most likely due to the small portion size.

Whilst underreporting of energy intake is a limitation in dietary interventions the findings of the present study support conclusions drawn in previous research using the same diet in a similar population group and are representative for the mean reported energy intake of the Irish population as reported by the Irish Universities Nutrition Alliance [7,14,26].

A novel feature of the present study was the analysis of meal compositions of individuals. The Special K Challenge led to significant reductions in reported energy and fat intake at breakfast, lunch and during snacking but no change during dinner. It may be assumed that a lower reported energy intake at breakfast and lunch may result in overcompensation during dinner; however the present study found that the Special K Challenge was effective as a partial meal replacement diet by reducing energy intake at two main meals but appearing to have no influence on the third main meal. The recommended inclusion of Special K snacks led to a further significant reduction in reported energy intake from snacking (135 (239)kcal) equating to approximately 20% of the total energy reduction.

Body mass was reduced by a mean of 1.6 (1.4)kg (Range -6.0 to 0.0kg) in response to the Special K Challenge. Our findings agree with those reported in previous interventions [7,14] that report a mean reduction in body mass of 2.0kg (Range 0.2 to 4.6kg) and 1.9 (0.19)kg (Range -4.2 to -0.1kg) respectively where the meal replacements were the same. Our results were also consistent with the UK's NHS recommendation of a reduction in 600kcal for a reduction of 0.5-1.0kg body mass, for most participants [4].

In the present study the Special K Challenge led to a statistically significant -0.7 (0.8)kg (Range -2.8 to 0.6kg) reduction in body fat mass. This reduction represented up to 10% of total body fat mass in some participants. The inter-individual variability in body mass reduction in response to the Special K Challenge can be caused by differences in baseline body composition and energy expenditure. Those with higher baseline fat tissue mass will expend a greater proportion of net energy deficit towards loss of body fat mass versus lean tissue mass than do those with lower baseline body fat mass [27]. In a review of several body mass reduction programmes in the UK, a comparable meal replacement diet (SlimFast) led to a 2.3kg reduction in body fat mass after 8 weeks [10]. Therefore, the 2 week duration of the Special K Challenge may be too short to cause clinically significant reductions in body fat mass as reduction in fat mass during the first few days of energy restriction is minimal and increases as the reduction in lean mass begins to cease [28].

Irrespective of total body fat mass, excess abdominal fat presents a higher risk for the development of the metabolic syndrome [29]. The Special K Challenge was found to be effective in significantly reducing abdominal fat when measured by waist circumference, waist-to-height ratio and DXA. Approximately 20% of the reduction in fat tissue mass occurred within the abdomen.

A secondary aim of the present study was to evaluate the effects of the Special K Challenge on blood lipid biomarkers. It was hypothesized that a reduction in fat intake would result in reductions in plasma total, LDL, and HDL cholesterol and TAGs however we found no significant effect on biomarkers of metabolic risk. The efficacy of meal replacements was reviewed in a meta-analysis and was found to be effective in improving blood lipid biomarkers and reducing the risk of the metabolic syndrome after 12 weeks [13]. The 14 day duration of the Special K Challenge may not, therefore be sufficient to effect a significant change in biomarkers of metabolic risk. Furthermore, the small sample size is a limitation of this study.

Conclusion

In conclusion, the Special K Challenge was found to be effective in reducing body mass, total and regional fat mass and waist circumference through a reduction in total energy and fat intake in accordance with international guidelines for body mass reduction but did not confer significant reduction in biomarkers of metabolic risk in these subjects.

Acknowledgement

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