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Dietary patterns and fatigue in female slimmers

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Abstract

Purpose – This paper aims to understand the association of dietary patterns with perceived fatigue and identify predictors for presence of fatigue in women who are obese and trying to lose weight.

Design/methodology/approach – An online survey, hosted by Slimming World (SW), compromised of questionnaire regarding weight, level of fatigue and food frequency questionnaire before joining the weight management programme (T0) and current data (T1) was conducted. 543 non-pregnant women with obesity of child-bearing age (19-49 years) completed the survey (T0-T1). Principal components analysis was used to determine dietary patterns and multinomial logistic regression was used to analyse predictors for presence of fatigue.

Findings – Participants who have a “carbohydrate and high fat” dietary pattern were more likely to have fatigue at T0 ($p \leq 0.001$) and those who followed a “vegetables” dietary pattern were less likely to have fatigue at T1 ($p \leq 0.05$). Study findings indicate that whilst “carbohydrate and high fat” dietary pattern was associated with increased risk of fatigue, “vegetables” dietary pattern was associated with reduced risk of fatigue and higher percentage of weight loss.

Originality/value – The present study appears to be the first study to examine associations between dietary patterns and fatigue. The strengths of the study included the in-depth analysis of this association in both before joining a weight management programme (SW) and currently as member of SW with an adequate sample size.

Keywords Dietary pattern, fatigue, weight management, principal component analysis

Paper type Research paper

1.1 Introduction

Fatigue is defined as a subjective feeling of physical and/or mental tiredness (Vgontzas et al., 2006). An elevated body mass index is a risk factor for fatigue (Lafortuna et al., 2013). High levels of both physical and mental fatigue were observed in women who were severely obese (Gletsu-Miller et al., 2019). Valentine et al. (2009) found that fatigue was more prevalent in women than men independent of levels of inflammation, depression, physical activity and adiposity, and not significantly associated with global sleep quality in women or men. However, in a more recent narrative review, Cooper et al. (2018) reported that the bidirectional link between sleep deprivation and obesity might be associated with increased fatigue in people who are obese. Greater levels of fatigue in women who are obese might also be associated with a high prevalence of iron deficiency anaemia in obesity (Cepeda-Lopez et al., 2011).

In a weight-loss intervention study, Schrepf et al. (2017) explored the effects of a low-energy diet on pain, symptom severity (including fatigue and sleep difficulties), inflammation and depression in adults. It was shown that weight loss has the potential to improve levels of fatigue, metabolic parameters and inflammatory markers. A greater improvement was observed in people who lost at least 10% of body weight compared to those who lost less than 10%.

Fatigue is a critical obstacle for both sufficient physical activity and desire to make lifestyle changes. There is an inverse relationship between fatigue and physical activity (Kowal & Fortier, 2007; Ellingson et al., 2014). Tiredness and fatigue (20%) was identified as the fourth most common barrier to making lifestyle changes after lack of time (62.1%), environmental constraints (31.6%) and lack of motivation or laziness

(25.3%) (Timmerman, 1999). A cross sectional study (Boolani et al., 2019) reported that predictors of levels of perceived energy were not same as predictors of fatigue with the exception of sleep quality. Whilst sedentary behaviour and perceived mental workload were significant predictors of fatigue, higher muscle oxygen saturation and lower resting metabolic rate were significant predictors of levels of energy. Interventions which reduce levels of fatigue could be important in supporting long-term weight management by contributing to increased physical activity levels or reduced sedentary behaviour.

An energy imbalance between intake and expenditure is the main cause of overweight and obesity (WHO, 2018). Changes in the food supply towards highly-processed, energy-dense and nutrient-poor products is closely related with increased global obesity prevalence (Crino *et al.*, 2015). Although there is some evidence reporting the association between body mass index and fatigue (Lafortuna et al., 2013; Lima et al., 2019; Gletsu-Miller et al., 2019), there is limited evidence about the influence of general dietary patterns on fatigue. The majority of studies in this field are restricted to the effect of carbohydrate and fat on postprandial ratings of fatigue (Pasman et al., 2003; Lehrskov, et al., 2018). A randomised, cross-over trial (Pasman et al., 2003) showed that fatigue was reported by healthy male subjects to be higher three hours after the consumption of a breakfast containing simple carbohydrates compared to a breakfast containing complex carbohydrates. In another study (Wells et al., 1997), healthy female and male subjects reported a higher level of fatigue three hours after the consumption of a high-fat–low-carbohydrate than after the low-fat–high-carbohydrate meal. A double-blind, crossover study (Lehrskov et al., 2018) reported that postprandial fatigue due to an energy dense meal (high-fat, high-carbohydrate) is regulated by interleukin-1 (IL-1) with a more pronounced effect in adults who are obese.

Slimming World (SW) is a UK-based commercial weight management organisation, founded in 1969. Currently, there are over 19,000 groups held weekly around the UK and Ireland with further online support available. Each week approximately 900,000 members attend the groups, around 94% of whom are adult females. The SW programme uses a multi-component approach with three key under-pinning principles: nutrition, exercise and the psychology of behaviour change (Slimming World, 2018). The dietary approach of the programme promotes weight loss by encouraging the consumption of low energy dense foods with a high nutritional and satiety value which supports long-term appetite regulation (Buckland et al., 2018) whilst ensuring members are meeting their overall nutritional requirements. Members are encouraged to gradually increase their levels of physical activity.

This study investigates the short-term effects of a weight management programme (SW) on weight loss, levels of physical activity and fatigue with the aim to understand the association of dietary patterns with fatigue and identify predictors for presence of fatigue in women who are obese.

1.2 Methods

1.2.1 Study design and participants

This study data was collected in the UK between May 2016 and November 2016. An online questionnaire, using non-stigmatising language, was developed using questions from the Multidimensional Assessment of Fatigue (Belza et al., 1992) and iron food frequency questionnaire (FeFFQ) (Beck et al., 2012). Permission was obtained from both principal investigators to use each of the questionnaires. Questions were also included about participants' age, smoking status, number of pregnancies and general women's health and well-being. The survey was uploaded using the

Bristol Online Survey tool. Non-pregnant women with obesity, of child-bearing age (19-49 years) were invited to participate in the study if they had recently (less than eight weeks) joined Slimming World (SW). Ethical approval was granted by the University of Nottingham (SBREC150132A).

The link for the online survey was available on the SW member's web site for two weeks at the beginning of the data collection period. The survey collected baseline data (T0) (self-reported data for before they joined) and data representing that time-point (T1) following their recent engagement with the SW programme. Since women who had joined SW within the last seven weeks participated in the study, the minimum time interval between T0 and T1 was 1 week and the maximum was 7 weeks.

1.2.1.1 Characteristics of participants

Eight hundred and twenty-five SW members completed the online survey with 282 excluded from the analysis because; 257 women were ≥50 years old, 3 women were ≤18 years old and 22 women joined SW ≥8 weeks ago. 543 participants were eligible for data analysis at T0 and T1.

The characteristics of the 543 participants are presented in Table 1. The majority of women (mean age 37 years) were non-smokers, eating a variety of all foods including animal products, healthy with no/little chronic disease, pre-menopausal and having moderate period losses with a period duration of approximately five days. Approximately one-third of women experienced low iron stores, iron deficiency or iron deficiency anaemia. The majority had experienced one full-term pregnancy.

1.2.2 Questionnaires and measures

1.2.2.1 Weight, height and body mass index: Height was self-reported as feet and inches or centimeters and body weight was self-reported as stones and pounds or in kilograms. Microsoft Excel (2016) was used to convert the weights which were in stones and pounds into kilograms and the heights which were in feet and inches into meters. Body mass index was calculated as weight (kg)/ the square of height (m) for the two time periods (T0 and T1).

1.2.2.2 Global fatigue index (GFI): The Multidimensional Assessment of Fatigue (MAF) is a self-administrated questionnaire. The MAF was developed for research purposes and revised from the Piper Fatigue Scale (Piper et al., 1989). The MAF measure four dimensions of fatigue with 16 items: degree and severity (items 1,2), amount of distress it causes (item 3), the degree to which fatigue interferes with activities of daily living including household chores, cooking, bathing, dressing, working, socializing, sexual activity, leisure/recreational, shopping, and walking (items 4-14), and timing (items 15,16). Respondents were asked to express their fatigue patterns for the past week. Numerical rating scale was 1-10 for item 1-14 and responses were categorical (from every day to hardly any days) for item 15. Because only the first 15 items are used to calculate the GFI, the 16th item which asks if it changed over the past week was not included in the survey (T0 and T1).

In order to calculate GFI, each score for item 15 was multiplied by 2.5 and converted to a 0-10 scale. Items 1,2, and 3, average of items 4-14, and newly scored item 15 was summed. If respondents reported that they “do not do any activity for reasons other than fatigue”, a score to items was not assigned. If respondents reported “no fatigue” on item 1, a zero to items 2-15 was assigned. For GFI, score range was 1-50 (1= no fatigue, 50= severe fatigue) (Neuberger, 2003).

Presence of fatigue

A cut-off score was used to discriminate between cases and non-cases for presence of fatigue. Although GFI has been used to define fatigue level in a diverse range of disease states and healthy populations, a specified cut-off score for women of child-bearing age did not exist. Hence, in our study, a cut-off score was determined based on the studies with the most similar study populations (Anandacoomarasamy et al., 2009; Thorp et al., 2014). Belza et al. (1995) was also considered given their work was instrumental in developing and validating the MAF. These studies enabled us to identify a cut-off score between 25 and 30, with a score of 28 for our GFI determined.

1.2.2.3 Food frequency questionnaire (FFQ): Participants completed an iron food frequency questionnaire (FeFFQ) (Beck et al., 2012) for both T0 and T1 to determine dietary patterns at each time-point. The questionnaire was divided in two parts. The first part was a quantitative FFQ that contained 144 food groupings (each corresponding to a single question) divided into the following 15 food categories: meat, fish and chicken; prepared meat; seafood; fruit; vegetables; legumes; breakfast cereals; breads, cakes, biscuits and crackers; grains; dairy products; eggs; nuts; miscellaneous foods and snacks; alcohol; and non-alcoholic beverages. The purpose of this part of the questionnaire was to get an idea on the overall consumption pattern of the participants. In order to define certain clusters of food consumption, participants were asked how often they consumed items from each food grouping. Suggested portion sizes were included for each food groupings. Options for frequency of intake included never or less than once per month, one to three times per month, once per week, two to three times per week, four to six times per week, once per day, two to three times per day, and four plus times per day. The second part of the iron-questionnaire focused on food habits/behaviour. This part enabled the researchers to gain more information on how the participants consume the different food items that were included in the first part.

Responses from the FeFFQ were converted into eight frequencies of intake per week for each food grouping for each participant, ranging from zero to 28 times eaten per week. The average weekly consumption of each food grouping was determined.

1.2.2.4 Physical activity (PA): The short form of the International Physical Activity Questionnaire (IPAQ) was used to assess participants' physical activity levels. The questionnaire includes seven questions record the activity at four levels (vigorous-intensity activity, moderate-intensity, walking, and sitting). Total physical activity Metabolic Equivalent of Task (MET)-minutes/week were obtained from the questionnaire.

1.2.3 Statistical Analysis

Analysis were conducted using the Statistical Package for the Social Sciences, SPSS version 22.0 for Windows with statistical significance assumed at $p \leq 0.05$.

1.2.3.1 Determination of dietary patterns

The 35 most frequently consumed food groupings (as number of times consumed per week) were identified for use in factor extraction. Factor extraction is a technique which allows the researcher to determine the smallest number of factors that can be used to best represent the interrelationships among the set of variables. Principal components analysis (PCA) is the most commonly used approach for factor extraction (Pallant, 2016). There are two conflicting needs to balance while determining the number of factors: the need to find a simple solution with as few factors as possible; and the need to explain as much of the variance in the original data set as possible (Pallant, 2016). First, the Kaiser-Meyer-Olkin Measure of Sampling Adequacy (KMO) value was checked to verify if the data set was suitable for factor analysis. To determine how many components (factors) to 'extract', three different techniques (Kaiser's criterion, scree test and parallel analysis) were interpreted.

1.2.3.1.1 Kaiser's criterion

This is also known as the eigenvalue rule and according to this, only components that have an eigenvalue of 1 or more should be considered. Each eigenvalue represents the amount of variance that has been captured by one component (Wuensch, 2012)

1.2.3.1.2 Scree test

The scree test involves plotting each of the eigenvalues of the factors and inspecting the plot to find a point at which the shape of the curve changes direction and becomes horizontal (Pallant, 2013). Catell (1966) suggested that all factors above the elbow or break in the plot must be retained because these factors contribute the most to the explanation of the variance in the data set.

1.2.3.1.3 Parallel analysis

Horn's parallel analysis (Horn, 1965) is an additional technique to identify the correct number of factors to retain. In order to carry out parallel analysis, another statistical program (developed by Watkins, 2000) that is called Monte Carlo PCA for Parallel Analysis was used. The programme generated 100 sets of random data of the same size as the real data file and calculated the average eigenvalues for these 100 randomly generated samples. The size of the eigenvalues was compared with those obtained from a randomly generated data set of the same size. Only those eigenvalues that exceed the corresponding values from the random data set were retained

1.2.3.2 Dietary patterns and presence of fatigue

A dietary pattern score was created for each individual for each dietary pattern by using component scores. These scores were divided into quintiles. The higher dietary pattern scores (and thus higher quintile) were indicative of higher adherence of that particular dietary pattern. The quintiles were used to understand the relationship between these dietary patterns and presence of fatigue. Also, differences in the mean age and BMI for the lowest (quintile 1) and the highest (quintile 5) quintiles for the dietary patterns at T0 and T1 were investigated by applying independent-samples t test or chi-square test.

Predictors of fatigue

A multinomial logistic regression was used to analyse predictors for presence of fatigue. The reference category was "no fatigue" (GFI<28); "presence of fatigue" (GFI≥28) was compared to this reference group. The main interest of current analysis was focusing on the association of age and BMI with fatigue while controlling for dietary patterns.

1.3 Results

1.3.1 Changes in BMI, GFI and PA from T0 to T1

Mean time interval between T0 and T1 was 2.5 weeks with the minimum 1 week and the maximum 7 weeks. Both mean BMI and GFI decreased from T0 to T1 (BMI: 35.0±7.1 vs 34.1±6.9 kg/m^2, $p<0.001$; GFI: 29.2±12.8 vs 21.8±11.8, $p<0.001$). Mean total PA increased from T0 to T1 (1335.1±2506.9 to 3000.2±3762.4 MET-minutes/week, p<0.001).

1.3.2 Dietary patterns

The 35 most frequently consumed food groupings were identified at T0 and T1 for use in the PCA. Prior to performing PCA, the suitability of data for factor analysis was assessed and verified by the KMO value (0.747 at T0 and 0.730 at T1) and Barlett's Test p value (0.001 at T0 and T1).

PCA revealed that the presence of eleven components at T0 and fourteen components at T1 with eigenvalue exceeding 1. Interpretation of scree test and parallel analysis for both T0 and T1 suggested retaining five components for further investigation.

In order to make an easier interpretation, rotation -defined as an important and necessary step in the PCA because the factors generated by the initial unrotated solution tend to be arbitrary uninterpretable linear combinations of the true latent variables (Dien, 2010)- was applied and the factor structure were simplified. The 35 most frequently consumed food groupings were considered with the factor loadings for each dietary pattern and five dietary patterns were labelled as follows:

1.3.2.1 Dietary patterns at T0

1) Simple carbohydrate and high fat: Milk chocolate; biscuits, chocolate or chocolate covered; potato crisps; biscuits, plain sweet; cakes; white bread and rolls; butter or margarine; potato; hard cheese; crackers; cooking oil (all varieties)

2) Savoury staples: Potato; onions (all varieties), leeks, celery; peppers (all varieties); onions (all varieties), leeks, celery; lettuce; mushrooms; carrots; cooking oil (all varieties); herbal tea, fruit tea; eggs
3) Healthy snacks: Biscuits, plain sweet; crackers; herbal tea, fruit tea; bananas, green bananas; strawberries, blackberries, cherries, blueberries, boysenberries, loganberries, cranberries, gooseberries, raspberries; citrus fruits; apples; yoghurt; eggs; milk (cow's milk) (all varieties) added to food
4) Animal proteins and sugary drinks: Beef; chicken, turkey or duck; ham, bacon; eggs; cordials (including syrups, powders)
5) Coffee and extras: Butter or margarine; milk (cow's milk) (all varieties) added to drinks; coffee (all varieties); milk (cow's milk) (all varieties) added to food; sugar (all varieties)

1.3.2.2 Dietary patterns at T1

1) Vegetables: Onions (all varieties), leeks, celery; beetroot, radishes (all varieties); lettuce; green beans, broad beans, runner beans, asparagus; tomatoes (all varieties); carrots; peppers (all varieties); courgette, zucchini, cucumber, gherkins or marrow (all varieties); broccoli (all varieties); spinach, silver beet, swiss chard (all varieties); peas, green; mushrooms
2) Fruits and yoghurt: Tomatoes (all varieties); grapes; citrus fruits; strawberries, blackberries, cherries, blueberries, boysenberries, loganberries, cranberries, gooseberries, raspberries; bananas, green bananas; pears; apples; stone fruit; yoghurt
3) Healthy carbohydrate and eggs: Beans in sauce; potato; eggs; pasta, noodles (white); peas, green; mushrooms

4) Coffee and extras: Milk (cow's milk) (all varieties) added to drinks; black tea; coffee (all varieties); milk (cow's milk) (all varieties) added to food
5) Animal proteins and healthier beverages: Chicken, turkey or duck; beef; ham, bacon; herbal tea, fruit tea

1.3.2.3 Associations of dietary patterns with BMI and presence of fatigue at T0 and T1

The results indicated that at T0, participants in the highest quintile for the "savoury staples", "healthy snacks" and "coffee and extras" dietary patterns were significantly older than those in quintile one. In terms of BMI, participants in the highest quintile for the "simple carbohydrate and high fat" and "animal proteins and sugary drinks" dietary patterns had significantly higher BMI than those in quintile one. Regarding fatigue, participants in the highest quintile for the "simple carbohydrate and high fat" were more likely to have fatigue than those in quintile one ($p \leq 0.001$). There were no significant differences in percentage of fatigue between quintiles one and five for the "savoury staples", "healthy snacks", "animal proteins and sugary drinks" and "coffee and extras" dietary patterns (table 2).

At T1, analysis of independent-samples t test or chi-square test revealed that participants in the highest quintile for the "vegetables" and "coffee and extras" dietary patterns were significantly older than those in quintile one. However, participants in the highest quintile for the "animal proteins and healthier beverages" dietary pattern were significantly younger than those in quintile one. In terms of BMI, although participants in the highest quintile for the "healthy carbohydrate and eggs" dietary pattern had significantly higher BMI than those in quintile one, participants in the highest quintile for the "coffee and extras" dietary pattern had significantly lower BMI than those in quintile one. Regarding fatigue, participants in the highest quintile for the "vegetables" were less likely to have fatigue than those in quintile one. Participants in the highest quintile for the "vegetables" dietary pattern lost significantly more weight from T0 to T1 than those in quintile one (table 3).

1.3.3 Predictors of fatigue at T0 and T1

Analysis of multinomial logistic regression suggested that age and BMI had no significant effect on presence of fatigue at T0. The probability of fatigue was significantly increased by the "simple carbohydrate and high fat" dietary pattern (OR=1.6, p=0.001). Other dietary patterns were not significant predictors of fatigue at T0 (table 4).

Higher BMI (OR=1.05) increased the probability of fatigue at T1 (p=0.05) and the probability of fatigue was significantly decreased by the "vegetables" dietary pattern (OR=.719, p=0.01). Other dietary patterns were not significant predictors of fatigue at T1 (table 4).

1.4 Discussion

This study explored the changes in levels of fatigue, weight, reported as BMI changes, and physical activity in non-pregnant women with obesity who had recently joined SW. The mean GFI of the females before joining was 29.2, with 60.5% fatigued, and a mean BMI of 35.0 kg/m^2. Improvements were seen across all of the key reported outcomes with a mean GFI after joining SW of 21.8, with only 31.4% reporting levels of fatigue and the mean BMI reduced to 34.1 kg/m^2. Physical activity level increased significantly in the relatively short period of time. Our results are in agreement with a six month intervention of physical activity support treatment paired with cognitive-behavioural nutrition for weight loss which showed significant improvements in fatigue ($F=133.35$, $p<0.001$, $\eta^2_p =.450$) (Annesi *et al*., 2015). These findings are suggestive of a complex interaction between physical activity, weight loss and fatigue. Whilst women who feel less fatigued are likely to become more physically active, women who are more physically active might feel less fatigued.

A high prevalence of fatigue in obese subjects reported in studies conducted in Switzerland (Galland-Decker et al., 2019), in the USA (Resnick et al., 2006) and in the UK (Basu et al., 2016). Our reported prevalence of fatigue was in accord with a study (Impellizzer *et al*., 2013) indicating that the prevalence of fatigue in adults who are obese (n=220, mean BMI=44.4 kg/m^2) was 59%. Impellizzer *et al.* (2013) used the Fatigue Severity Scale to examine fatigue. The different fatigue scales prevent a fair comparison of prevalence of fatigue. A high level of fatigue in women who are obese might be related to the excessive adipose tissue. Mehta (2015) reported that adiposity accelerates the development of stress-related neuromuscular fatigue. In an experimental study by Maffiuletti et al. (2007), muscle strength and,3 fatigue were compared between individuals with obesity (n=10, mean BMI=41 kg/m^2) and healthy weight individuals (n=10, mean BMI=23 kg/m^2). Quantification of voluntary fatigue and relative strength indicated that quadriceps muscle function impairments were observed in people who are obese. It was suggested that this can contribute to the reduced functional capacity of individuals who are obese during daily-life activities and higher physiological demanding activities such as stair climbing and uphill walking.

Fatigue is one of the most frequent nonspecific symptoms of inflammation and it is promoted by the increased production of acute-phase proteins and cytokines such as CRP, IL-6 and TNF-α in metabolic disorders, including obesity, type 2 diabetes and the metabolic syndrome (Lasselin & Capuron, 2014). In terms of the relationship between the identified dietary patterns and presence of fatigue (GFI≥28), participants who follow a "simple carbohydrate and high fat" dietary pattern were more likely to have fatigue at T0 and those who followed a "vegetables" dietary pattern were less likely to have fatigue at T1. Whilst energy-dense foods in the "simple carbohydrate and high fat" dietary pattern may lead to increase inflammation due to oxidative stress (Lüscher, 2015), the high content of dietary fibre and antioxidants in the "vegetables" dietary pattern might be related to reduced inflammation (Jiao *et al.*, 2015; Chaiyasit *et al.*, 2005). A recent study (Tayyem et al, 2019) found a link between 'fast food dietary pattern' which contains high carbohydrate and fat foods (e.g. falafel, mayonnaise and processed meat) and the risk of metabolic syndrome. A meta-analysis (Varkaneh et al., 2018) reported that consumption of foods with high dietary inflammatory index score (evaluation of properties of the diet regarding pro-inflammatory and anti-inflammatory content) was related to increased BMI and obesity.

The inverse relationship between “vegetables” dietary pattern and level of fatigue may partly be explained by high content of prebiotic fibre in vegetables. Because prebiotic intake increases bioavailability of haem iron (Weinborn *et al*., 2017), it may lead to a reduction in fatigue levels in iron deficient women who are obese. The associations which have been described above might also explain that mean percentage of weight loss from T0 to T1 was higher in participants in the highest quintile for the “vegetables” dietary pattern than those in quintile one.

In a randomised exercise study (Guest et al., 2013), the relationship between dietary intake and fatigue were determined in breast cancer survivors (n=42). Results from 3-day diet records and Functional Assessment of Cancer Therapy for fatigue showed that there was a positive correlation between fatigue and percentage of energy intake from fat per day ($r = 0.31$, $p < 0.05$) and a negative correlation between fatigue and dietary fibre intake (g) per day ($r = -0.38$, $p < 0.05$).

This study supports the importance of multi-component weight management interventions that include promoting healthier eating and physical activity, and behavioural change techniques which not only focus on weight loss but also psychosocial health. Since fatigue in people who are obese may lead to a lack of motivation to do exercise and make lifestyle changes, decreasing fatigue levels in a relatively short period of time by a multi-component weight management intervention could help people overcome these barriers. This study also successfully demonstrated, for the first time, the association of dietary patterns with fatigue and predictors for presence of fatigue in women who are obese. The strengths of the study included the in-depth analysis of this association both before joining a weight management programme (SW) and currently as member of SW with an adequate sample size.

However, the study suffers from an over-reliance on self-report methodology. Another weakness of this study was the paucity of data on sleep quality and total energy intake. Although SW provides guidance on the importance of healthy sleep patterns as part of the multi-component weight management approach, data about sleep quality or quantity was not collected. In terms of energy intake, since the FFQ was validated to identify dietary patterns, energy intake was not obtained from the questionnaire. Further studies are required to shed light on energy intake and sleep quality as underlying factors of fatigue. Another source of uncertainty is that the study findings reflect short-term observation. Therefore, large randomised controlled trials are needed to determine the effects of these changes in a longer period to understand reality and sustainability of these changes.

1.5 Conclusion

The weight management intervention resulted in mean weight losses and increases in physical activity levels over a relatively short period of time. The study set out to examine the association between dietary patterns and fatigue in women who are obese and trying to lose weight. Principal component analysis revealed that whilst "simple carbohydrate and high fat" dietary pattern was associated with increased risk of fatigue, a "vegetables" dietary pattern was associated with reduced risk of fatigue and higher percentage of weight loss.

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Table 1. Characteristics of the study population (n=543).

Mean age (years)	36.7 ± 8.4*
Mean number of weeks as a SW member	2.5 ± 1.4*
Weight measurement method (%)	
Measured on scales at SW group	89.0
Bathroom scales	8.4
Smoking status (%)	
Yes	10.2
No	68.9
An ex-smoker	20.5
Eating pattern (%)	
Eat a variety of all foods, including animal products	87.1
Eat eggs, dairy, fish and chicken but avoid other meats	2.3
Eat eggs but avoid dairy products, all meats and fish (ovo-vegetarian)	0.8
Eat dairy products but avoid eggs, all meats and fish (lacto-vegetarian)	0.0
Eat eggs and dairy but avoid all meats and fish (ovo-lacto vegetarian)	2.5
Eat no animal products including eggs, dairy, and honey (vegan)	1.6
Eat fish or other sea food but avoid all other meats (pescatarian)	2.3
Other	3.3
Acute or chronic illness status (%)	
Yes	13.9
No	85.3
Low iron stores, ID or IDA status (%)	
Yes	37.8
No	52.1
Receiving a treatment for ID or IDA (%)	
Yes	36.9
No	59.8
Number of full-term pregnancies	1.26 ± 1.3*
Post-menopausal status (%)	
Yes	6.5
No	92.6
Prefer not to answer	1.6

Notes: *Age, number of weeks as a Slimming World (SW) member and number of full-term pregnancies are presented as mean ± standard deviation (SD).

Table 2. Characteristics of participants with dietary pattern scores in the lowest (quintile 1) and in the highest (quintile 5) quintiles for the five dietary patterns at T0

	Age (years)	BMI (kg/m²)	Presence of fatigue (GFI≥28) n (%)
DP1: Simple carbohydrate and high fat			
Quintile 1	84 | 37.7 ± 8.9	84 | 32.6 ± 6.0 ⁺	41 (46.6) ⁺
Quintile 5	83 | 36.8 ± 8.1	83 | 38.3 ± 7.3 ⁺	69 (77.5) ⁺
DP2: Savoury staples			
Quintile 1	85 | 35.2 ± 8.7 *	86 | 35.9 ± 7.3	61 (69.3)
Quintile 5	78 | 38.3 ± 7.6 *	79 | 34.0 ± 7.3	56 (62.9)
DP3: Healthy snacks			
Quintile 1	82 | 35.4 ± 8.5 ⁺	84 | 36.1 ± 8.1	54 (60.0)
Quintile 5	81 | 39.7 ± 7.1 ⁺	79 | 34.7 ± 6.8	56 (64.4)
DP4: Animal proteins and sugary drinks			
Quintile 1	80 | 39.0 ± 8.0 *	81 | 34.1 ± 6.5 *	55 (62.5)
Quintile 5	87 | 35.2 ± 9.1 *	87 | 37.3 ± 7.5 *	55 (62.5)
DP5: Coffee and extras			
Quintile 1	82 | 33.2 ± 8.5 ⁺	83 | 36.9 ± 8.2	56 (64.4)
Quintile 5	83 | 38.6 ± 8.0 ⁺	82 | 34.9 ± 7.1	59 (66.3)

Notes: BMI, Body Mass Index; GFI, Global Fatigue Index; DP, Dietary pattern

Independent-samples t test or chi-square test were applied to explore differences in the mean age and BMI for the lowest and the highest quintiles for the dietary patterns.

Significance is at p-value ≤ 0.05 (*) and ≤0.001 (⁺). Data are presented as number | mean ± standard deviation (SD). Presence of fatigue are presented as number (percentage).

Table 3. Characteristics of participants with dietary pattern scores in the lowest (quintile 1) and in the highest (quintile 5) quintiles for the five dietary patterns at T1

	Age (years)	BMI (kg/m²)	Presence of fatigue (GFI≥28) n (%)	Mean percentage of weight loss between T0 and T1
DP1: Vegetables				
Quintile 1	79 | 35.6 ± 8.9 *	81 | 34.6 ± 7.4	36 (44.4) *	81 | 1.9 ± 1.7 ⁺
Quintile 5	78 | 38.8 ± 7.9 *	78 | 33.2 ± 6.5	20 (25.0) *	77 | 3.2 ± 2.2 ⁺
DP2: Fruits and yoghurt				
Quintile 1	80 | 35.3 ± 8.6	80 | 34.9 ± 7.0	30 (36.6)	80 | 2.9 ± 4.8
Quintile 5	80 | 37.2 ± 8.0	80 | 34.8 ± 6.5	27 (33.3)	79 | 2.8 ± 1.9
DP3: Healthy carbohydrate and eggs				
Quintile 1	73 | 37.8 ± 8.2	75 | 32.3 ± 6.6 *	21 (26.2)	75 | 2.9 ± 2.0
Quintile 5	79 | 35.8 ± 8.6	78 | 35.1 ± 7.9 *	21 (25.9)	77 | 2.6 ± 2.2
DP4: Coffee and extras				
Quintile 1	78 | 32.77 ± 8.3 ⁺	77 | 36.7 ± 7.4 ⁺	27 (33.3)	76 | 2.5 ± 2.2
Quintile 5	76 | 39.96 ± 7.2 ⁺	76 | 32.6 ± 6.2 ⁺	31 (37.8)	75 | 2.9 ± 4.7
DP5: Animal proteins and healthier beverages				
Quintile 1	81 | 38.3 ± 8.0 *	81 | 34.2 ± 7.0	24 (28.6)	80 | 2.7 ± 2.2
Quintile 5	79 | 35.3 ± 8.7 *	78 | 34.9 ± 7.0	24 (28.9)	78 | 2.9 ± 2.1

Notes: BMI, Body Mass Index; GFI, Global Fatigue Index; DP, Dietary pattern

Independent-samples t test or chi-square test were applied to explore differences in the mean age, BMI and mean percentage of weight loss between T0 and T1 for the lowest and the highest quintiles for the dietary patterns.

Significance is at p-value ≤ 0.05 (*) and ≤0.001 (⁺). Data are presented as number | mean ± standard deviation (SD). Presence of fatigue are presented as number (percentage).

Table 4. Predictors of presence of fatigue (GFI≥28) at T0 and T1

T0				T1			
Variables	**OR (95% CI)**	**SE**	**p value**	**Variables**	**OR (95% CI)**	**SE**	**p value**
Age	1.01 (.98/1.04)	.01	.62	Age	.99 (.97/1.02)	.02	.70
BMI	1.02 (.98/1.05)	.02	.21	BMI	1.05 (1.01/1.08)	.02	.005
Dietary Patterns	**OR (95% CI)**	**SE**	**p value**	**Dietary Patterns**	**OR (95% CI)**	**SE**	**p value**
Simple carbohydrate and high fat	1.59 (1.22/2.07)	.14	.001	Vegetables	.72 (.56/.93)	.13	.013
Savoury staples	.94 (.76/1.17)	.11	.58	Fruits and yoghurt	1.08 (.86/1.34)	.11	.52
Healthy snacks	1.04 (.83/1.30)	.11	.74	Healthy carbohydrate and eggs	.86 (.67/1.09)	.12	.21
Animal proteins and sugary drinks	1.10 (.88/1.34)	.11	.41	Coffee and extras	1.24 (.96/1.60)	.13	.10
Coffee and extras	1.10 (.88/1.37)	.11	.41	Animal proteins and healthier beverages	.92 (.74/1.16)	.12	.48

Notes: OR, Odds Ratio; SE, Standard Error; 95% CI, Confidence Interval

A multinomial logistic regression was used to analyse predictors for presence of fatigue.

Significance is at p-value ≤ 0.05. Data are presented as OR (95% CI).