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DIETARY FIBRE REGIMEN TO MODULATE WEIGHT MANAGEMENT: A PILOT INTERVENTION BASED ON FIBRE RICH FRUIT-MIX (FRFM)

J. Khawandanah* and I. Tewfik

Department of Life Sciences,
Faculty of Science and Technology,
University of Westminster,
115 New Cavendish Street,
London W1W 6UW,
United Kingdom
Email: J_khawandanah@hotmail.com

ABSTRACT

Purpose: This pilot intervention aimed to compare and contrast two diet regimens (fruit salad versus fruit juice) on weight management in healthy individuals.

Design/methodology: The effect of the daily consumption of a selection of fibre rich fruit (green apple, orange, pineapple and grapefruit) was examined in 15 subjects for three weeks. Dietary intake and anthropometric measurements were determined pre- and post-intervention.

Findings: Most subjects (n=9) managed to lose weight and their percentages of body fat were reduced after three weeks (p=0.034). The average weight losses were 720g versus 817g for the fruit juice group and fruit salad group respectively.

What is the value of the paper: Given its richness in dietary fibre, fruit salad is highly recommended over fruit juice to modulate weight management in healthy subjects, with up to 4.8% body fat reduction achieved within the three-week period.

***Keywords*:** fruit juice; fruit salad; body weight; weight management; body fat; intervention; lifestyle; green apple; orange; pineapple; grapefruit; anthropometric measurements; obesity

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*Corresponding author

INTRODUCTION

Since 1980 the number of people suffering from obesity has doubled on a worldwide level. According to the World Health Organization, almost two billion (39%) adults are overweight (Body Mass Index, BMI $\geq$25 Kg/m^2), with 600 million (13%) being obese (BMI $\geq$30 Kg/m^2). These two conditions are characterized by excess fat mass in the body (WHO, 2015). The problem of obesity in adults has also been highlighted in England, where following a Health Survey for England (HSE) in 2012, 24% of men and 25% of women were obese, while 42% and 32% of them were classified as overweight (HSCIC, 2013b). These figures pose a threat to society, which can be translated into non-communicable diseases, morbidity and mortality if not treated, with a high economic burden to the National Health Service (NHS, 2014a).

The main factors causing obesity include excessive calorie intake, unhealthy eating habits such as consuming processed food, and a sedentary lifestyle. There are also medical conditions such as hypothyroidism or genetics such as the Prader-Willi syndrome (NHS, 2014a). Obesity is promoted by environments (obesogenic environment) that encourage a high-energy intake and minimal physical activity while being influenced by social, cultural and natural determinants (Caplan, 1996; Lake and Townshend, 2006). It is known that obesity has potentially harmful effects to one's health, including cardiovascular diseases (especially heart attack and stroke), diabetes, and cancer, as well as musculoskeletal disorders, mainly osteoarthritis (WHO, 2015). In more detail, being obese can cause a sex hormone imbalance that can potentially lead to hormone-dependent tumours and mortality. Also, the increase of free fatty acid can cause insulin resistance and dyslipidemia, which are linked with hypertension and metabolic syndrome (Visscher and Seidell, 2001).

Obesity and its linked outcomes can, however, be preventable; this can be achieved not only by adopting healthier choices at the individual level but also by providing a supportive environment at the societal level (WHO, 2015). As an example, within the UK the NHS has initiated the Change4life campaign that promotes '5-a-day'; this includes consuming at least five portions of fruit and vegetables per day as part of a balanced diet (Change4life, 2015).

Adjusting dietary habits and physical activity is critical in weight management, including weight loss, gain or maintenance, as they are the main modifiable risk factors linked to obesity. However, most of all, to achieve the desirable results in weight management, behavioural adjustments are necessary. The importance of the individual's psychology during the phase of changing eating habits should not be overlooked. To gain the required knowledge and progress positively towards long-term effects, one has to go through various stages of adaptation such as commitment to change and maintenance of this change. Self-efficacy is important and guarantees the sustainability of weight reduction.

There is evidence showing that being physically active on a regular basis not only helps obese subjects to lose weight but also reduces the risk of chronic health conditions (HSCIC, 2014). Present UK guidelines for aerobic activity suggest that adults should perform moderately intense physical exercise for at least 150 minutes a week or very intense activities for 75 minutes per week (HSCIC, 2013a). In 2012, the HSE revealed a clear correlation between meeting the recommendations for physical activity and BMI category (HSCIC, 2013a). Therefore, there is a clear indication that physical inactivity may contribute to abnormal weight.

There is no doubt that adjusting daily nutritional intake and eating habits can have a major impact on weight management. Although reducing daily calories can help towards this goal, healthy eating, together with being physically active, should be the right choice if obese subjects aim to achieve long-term/sustainable weight loss (NHS, 2014c). On the other hand, fad diets promise swift weight loss and are known to limit the range of available food types, which makes them unbalanced and difficult to sustain – for example, high-protein, low-carbohydrate diets such as the Atkins diet (CDC, 2014; Dolson, 2014). Additionally, most fad diets involve physiological effects on the body including changes in the metabolism (Westman et al., 2007), a distressing calcium balance (Reddy et al., 2002) and may lead to various nutritional deficiencies (Dietz and Hartung, 1985).

To overcome fad dieting's drawbacks, it has been recommended by various researchers to follow a high in fruit and vegetables (50%) but low in fat and sugars diet in order to reduce energy intake (NIH, 1998). Following a study on the

effects of fruit consumption on weight loss in 77 overweight and obese subjects, it was shown that eating fruit was significantly associated with improved BMI and subsequent weight loss (Schroder, 2010). However, the study indicated a separation of effects for fruit and vegetable food groups, and a difference in their association with body weight and weight loss.

It is commonly believed that a high-fruit diet is ideal for weight loss since fruit is known to have unique properties and play an important part of a healthy and balanced diet (He et al., 2004). Fruit is high in water, high in sugar, low in fat and high in fibre, have only a few calories as well as essential minerals, vitamins and antioxidants (Martin et al., 2002; Swinburn et al., 2004). Research has shown that by increasing the water amount of a specific food (meaning reducing its energy density while sustaining its micronutrient and energy content), one can increase satiety but decrease energy intake at the same time (Rolls et al., 1999; CDC, 2015b). On the other hand, consuming fruit juices should be limited because of their high in sugar, therefore high in calories, content (Walker, 2014).

Both soluble and insoluble fibres are found in considerable amounts in fruit (especially in their skins), and have been reported to help with weight management (Pereira and Ludwig, 2001). Researchers have shown that dietary fibre increases post-consumption satiety and decreases any residual hunger (Howarth et al., 2001). Therefore, consuming fruit with a low energy density rather than foods with a high energy density, one can consume greater amounts of food but retain the same calorie content (CDC, 2015a). At the same time, increasing daily fibre intake to an extra 14g per day for two days decreased the energy intake by 10% and resulted in ~2Kg weight loss over four months (Howarth et al., 2001). Furthermore, soluble fibre has a beneficial impact in controlling post-meal glycemic and insulin responses as it affects gastric emptying and the way macronutrients are absorbed by the gut (Babio et al., 2010).

Although fruit consumption among children and adolescents could be lower than the recommended international guidelines (Lazzeri et al., 2013), fruit-enriched diets have been successfully implemented when investigating childhood obesity (Epstein et al., 2001). It has been proven that a high fruit and vegetable intake (two servings of fruit and three servings of vegetables a day) is associated with a decrease in high fat and sugar intake (less than 10 servings of high fat/high sugar foods per week), and is potentially helpful in families with a history of obesity (Epstein et al., 2001). Moreover, in contrast with fad diets, as illustrated after a 4-year intervention, subjects can sustain drastic dietary changes that mainly include high fibre, low fat food, providing the appropriate support for any change (Lanza et al., 2001).

Fruit such as apples, grapefruit and pineapples have shown to be especially beneficial in aiding weight loss. Apples and oranges are not only a great source of soluble fibre (Zelman and Nazario, 2010) but these fruit also have a great range of phytochemicals consisting of phenolics, carotenoids and flavonoids (Boyer and Liu, 2004). For example, eating green apples (one cup) when following a reduced calorie diet could aid with weight loss (Coleman, 2014). Moreover, overweight women who consumed three apples a day for 12 weeks managed to lose 1.22Kg as well as decrease their blood glucose levels (Conceição de Oliveira et al., 2003). Once again, caution should be taken regarding the sugar content of fruit, which in some cases could be higher than expected.

Similar results were obtained when researchers tested the effects of grapefruit and its products on obese patients (Fujioka et al., 2006). In particular, eating half a freshly prepared grapefruit before each meal was significantly associated with weight loss: however, the underlying mechanism still remains unknown (Fujioka et al., 2006). Also, the importance of pineapples on weight management has been highlighted; researchers have identified a compound called bromelain that speeds up digestion and acts as a metabolism boost (Samuels, 2014).

However, the form of fruit to be consumed plays an important role since studies have demonstrated that fruit juices resulted in a smaller satiety level compared to whole fruit. While various research studies have suggested that fruit intake can have a preventable effect on body weight gain, some studies showed the opposite if the same fruit were consumed as juice (Tetens and Alinia, 2009). Based on these observations, the aim of this pilot intervention was to compare and contrast two diet regimens (fruit salad versus fruit juice) on weight management in healthy subjects, and furthermore to ascertain the effectiveness of the daily consumption of a selection of a fibre rich mix of

fruit (green apple, orange, pineapple and grapefruit) on body weight and composition among adults over a three week period.

SUBJECTS, MATERIALS AND METHODS

Subjects

This pilot study was approved by the University of Westminster Ethics Sub-Committee. All recruited subjects must sign an informed consent form prior to the study. Inclusion criteria: healthy individual with either normal body weight ($18.5 \leq BMI \leq 24.9 Kg/m^2$), overweight ($BMI \geq 25 Kg/m^2$) or obese ($BMI \geq 30 Kg/m^2$). Subjects who are pregnant or suffer from chronic diseases, such as thyroid disorders, diabetes (type I and II) and heart conditions were excluded from the study.

A total of 15 adults (females and males) aged 18–45 (23.8 ± 6.59) years from various ethnic backgrounds (Caucasian, Asian, African and Middle Eastern) were recruited after fulfilling the inclusion criteria. Information regarding their physical activity levels [Table 1] was captured via a self-reported questionnaire:

- Sedentary: little or no exercise;
- Moderately active: <150 minutes of exercise per week;
- Active: 150–200 minutes of exercise per week;
- Extremely active: >75 minutes of vigorous exercise per week.

Table 1 Exercise intensity classification using VO_2 max ()

Intensity	*VO2 max %*	*Heart rate maximum %*
Sedentary	<30	<35
Moderately active	30–49	35–59
Active	50–74	60–79
Extremely active	75–84	80–89

Source: Wilmore and Costill, 2004

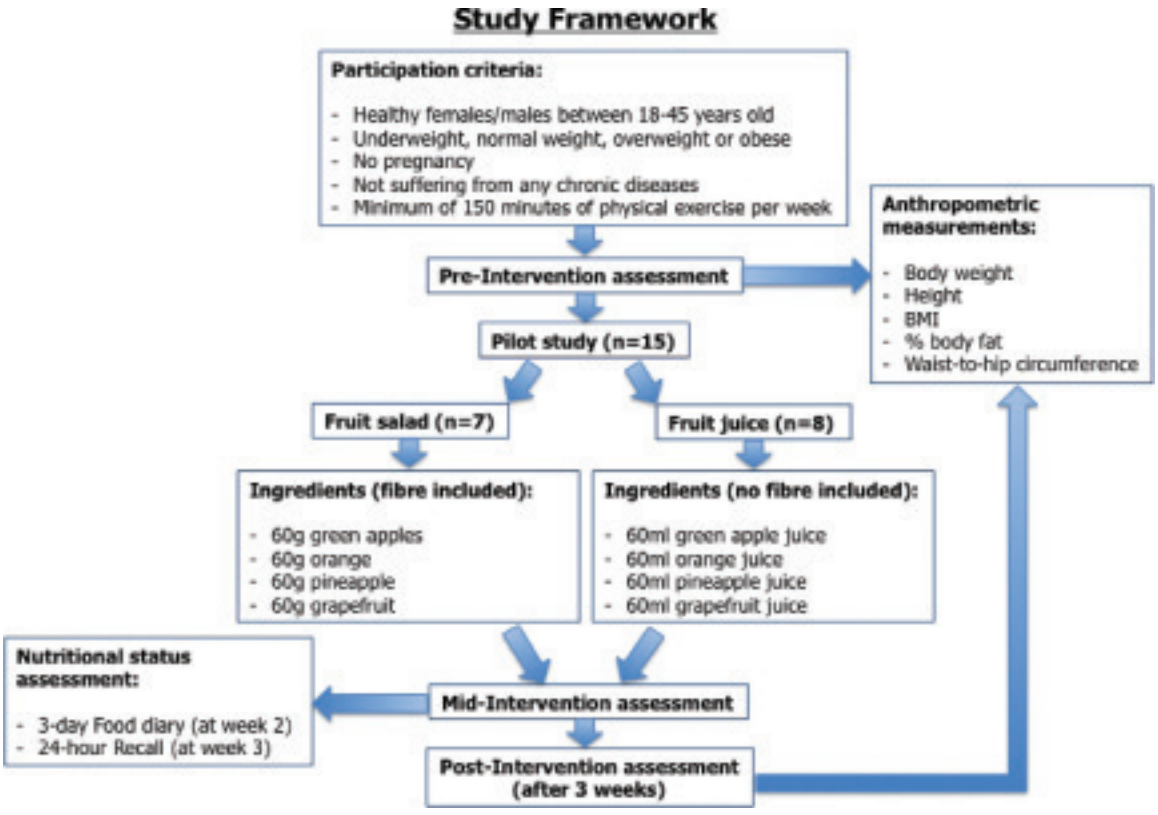

Figure 1 Schematic representation of the study design

Source: Devised by authors

Study Design and Procedure

The study's framework is described in detail in Figure 1 and includes three phases [pre-intervention, intervention and post-intervention]. During the pre-intervention phase, subjects were divided into two groups; eight of them were asked to drink a fruit juice, while the remaining seven consumed the same fruit but in the form of fruit salad. Both the fruit salad and the fruit juice consisted of four different fruit (60 grams or 60ml each), including green apple, orange, pineapple and grapefruit (i.e. total of 240g as fruit salad or 240ml as fruit juice). Subjects were asked to consume the fruit salad or fruit juice once every day for a total period of three weeks. Physical and anthropometric measurements (weight, height, BMI, percentage of body fat and waist-to-hip ratio (W:H)) were assessed pre- and post-intervention for all subjects. Regarding the subjects' nutritional intake, two types of food questionnaires were also provided to them during this phase.

The fruit salads and juices were freshly cut, prepared and served on daily basis to all subjects. Preparation of either fruit salads or juices was according to the safety and hygiene guidelines set out by the Food Standards Agency (FSA, 2012). In the case of subjects being unable to attend the kitchen due to unforeseen circumstances, a sufficient fruit supply was provided to them so that they could prepare the meal at home according to the instructions given. All subjects were asked to perform a 30-minute moderate physical exercise at least three times a week.

Physical and Anthropometric Measurements

Body weight (Kg) was measured using a calibrated scale (Seca), and the height (cm) was measured on a wall-mounted stadiometer. Body mass index (BMI – Kg/m^2) was derived for each participant. The waist and hip measurements were taken by using a measuring tape (cm). Applying the 'Body Fat Monitor' equipment, the percentage of total body fat was calculated.

Nutritional Assessment

A 3-day food diary form (KUMC, 2012) was provided during the second week of the experiment, while a 24-hour record was given in the last week of the study. Firstly, the 3-day food diary provided detailed information on dietary intake and eating habits as it was being completed in real time for three consecutive days. It does not rely on the subjects' memory and the given well-described portion sizes reduce potential errors. Although it provides a good estimate of nutrient intake, it is time consuming and has a higher respondent burden (MRC, 2015a). On the other hand, the 24-hour recall is quick and can assess the very recent past diet. However, it cannot assess daily variation in diet, and potential biases caused by poor memory cannot be excluded (MRC, 2015b). Therefore, the 24-hour recall was used as a confirmatory tool.

Data Analysis

Data gathered from the anthropometric measurements, as well as demographical details, were analysed to obtain the minimum, maximum, average and standard deviation (SD) of each variable. The statistical significance was estimated by the p-values on the SPSS statistical program. Nutritional data were analysed using the NetWISP V4.0 software in order to calculate the precise nutrient intake for each individual and compare it with the Guideline Daily Amounts (GDA).

RESULTS AND DATA INTERPRETATION

Pre-Intervention Phase

In total, 13 out of 15 subjects had a normal body weight while two were found to be obese, with a BMI of 31.1Kg/m^2 and 33.9Kg/m^2 respectively. Additionally, regarding the measured body fat percentage, values ranged between 21.1–48.0%; however, the two highest percentages correspond to the two obese subjects. The lowest body fat percentage was obtained by the only male included in the study (21.1%), which corresponds to the average body fat found in men following a survey conducted by the American Council on Exercise (Muth, 2009). The other 14 females had normal body weight; there was a significant inter-individual variation in the percentage of body fat (25.3–40.5%), which could be expected when taking into account various factors such as body type, age, ethnicity or genetic predisposition (WHO, 2008). The reported range of the percentage of body fat measured in average-weight women was 25–31% (Muth, 2009), slightly lower than what was observed in this experiment.

The range of W:H ratios was between 0.72–0.86. As expected, using the Ashwell® Shape Chart, it was

confirmed that the two obese subjects had abdominal adiposity (abnormal waist-to-height ratio), which was found on the 'yellow' zone meaning that they should 'consider action' (Ashwell Associates, 2011). Lastly, subjects self-reported their physical activity levels as defined in the methods section above. Three subjects described themselves as sedentary (i.e. little or no exercise), two subjects reported that they are active (i.e. 150–200 minutes of exercise per week), while the rest were moderately active (i.e. <150 minutes of exercise per week).

Intervention Phase

The intervention phase lasted for three weeks, during which subjects had to consume either the fruit salad or the fruit juice once a day. At the end of week 2 and start of week 3, the subjects also completed two food questionnaires (3-day food diary and 24-hour recall) to assess their eating habits. The subjects were asked to attend the Food-Kitchen at the university every day during lunch break to consume their daily fruit (salad or juice). However, during both weekends or due to personal circumstances they could not attend. Some subjects showed better adherence to the intervention, that it is believed it could affect the final result and interpretation. Only three subjects reported that they skipped a meal once. The nutritional intake of all subjects as reported by both the 3-day food diary and the 24-hour recall were analysed using the NetWISP V4.0 software. Both sets of food intake data were used and compared with the Guideline Daily Amounts (GDA).

As a general observation, most subjects reported to have eaten fewer calories compared to the recommended values/calories (for instance, some have reported to consume 1,080kcal, 923kcal, 1,060kcal and 1,162kcal respectively, according to 3-day food diary data). On the other hand, most subjects reported a high consumption of protein, which could mean they followed a high protein diet. As an example, and taking into account data from the 24-hour food questionnaire, two subjects reported to have consumed 245% and 235% of GDA for protein intake. This could be due to specific dietary habits or part of an attempt to reduce appetite and lose weight. Additionally, the subjects' carbohydrate and fat intake was slightly lower (~60–80%) than the GDA guidelines.

Table 2 Anthropometric measurements after the 3-week intervention

Subjects	*Weight (Kg)*	*Height (m)*	*BMI (Kg/m2)*	*Waist (cm)*	*Hip (cm)*	*W:H*	*% body fat*
1	64.2	1.64	23.9	75	94	0.8	36.5
2	63.9	1.62	24.3	76	102	0.75	33.8
3	58.8	1.69	20.6	75	93	0.81	20.7
4	60.2	1.56	24.7	78	101	0.77	40.5
5	59.9	1.58	24	79	100	0.79	34
6	55.5	1.68	19.6	70	93	0.75	30.7
7	59.7	1.61	23	75	99	0.76	33
8	61	1.6	23.8	75	92	0.82	31.7
9	53.1	1.55	22.1	70	94	0.74	25.1
10	57.7	1.59	22.8	74	93	0.8	38
11	76	1.57	30.8	87*	109	0.8	42.6
12	54.7	1.59	21.6	70	92	0.76	33
13	45.9	1.59	18.1	70	90	0.78	32.4
14	88.8	1.63	33.4	89*	120	0.74	47.1
15	61.9	1.60	24.2	76	94	0.8	35.7

***Waist circumference** above the 'action level' (94cm in men and 80cm in women). According to Lean et al. (1995), people with waist circumferences between action levels 1 and 2 (94–101cm in males, 80–87cm in females) have up to double the possibility of having one or more cardiovascular risk factors.

Source: Devised by authors

Post-Intervention Phase

At the end of the 3-week intervention, data on physical/anthropometric measurements and physical activity levels were collected from all 15 subjects to assess if there were any differences (Table 2).

Outcomes Over 3-Week Intervention

The physical measurements before and after intervention were compared for all variables; these included body weight, W:H and percentage of body fat (Table 3).

Weight management: From the final measurements it was demonstrated that most subjects (nine out of fifteen) managed to lose weight (up to 1.8Kg), while five subjects gained weight (up to 1.9Kg); one subject showed no change. Taking all subjects as a whole, the average body weight before intervention was 61.55±10.46Kg; after three weeks, the average body weight was 61.42±9.98Kg. A paired t-test revealed no significant correlation between weeks 1 and 3 ($p=0.666$).

Statistical analysis when analysing the fruit juice and fruit salad groups separately also revealed no significance ($p=0.958$ and $p=0.434$ respectively). However, as demonstrated in Figure 2a, on average the fruit juice group gained 0.03±1.29Kg, while the fruit salad group lost 0.30±0.95Kg. As shown from the error bars, the variation is also smaller in the latter. In addition, when assessing if the weight change between the two groups (juice/salad) was significantly different, an independent samples test was carried out; the p-value was 0.57. Lastly, individual weight loss achievements are shown in Figure 3 for (a) fruit juice (five subjects) and (b) fruit salad (four subjects). As expected, since there were weight changes, changes in the BMI were also observed; however, these were minor and did not result in change of BMI category for any individual (Table 3 and Figure 2b).

Changes in Waist-to-Hip Ratio: Post-intervention measurements revealed that eight out of the fifteen subjects had a reduction in their waist-to-hip ratio. Taking both groups into account, the average waist-to-hip ratio before intervention was 0.79±0.01, which did not greatly change ($p=0.878$). Further statistical analysis when analysing the fruit juice and fruit salad groups separately also showed no significance ($p=0.444$ and $p=0.498$, respectively).

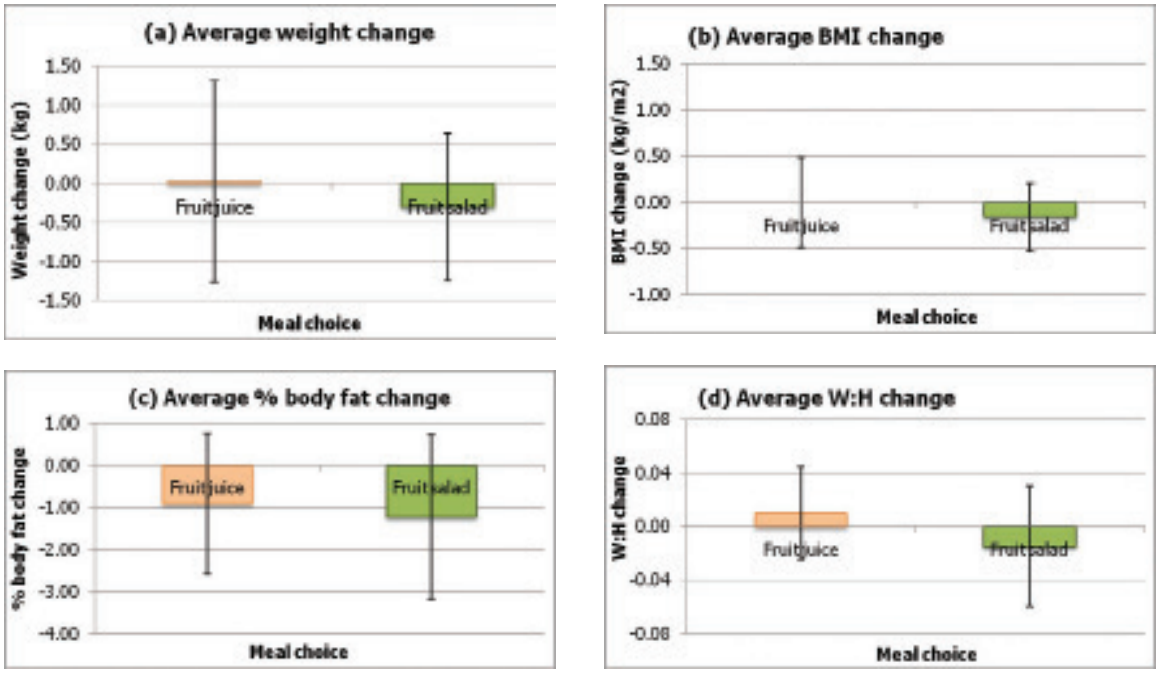

Figure 2 Average change of (a) weight (Kg), (b) BMI (Kg/m^2), (c) % body fat and (d) W:H ratio after the 3-week intervention depending on the meal choice (fruit juice or fruit salad)

Source: Devised by authors

Table 3 Summary of physical measurements before and after intervention

Subjects	Meal choice	Weight (kg)		Body weight change	BMI (kg/m2)		BMI change	W:H		W:H change	% body fat		Change in % body fat
		Week 1	Week 3		Week 1	Week 3		Week 1	Week 3		Week 1	Week 3	
1	Fruit juice	66	64.2	-1.8	24.5	23.9	-0.6	0.80	0.80	0	36.6	36.5	-0.1
2	Fruit salad	64	63.9	-0.1	24.5	24.3	-0.2	0.80	0.75	-0.05	33.5	33.8	0.3
3	Fruit salad	58	58.8	0.8	20.3	20.6	0.3	0.85	0.81	-0.04	21.1	20.7	-0.4
4	Fruit juice	60	60.2	0.2	24.7	24.7	0	0.80	0.77	-0.03	40.5	40.5	0
5	Fruit juice	60	59.9	-0.1	24	24	0	0.77	0.79	0.02	37.8	34	-3.8
6	Fruit juice	55.8	55.5	-0.3	19.8	19.6	-0.2	0.77	0.75	-0.02	32.9	30.7	-2.2
7	Fruit salad	59.7	59.7	0	23	23	0	0.75	0.76	0.01	37.8	33	-4.8
8	Fruit salad	63	61	-2	24.6	23.8	-0.8	0.75	0.82	0.06	34.8	31.7	-3.1
9	Fruit salad	52.5	53.1	0.6	21.9	22.1	0.2	0.73	0.74	0.01	25.3	25.1	-0.2
10	Fruit salad	58.5	57.7	-0.8	23.1	22.8	-0.3	0.87	0.80	-0.07	38	38	0
11	Fruit salad	76.6	76	-0.6	31.1	30.8	-0.3	0.82	0.80	-0.02	43	42.6	-0.4
12	Fruit juice	53	54.7	1.7	21	21.6	0.6	0.72	0.76	0.04	34.8	33	-1.8
13	Fruit juice	46	45.9	-0.1	18.2	18.1	-0.1	0.78	0.78	-0.01	32.6	32.4	-0.2
14	Fruit juice	90.1	88.8	-1.3	33.9	33.4	-0.5	0.75	0.74	-0.01	48	47.1	-0.9
15	Fruit juice	60	61.9	1.9	23.4	24.2	0.8	0.73	0.81	0.08	34	35.7	1.7
				Loss			Maintenance			Gain			

Source: Devised by authors

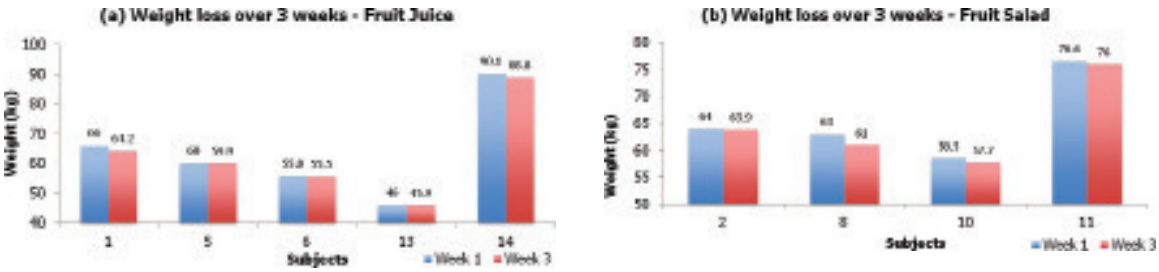

Figure 3 Demonstrating the effect of (a) fruit juice (5 subjects) and (b) fruit salad (4 subjects) on weight reduction after a period of three weeks ($p>0.05$)

Source: Devised by authors

Nevertheless, as illustrated in Figure 2d, on average the fruit juice group had a change of 0.01 ± 0.03 in their W:H ratio, whereas the fruit salad group had a difference of -0.01 ± 0.04. Furthermore, when examining whether the W:H change between the two groups (juice/salad) was significantly different, an independent samples test was performed (p-value$=0.25$). In general, it was observed that body weight changes did not necessarily cause the same effect in waist-to-hip ratio; for example, one subject gained 800 grams, but had a reduced waist-to-hip ratio after intervention (Table 3).

Percentage (%) body fat changes: As shown in both Table 3 and Figure 2c, the changes in the percentage of body fat after intervention were very interesting for both the fruit juice and fruit salad groups. The majority of the subjects lost body fat (up to 4.8%) as a result of fruit consumption, leading to a 1% reduction in the average body fat in week 3 ($34.3\pm1.67\%$). The average change in the percentage of body fat was $-0.91\pm1.67\%$ in the fruit juice group, and $-1.23\pm1.94\%$ for the fruit salad. Using a paired t-test for the pre- and post-intervention results, the correlation was found to be statistically significant ($p=0.034$) when considering all subjects together. Surprisingly, the p values when splitting the subjects according to their meal choice were slightly higher ($p=0.167$ for fruit juice and 0.145 for fruit salad), resulting in no significance. It is believed that this could be due to the large inter-individual variation as indicated from the error bars in Figure 2c.

Effect of physical activity: As mentioned in the methodology section, subjects were asked to perform moderate exercise three times a week to aid with weight management. As shown in Table 4, these instructions were not followed by all subjects; two subjects reported to still be sedentary, while only four subjects (indicated with red colour) changed their physical activity category. Interestingly, three out of these four subjects lost weight.

Table 4 Self-reported physical activity as defined in Table 1

Subjects	*Week 1*	*Week 3*
1	Sedentary	Sedentary
2	Moderately active	Moderately active
3	Moderately active	Moderately active
4	**Sedentary**	**Moderately active**
5	Sedentary	Sedentary
6	Moderately active	Moderately active
7	Moderately active	Moderately active
8	**Moderately active**	**Active**
9	Active	Active
10	**Active**	**Extremely active**
11	**Moderately active**	**Extremely active**
12	Moderately active	Moderately active
13	Moderately active	Moderately active
14	Moderately active	Moderately active
15	Moderately active	Moderately active

Source: Devised by authors

DISCUSSION

In this study, the effect of fibre (through fibre-rich fruit mix) consumption on weight management has been assessed for a period of three weeks on a total of 15 subjects. The subjects were divided into two groups, one group eating a fruit salad while the other drinking a fruit juice once a day.

Weight Management Modulated by Dietary Fibre Regimen

On average, the fruit juice group gained 30±1290g (10g per week) whereas the fruit salad one lost 300±950g (100g per week). However, as noted from the derived standard deviations, there was a large inter-individual variation in both groups, with subjects either losing or gaining weight regardless of their meal choice. Although it seems that there is a difference between the two groups on pre- and post-intervention measurements, no statistically significant relationships were obtained ($p=0.666$). The achieved weight loss in this study was found to be comparable with existing studies published in the literature: e.g. Conceição de Oliveira et al. (2003) reported an average loss of 1,220g following a 12-week-long intervention of eating three apples or pears a day; an observation that could be potentially accomplished if the current study was extended (100g*12=1200g). Similarly, Fujioka et al. (2006) reported a weight loss of 1,600g after consuming grapefruit daily for 12 weeks.

On the other hand, it was observed that most subjects lost body fat regardless of their meal choice, amount of consumed calories or self-reported physical activity (with an average of 1.06%). This highlights the importance of fruit consumption, dietary fibre and moderate physical exercise on body fat loss. The effect of dietary fibre on body weight and metabolism has been extensively reported, which is believed to occur through the short-term increase of satiety and decrease of glucose levels (Babio et al., 2010). The feeling of fullness could be one reason that, according to the food questionnaires, most subjects reported consuming less energy. When taking into account the subjects' nutritional intake, the obtained reduction in the percentage of body fat could be expected. Therefore, it is considered challenging to draw conclusions for the cause of this reduction, as it could be a combination of factors, such as the behavioural change and psychology of the subjects.

Furthermore, in order to assess the influence of various factors altogether, outcomes for particular subjects can be highlighted. In total, nine out of the fifteen subjects from both groups lost weight, however, the fat loss results varied among subjects. The subject with the highest weight loss belonging to the fruit salad group lost a total of 3.1% of body fat while maintaining a low calorie daily intake (~900kcal, Table 3) and adopting a more active lifestyle (Table 4). On the other hand, the subject with the second highest weight loss belonged to the fruit juice group and showed minimal body fat loss (0.1%). Considering that the subject's daily intake was also around 50% of the GDA and reported a sedentary status, it can assumed that it could be water and muscle that was lost, which could be easily gained back.

The effect of following a healthy diet, together with daily fruit consumption, can be indicated when focusing on the two subjects that demonstrated the highest weight gain. While they both gained similar body weight (1.7Kg and 1.9Kg respectively) and had similar calorie intake and physical activity levels, only one managed to lose body fat (1.8%) while the other gained 1.7%. This could be due to the first subject's very low fat intake (37% GDA, Table 3). This highlights and interlinks the importance of behavioural modification together with dietary fibre intake, mainly by introducing/increasing one's physical activity as a combined action to modulate obesity. This could potentially become integrated into a therapeutic regime that may help obese individuals sustain optimum body weight and a healthy lifestyle.

It is essential to take into account the limitations of the current study before drawing any conclusions as they could interfere with the observed outcomes and interpretation. One of the main drawbacks of the current intervention is thought to be its subjects group. It is recommended that researchers test such interventions on overweight or obese subjects since these are usually the ones with weight management issues; however, only two obese subjects were included. Even so, both these subjects managed to lose weight (0.6Kg and 1.3Kg) as well as body fat (0.4% and 0.9%), while one also reported to be extremely active.

The application of a placebo group, together with the proposed fruit salad and fruit juice ones, could be suggested. Also, 15 subjects could be an acceptable number of subjects for a pilot intervention; however, more subjects (preferably overweight or obese) should be included in future experiments. Moreover, to assess the possible influence of gender and age, having a more balanced group of subjects (only one male included at present) would be very beneficial. Also, analysing glucose and cholesterol levels in blood would

provide a better insight of the underlying metabolic effect in the body. Ethnic variations cannot be excluded either.

Moreover, it is believed that the food questionnaires should have been submitted to the subjects at baseline (week 1) in order to assess their before-intervention eating habits. This could introduce further bias or errors in the reported results. Lastly, it is also thought that three weeks is potentially not a long enough period for such an experiment; this fact that could explain the failure of obtaining statistically important outcomes ($p<0.05$). As shown in previous studies (Conceição de Oliveira et al., 2003; Fujioka et al., 2006), a 12-week-long intervention would result in a better evaluation.

CONCLUSIONS

To sum up, following a 3-week intervention testing the effect of a fruit mix (apple, orange, pineapple and grapefruit) on weight management, most subjects lost weight and became physically more active. However, large inter-individual variation was observed that did not allow for statistically significant conclusions to be drawn. Comparing the results in the two groups (fruit juice/fruit salad), it can be concluded that the fruit salad should be preferred as it potentially results in higher body fat loss and can also offer great health advantages. The factor of psychological motive and behavioural change cannot be overlooked, as they are the key to success for a balanced diet. It should be noted that in order to retain the detected weight reduction among some subjects, it is important to follow a subsequent programme instead of yo-yo dieting and or fad diets. A larger cohort study in the future that would last for at least 12 weeks, including biochemical tests, could potentially add further light on the effect of fruit consumption on weight management.

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BIOGRAPHICAL NOTES

Jomana Khawandanah has completed an undergraduate course in Human Nutrition at the University of Westminster and a Masters course in Eating Disorders and Clinical Nutrition at University College, London. She is an Associate Nutritionist of the Association for Nutrition and a certified Sports Nutritionist of the International Society of Sports Nutrition. She is particularly interested in the field of Clinical Nutrition and she is a registered Clinical Dietitian in Saudi Arabia.

Dr Ihab Tewfik is the Programme Leader for the BSc (Hons) Human Nutrition, Department of Life Sciences at the University of Westminster. Ihab is a Registered Practitioner in Higher Education—UK, as well as a Fellow of the Royal Society of Public Health (FRSPH). He has carried out several research projects with UNICEF-UN in aspects of public health nutrition and food safety, and has published a number of publications in refereed journals and international conferences. As a Registered Nutritionist (Public Health) at the Association for Nutrition, he organized several international conferences, workshops, CPD and short training courses on Nutrition-related diseases and public health. He is a Member of the Editorial Advisory Board of many international scientific journals.