Short-Term Benefits of High Protein, High Fiber Meal Replacements for Weight Loss in Overweight and Obese Adults

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Abstract

Obesity is a critical global health issue that increases the risk for non-communicable diseases such as cardiovascular disease and diabetes. Dietary interventions like meal replacements are potential strategies for effective weight management. This randomized controlled trial aimed to evaluate the effects of high protein, high fiber meal replacement products on body composition, and gastrointestinal health in overweight and obese adults. The sixty-one participants (BMI 23.0 - 29.9 kg/m^2) were randomly assigned to either a control group (n = 30) consuming a regular diet or a meal replacement (MRP) group (n = 31) consuming meal replacement once daily. Anthropometric data, dietary intake, and gastrointestinal health markers were assessed at baseline, week 2, and week 4. The results showed significant reductions in body weight (-0.8 ± 1.3 kg or -1.1% ± 1.8%, p = 0.004) and body mass index (-0.3 ± 0.5 kg/m^2 or -1.1% ± 1.9%, p = 0.024) in the MRP group compared to the control group. The MRP group maintained a high level of protein intake with corresponding reductions in carbohydrate and fat intake (p < 0.01). However, no significant changes were found in body fat percentage or visceral fat. The MRP group experienced a notable decline in basal metabolic rate (p = 0.022), indicating potential metabolic adaptation to caloric restriction. Additionally, improvements in gastrointestinal health, specifically a reduced need for bowel movement assistance (p = 0.024), were observed in the MRP group. In conclusion, meal replacements were effective in promoting short-term weight loss and improving dietary patterns, though metabolic adaptations and fat loss require further exploration in longer-term studies.

Keywords: Meal replacement, Obesity, Weight loss, Weight management, Gastrointestinal health

What was Known

- Meal replacements can be an effective strategy for weight management.
- Meal replacements are a convenient option for individuals aiming to reduce caloric intake while maintaining a balanced diet.

What's New and Next

- The results showed significant short-term reductions in body weight and BMI in the meal replacement group, confirming their efficacy for weight management.
- Future research should focus on the long-term effects of meal replacements on weight maintenance to understand the sustainability of weight loss and potential metabolic adaptations.

Introduction

Obesity poses a serious global public health issue with an increasing prevalence. Individuals with excessive fat accumulation are at heightened risk of developing non-communicable diseases (NCDs), which are the leading causes of mortality worldwide.[1] In Thailand, one-third of the working-age population is obese, with particularly high obesity rates in the capital, where nearly 40% are affected.[2] As obesity rates continue to rise, it is crucial to develop sustainable prevention strategies that can reduce its impact on healthcare systems. Strategies should be designed to allow for independent implementation by key stakeholders.

Diet plays a crucial role in managing and preventing obesity. Consuming foods with improper energy and macronutrient content can contribute to overweight and obesity. In contrast, adopting a balanced dietary pattern can help maintain a healthy weight and lower the risk of obesity-related NCDs.[1] Therefore, adjusting dietary habits or opting for alternative products, such as meal replacements, can be a viable strategy to reduce the risk of overweight or obesity.[3] These methods can be self-administered by individuals at risk of obesity, following expert recommendations. Meal replacement products are discrete foods, food products, or drinks designed to provide a nutritionally complete and balanced alternative to regular meals. They replace one or more meals to reduce daily energy intake, facilitating calorie control while ensuring nutritional needs are met, thereby aiding in weight management.[3]

A previous multicenter study in overweight and obese individuals found that lifestyle modifications combined with the consumption of high-protein, low-glycemic meal replacement beverages were more effective in reducing weight and cardiovascular risk than lifestyle changes alone. Additionally, other cardiovascular risk indicators, such as body fat mass, waist circumference, blood pressure, fasting blood glucose, and blood lipid levels, showed significant improvements from week 4 ($p < 0.001$).[4, 5] This aligns with a study that evaluated the effectiveness of weight loss methods, including the consumption of high protein, fiber-enriched meal replacement beverages and dietary advice via telephone, for weight reduction before the first 10 weeks of pregnancy. The study showed that meal replacement consumption resulted in greater weight loss than general dietary advice alone ($p = 0.029$).[6] Similarly, previous studies comparing the effectiveness of total meal replacement consumption and dietary plan adjustments for weight loss revealed that both methods could reduce weight, but high protein, high fiber meal replacement consumption was more effective.[7, 8] Additionally, blood lipid levels decreased, and insulin function improved.[8] However, dietary patterns and food composition differences across regions may affect the effectiveness of meal replacement products in reducing weight and other NCD risk factors.[9]

Therefore, clinical studies are needed to determine the guidelines and effectiveness of meal replacement products. This study aims to evaluate the effectiveness of a high-protein, high-fiber meal replacement product in altering body composition in overweight and obese adults in Thailand.

Materials and Methods

Participants

Sixty-one overweight and obese Thai adults [body mass index (BMI) 23 - 30 kg/m^2, as classified by the Steering Committee of the Regional Office for the Western Pacific Region of WHO, 2000], aged 20 - 59 years, were enrolled in this randomized controlled trial. Exclusion criteria included individuals with non-communicable chronic diseases, infections, nutrient digestion or absorption abnormalities within six months prior, current medication or supplement use, smoking, regular alcohol consumption, pregnancy, or lactation. The participants with irregular dietary patterns or recent changes in physical activity were also excluded. The participants were required to complete an online screening questionnaire and were informed of the study's risks, discomforts, and benefits before providing signed informed consent.

Study intervention and supplement characteristics

The participants were assigned to either the control group or the meal replacement (MRP) group through pair-matching based on gender, age, and BMI, followed by random allocation. The control group continued their regular diet, with participants responsible for providing their own meals. In the MRP group, the participants consumed their regular diet for breakfast and lunch, while replacing dinner with one serving (sachet) of a cocoa-flavored meal replacement product. Each serving provided 200 kcal, 4 g total fat, 825 mg linoleic acid, 22 g protein, 28 g carbohydrates, 10 g dietary fiber, 10 g sugar, and 250 mg L-carnitine. This regimen was followed for 28 consecutive days.

Study parameters assessment

Dietary intake was recorded three times per week (two weekdays and one weekend) using a 3-day food record. To monitor the consumption of the MRP product and regular diet, the participants were instructed to take photos of their meals before and after consumption. Additionally, trained staff inquired about the participants' dietary intake at least three times per week. Energy and nutrient intakes were calculated using the INMUCAL-Nutrient v.2 program. Anthropometric assessments were conducted, and the participants completed questionnaires on satiety-hunger, excretory symptoms, and physical activity levels (based on the global physical activity questionnaire by WHO)[10] at baseline and at the end of weeks 2 and 4. Body weight, BMI, total body fat, visceral fat, muscle mass, and basal metabolic rate (BMR) were measured using a body composition analyzer (DC-360, Tanita Corporation, Japan). Blood pressure was assessed with an automatic monitor (HEM-7130, OMRON Corporation, Japan), and waist circumference (WC) was measured at the umbilical level.

Statistical analysis

Statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS) version 18 (SPSS Inc., Chicago, USA). Independent t-tests and chi-square tests were used to compare differences between the two groups. Within-group, pre- and post-intervention differences were assessed using paired-samples t-tests. Results are reported as mean ± standard deviation (SD). A p-value of < 0.05 was considered statistically significant.

Results

Baseline characteristics

Seventy-five overweight and obese individuals were screened based on inclusion and exclusion criteria, with the 61 participants selected and randomly assigned to either the control group (n = 30) or the meal replacement (MRP) group (n = 31). All participants completed the 4-week intervention. As presented in **Table 1**, there were no significant differences in sex distribution between the groups. The mean age was similar, with 36.4 ± 10.2 years in the control group and 36.2 ± 10.5 years in the MRP group. No significant differences were observed in demographic or health parameters. Most participants held a bachelor's degree and were employed as officers. Both groups had comparable baseline body weight, BMI, waist circumference, body fat percentage, and physical activity, with no significant differences ($p > 0.05$). All participants exhibited abdominal obesity, as indicated by the average WC values above normal ranges (control group: 90.3 ± 7.3 cm, MRP group: 88.3 ± 7.9 cm). The intensity of physical activities in each group, expressed in metabolic equivalents (MET), revealed no significant differences ($p = 0.630$). The participants did not meet the World Health Organization (WHO) recommendations for physical activity, which state that individuals should achieve total physical activity MET-minutes of more than 600.

Table 1 Baseline characteristics of the study participants

Parameters	Control group (n = 30)	MRP group (n = 31)	*p*
Sex, n (%)			0.711
Male	8 (26.7)	7 (22.6)	
Female	22 (73.3)	24 (77.4)	
Age (year)	36.4 ± 10.2	36.2 ± 10.5	0.938
Educational level, n (%)			0.082
Lower than a bachelor's degree	7 (23.3)	2 (6.5)	
Bachelor's degree	18 (60.0)	18 (58.0)	
Higher than a bachelor's degree	5 (16.7)	11 (35.5)	
Occupation, n (%)			0.119
Officer	17 (56.7)	24 (77.4)	
Business owner	2 (6.7)	0 (0.0)	
Student	6 (20.0)	6 (19.4)	
Freelancer	5 (16.7)	1 (3.2)	
Blood pressure			
SBP (mmHg)	116 ± 10	119 ± 11	0.306
DBP (mmHg)	79 ± 9	82 ± 8	0.215
MAP (mmHg)	92 ± 9	95 ± 9	0.187
Body weight (kg)	69.7 ± 9.7	70.7 ± 11.9	0.710
Body mass index (kg/m^2)	26.7 ± 2.3	27.0 ± 2.5	0.600
Waist circumference (cm)	90.3 ± 7.3	88.3 ± 7.9	0.308
Body fat (%)	35.1 ± 6.6	35.7 ± 6.4	0.717
Fat mass (kg)	24.3 ± 5.1	24.7 ± 5.3	0.763
Visceral fat	8.5 ± 2.4	8.3 ± 2.5	0.820
Muscle mass (kg)	41.9 ± 7.5	42.3 ± 8.7	0.894
Free fat mass (kg)	44.5 ± 7.9	44.8 ± 9.1	0.889
Basal metabolic rate (kcal)	1340 ± 200	1350 ± 214	0.858
MET-minutes/week	104.6 ± 87.6	90.5 ± 76.8	0.531

SBP, Systolic blood pressure; DBP, Diastolic blood pressure; MAP, Mean arterial pressure; MET, Metabolic equivalent for task. Data are presented as mean ± standard deviation. p-values were calculated using chi- square test and independent t-test. A p-value < 0.05 was considered statistically significant.

Dietary intake during the intervention

Table 2 presents the average dietary intake of the control and meal replacement (MRP) groups over two and four weeks of the intervention. At baseline, there were no significant differences in energy intake or the proportions of carbohydrate, protein and fat intake. MRP group experienced a significant reduction in energy intake with a marked decrease from baseline to week 2 ($p < 0.001$) and to week 4 ($p = 0.001$), while control group showed no significant changes. Similarly, carbohydrate intake significantly decreased in MRP group at both week 2 ($p = 0.010$) and week 4 ($p = 0.019$), with no notable changes in control group. Protein intake proportions at baseline were similar between the two groups. However, after consuming the meal replacement, MRP group exhibited a higher proportion of protein intake than control group ($p < 0.001$). Fat intake in MRP group significantly decreased by week 2 ($p < 0.001$) and week 4 ($p = 0.001$), whereas control group showed no significant changes. Overall, MRP group demonstrated significant reductions in energy, carbohydrate, and fat intake by week 2 and week 4 which may be attributed to the consumption of the meal replacement product, while protein intake increased following the intervention and remained elevated throughout the study period.

Table 2 Dietary intake of the control and MRP groups during the intervention

Dietary intake	Control group (n = 30)	MRP group (n = 31)	p^*
Energy			
Week 0 (kcal/day)	1677 ± 215	1788 ± 231	0.172
Week 2 (kcal/day)	1642 ± 464	1543 ± 207†	0.358
Mean changes (Week 0 vs. Week 2)	94 ± 664	−456 ± 432	< 0.001
Week 4 (kcal/day)	1610 ± 390	1470 ± 217†	0.136
Mean changes (Week 0 vs. Week 4)	−66 ± 488	−343 ± 335	0.072

Table 2 Dietary intake of the control and MRP groups during the intervention (Con.)

Dietary intake	Control group (n = 30)	MRP group (n = 31)	p^*
Carbohydrate			
Week 0 (% of Energy intake)	48.5 ± 5.4	46.6 ± 9.0	0.057
Week 2 (% of Energy intake)	48.9 ± 8.4	47.2 ± 5.8	0.361
Mean changes (Week 0 vs. Week 2)	8.2 ± 85.4	-43.1 ± 64.8	0.010
Week 4 (% of Energy intake)	47.2 ± 6.4	47.4 ± 6.2	0.893
Mean changes (Week 0 vs. Week 4)	-4.8 ± 63.4	-45.2 ± 58.1	0.019
Protein			
Week 0 (% of Energy intake)	18.3 ± 3.6	19.4 ± 3.7	0.276
Week 2 (% of Energy intake)	18.1 ± 3.9	23.3 ± 3.5†	< 0.001
Mean changes (Week 0 vs. Week 2)	5.3 ± 37.4	-11.0 ± 36.3	0.090
Week 4 (% of Energy intake)	18.0 ± 2.9	23.4 ± 2.8†	< 0.001
Mean changes (Week 0 vs. Week 4)	-0.2 ± 20.9	-8.2 ± 23.8	0.191
Fat			
Week 0 (% of Energy intake)	33.3 ± 4.9	34.0 ± 6.8	0.655
Week 2 (% of Energy intake)	33.0 ± 6.5	32.0 ± 5.1	0.536
Mean changes (Week 0 vs. Week 2)	4.5 ± 30.3	-20.8 ± 22.9	< 0.001
Week 4 (% of Energy intake)	34.1 ± 5.0	31.5 ± 5.8	0.075
Mean changes (Week 0 vs. Week 4)	0.4 ± 24.2	-22.8 ± 22.6	0.001

Data are presented as mean ± standard deviation. p^*, Significant differences ($p < 0.05$) by paired t-tests for within-group comparisons (week 0 vs. week 2 or week 4); $p^{\dagger}$, Significant differences by independent t-tests for between-group comparisons.

Changes in health-related parameters among groups after the interventions

Comparison of health-related parameters between the control and MRP groups following two- week and four-week interventions presented in Table 3 and Figure 1. Significant differences emerged after the four-week intervention between the groups, particularly in muscle mass, free fat mass, body weight, BMI, basal metabolic rate (BMR), and the need for bowel movement assistance. Notably, MRP group exhibited a significant reduction in both body weight (Figure 1a) and BMI (Figure 1b) at week 2 and week 4 compared to control group ($p < 0.01$ for all). Within-group comparisons also revealed significant reductions in body weight and BMI in MRP group at both time points. Additionally, MRP group experienced a significant decrease in BMR, while control group showed a slight increase (p = 0.022). Excretion-related factors were also assessed, with MRP groups demonstrating a significant reduction in the need for bowel movement assistance by week 4 compared to control group (p = 0.024), although other related factor remained similar between groups

Table 3 Comparison of mean changes of health-related parameters between study groups following the 2-week and 4-week interventions.

Parameters	Week 2			Week 4		
	Control group (n = 30)	MRP group (n = 31)	p^*	Control group (n = 30)	MRP group (n = 31)	p^*
SBP (mmHg)	2 ± 8	-2 ± 8	0.966	3 ± 9	-1 ± 11	0.232
DBP (mmHg)	0.4 ± 6	-2 ± 8	0.814	-0.8 ± 7	-1 ± 7	0.892
MAP (mmHg)	0.9 ± 6	-2 ± 6	0.863	-0.3 ± 7	-1 ± 7	0.652
WC (cm)	0.2 ± 3.4	-0.4 ± 4.7	0.442	0.1 ± 4.9	-0.7 ± 4.3	0.512
Fat mass (kg)	-0.1 ± 0.9	0.1 ± 2.8	0.336	-0.0 ± 1.2	0.1 ± 2.6	0.803
Body fat (%)	-0.1 ± 1.1	0.3 ± 3.9	0.244	-0.1 ± 1.7	0.5 ± 3.6	0.407
Visceral fat	0.07 ± 0.5	0.2 ± 1.1	0.671	0.07 ± 0.5	0.1 ± 1.2	0.993
Muscle mass (kg)	0.1 ± 0.7	-0.5 ± 2.5	0.604	0.2 ± 1.2	-0.8 ± 2.3	0.035
Free fat mass (kg)	0.1 ± 0.7	-0.6 ± 2.8	0.446	0.2 ± 1.3	-0.9 ± 2.5	0.039
BMR (kcal)	3 ± 17	-16 ± 67	0.570	5 ± 32	-25 ± 61 †	0.022
MET-minutes/week	5 ± 76	-37 ± 86	0.107	-21 ± 99	-47 ± 86 †	0.370
Having bowel movement assistance, n (%)						
Yes	7 (23.3)	4 (12.9)	0.289	10 (33.3)	3 (9.7)	0.024
No	23 (76.7)	27 (87.0)		20 (66.6)	28 (90.3)	
Constipation health impact, n(%)						
Strongly satisfied	18 (60.0)	24 (77.4)	0.337	24 (80.0)	25 (80.6)	0.578
Satisfied	10 (33.3)	6 (19.4)		5 (16.7)	6 (19.4)	
Neutral	2 (6.7)	1 (3.2)		1 (3.3)	0 (0.0)	

SBP, Systolic blood pressure; DBP, Diastolic blood pressure; MAP, Mean arterial pressure; WC, Waist circumference; BMR, Basal metabolic rate; MET, Metabolic equivalent for task. Data are presented as mean ± standard deviation. p^*, Significant differences (p < 0.05) by paired t-tests for within-group comparisons (week 0 vs. week 2 or week 4); $p^{\dagger}$, Significant differences by independent t-tests for between-group comparisons.

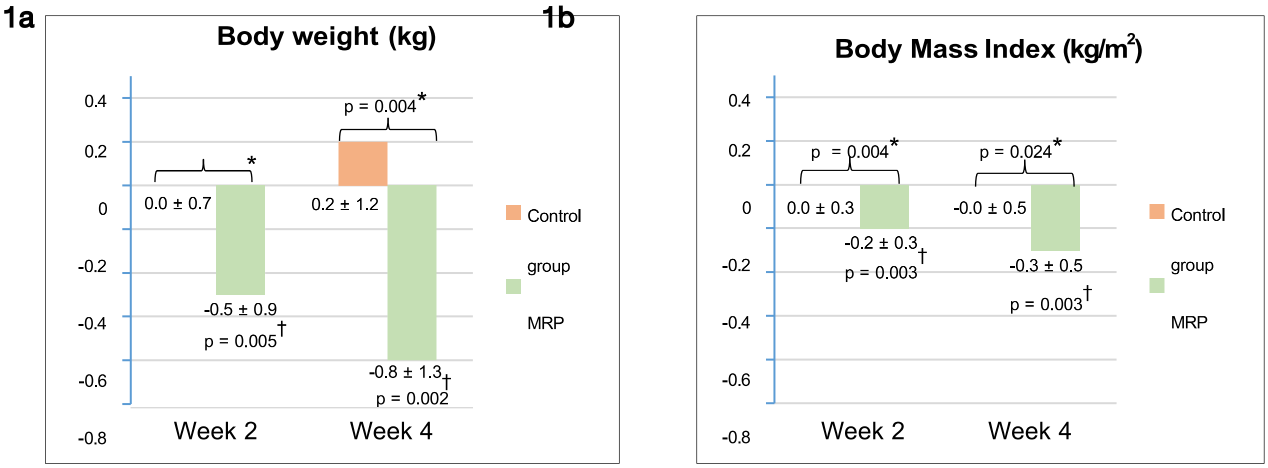

Figure 1 Mean changes in body weight and body mass index (BMI) during the intervention. **Figure 1a** illustrates the changes in body weight for both control and meal replacement (MRP) groups at weeks 2 and 4. **Figure 1b** depicts the changes in BMI between the control and MRP groups at the same time points. p^*, Significant differences ($p < 0.05$) by paired t-tests for within-group comparisons (week 0 vs. week 2 or week 4); $p^\dagger$, Significant differences by independent t-tests for between-group comparisons.

Self-reported satiety and hunger levels after consuming a meal replacement product

The participants in the MRP group (n = 31) self-reported their satiety and hunger levels 30 minutes after consuming the meal replacement product. More than two-thirds of the participants reported experiencing mild hunger following consumption at both week 2 and week 4 of intervention. The proportion of the participants reporting moderate to slight hunger decreased from week 2 to week 4, while those reporting severe hunger or starving remained consistent across both time points (**Figure 2a**). Regarding fullness, the majority of the participants indicated feeling very full to uncomfortably full after consuming the meal replacement product, with this proportion increasing from week 2 to week 4 (**Figure 2b**). In terms of desire to eat, over half of the participants reported a low or negligible desire to eat after consuming the meal replacement product at week 2, a figure that slightly increased in week 4. The percentage of the participants experiencing moderate to noticeable levels of desire slightly decreased during the same period, while those with strong desire to eat remained constant (**Figure 2c**). Satisfaction with the meal replacement product also increased over time (**Figure 2d)**. These findings suggested that the participants in the MRP group experienced increasing levels of fullness and satisfaction, alongside decreasing hunger and desire to eat, as the intervention progressed.

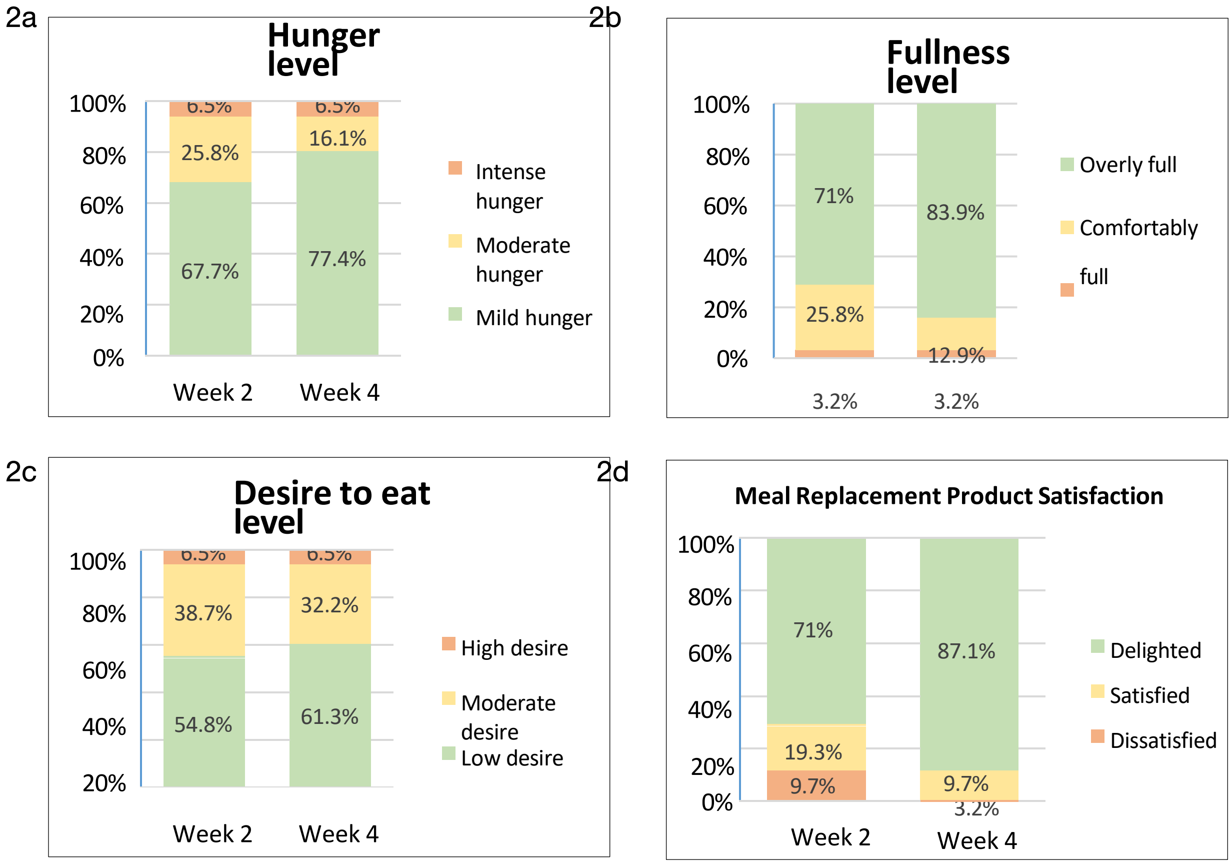

Figure 2 The distribution of responses from the participants in the meal replacement (MRP) group (n = 31) was assessed 30 minutes after consuming the meal replacement product at both week 2 and week 4 of the intervention. This assessment focused on hunger, fullness, desire to eat, and satisfaction with the meal replacement product. **Figures 2a**, **2b**, **2c**, and **2d** depict the percentage of the participants at various levels of hunger, fullness, desire to eat, and satisfaction, respectively.

Discussion

Dietary interventions, particularly the use of meal replacements, have emerged as effective strategies for managing obesity and mitigating associated health risks. Notably, meal replacements rich in protein and fiber can facilitate weight loss and positively impact metabolic and gastrointestinal health. This study demonstrated that meal replacement can facilitate significant reductions in energy, carbohydrate and fat intake while maintaining protein levels. These dietary changes led to notable weight loss and reductions in body mass index (BMI) within four weeks among the participants in the meal replacement (MRP) group, which aligns with previous studies[3] indicating that meal replacements support portion control and nutrient balance, helping to reduce overeating and maintain a healthier macronutrient profile.

The reduction in carbohydrate and fat intake observed in the MRP group highlights the potential benefits of meal replacements in lowering the consumption of macronutrients associated with weight gain. High carbohydrate diets, especially those rich in refined carbohydrates, have been linked to insulin resistance and fat storage, which contribute to obesity.[11, 12] The shift towards lower carbohydrate intake observed in this study supports strategies that prioritize low to moderate carbohydrate consumption for improved glycemic control and effective weight management.[13] Similarly, the reduction in fat intake aligns with recommendations aimed to minimize dietary fat to reduce cardiovascular risk, which is prevalent among individuals with obesity.[14] Additionally, the MRP product used in the study contains linoleic acid and L-carnitine, which provide significant health benefits. Linoleic acid, an essential omega-6 polyunsaturated fatty acid, has been shown to reduce key risk factors for cardiovascular disease (CVD), including lowering low-density lipoprotein (LDL) cholesterol, improving insulin sensitivity and reducing hypertension. By replacing saturated fat with this essential fatty acid, the MRP may improve lipid profiles and vascular health, thereby supporting heart health and weight management.[15] L-carnitine, on the other hand, is vital for fatty acid oxidation in skeletal and cardiac muscle and it also contributes to the formation of reactive oxygen species, energy production, acetyl group trapping, and glucose metabolism.[16] These mechanisms collectively enhance L-carnitine's role in effective weight management and help reduce CVD risk factors such as visceral fat and insulin resistance.[16]

Protein is known to enhance satiety and preserve lean body mass during weight loss which is critical for maintaining metabolic rate.[17] Previous studies revealed that a higher-protein diet can increase thermogenesis, elevating energy expenditure and promoting weight loss.[17,19] The present finding indicated that protein intake increased from baseline and was maintained throughout the intervention, potentially contributing to the observed reductions in hunger and increases in satiety. The high protein content of meal replacements likely played a key role in the significant weight loss seen in the MRP group, reinforcing the importance of protein in weight management interventions.

The significant reductions in weight and BMI observed over the two-week and continuing into the four-week intervention underscore the effectiveness of meal replacements for short-term weight loss, consistent with previous studies on their utility for weight reduction in overweight and obese individuals.[20, 22] However, the lack of significant changes in body fat percentage or visceral fat was unexpected, as weight loss is typically accompanied by fat reduction. This may be attributed to the brief duration of the study, as changes in fat distribution, particularly visceral fat, often require longer interventions.[23] Visceral fat, which surrounds internal organs, poses significant risks for metabolic disorders and cardiovascular disease, suggesting that its reduction may require sustained dietary interventions.[23] Future research should investigate the effects of extended meal replacement use on visceral fat to determine whether these products can effectively target this high- risk fat depot.

While the participants in the MRP group experienced significant weight loss, the observed reduction in basal metabolic rate raises concerns regarding metabolic adaptation to caloric restriction. This phenomenon, often referred to as adaptive thermogenesis, occurs when the body compensates for reduced energy intake by lowering overall energy expenditure, complicating further weight loss.[24] Although this response is a natural physiological adaptation, it may hinder continued weight loss and increase the risk of weight regain once the intervention concludes. Incorporating resistance training into future interventions could help preserve lean body mass and sustain metabolic rate during caloric restriction, potentially counteracting this adaptation.[25, 26]

Additionally, the high fiber content in the meal replacement product not only significantly promoted satiety, reducing the desire to eat more, but also improved bowel movement regularity in the MRP group. Fiber is essential for gastrointestinal health,[27] and its inclusion in the meal replacements may provide benefits beyond weight loss, such as enhanced bowel function and potential improvement in gut microbiota, both of which are linked to overall metabolic health[28,31] Despite these promising results, the study's short duration limits assessment of long-term effects. Furthermore, replacing dinner, the main meal for many Thais, with 200 kcal MRP may have influenced the findings, leaving uncertainty about whether similar results would be achieved if breakfast or lunch were substituted instead. Future research should explore the impact of meal timing, long-term adherence, and the sustainability of meal replacement strategies to optimize their effectiveness in weight management across diverse populations.

Conclusion

In conclusion, this study highlights the effectiveness of meal replacement interventions, particularly those high in protein and fiber, as a viable short-term strategy for managing obesity and reducing associated health risks. The substantial reductions in carbohydrate and fat intake, along with the maintenance of adequate protein and high fiber consumption, underscore the role of meal replacements in facilitating weight loss and improving metabolic health, with significant weight loss observed as early as week 2. Furthermore, the consumption of meal replacements contributed to increased satiety, reduced hunger, and diminished desire to eat. However, the observed decrease in basal metabolic rate suggests the presence of metabolic adaptations, which may hinder sustained weight loss and increase the risk of weight regain. In addition, improvements in gastrointestinal function noted in this study are likely attributable to the fiber content of the meal replacements.

Ethical Approval Statement

The study procedure was approved by the Ethics Committee of the Faculty of Public Health, Mahidol University, Thailand on March 4, 2024 (Certificate of Approval No. MUPH 2024-027) and was registered with the Thai Clinical Trials Registry (Registration number TCTR20240319001).

Author Contributions

CP, AB, and PP designed the study and formulated the content of the intervention tools and questionnaire. CP and PP collected the data. CP carried out the initial statistical analysis and interpretation of the data, following advice from PP. CP wrote the manuscript with the help of PP to revise it. All authors read and approved the manuscript prior to submission for publication.

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Conflicts of Interest

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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