Research Square

Preprints are preliminary reports that have not undergone peer review.
They should not be considered conclusive, used to inform clinical practice,
or referenced by the media as validated information.

A Comprehensive Multidisciplinary Remote Intervention Program for Weight Regain after Sleeve Gastrectomy: A Randomized Controlled Trial

Yafit Kessler

yafitke@gmail.com

Ariel University

Gal Churi

Ariel University

Mona Boaz

Ariel University

Limor Mardy-Tilbor

Assuta Medical Center

Danny Zalewski

Assuta Medical Center

Elaz Yosef

Assuta Medical Center

Nisan Alterovich

Assuta Medical Center

Karen Bronner

Assuta Medical Center

Amit Green

Assuta Medical Center

Coral Azouri-Shtibel

Assuta Medical Center

Tal Shavit

Ariel University

Asnat Raziel

Assuta Medical Center

Nasser Sakran

Assuta Medical Center

David Goitein

Assuta Medical Center

Shiri Sherf-Dagan
Ariel University

Research Article

Keywords:

Posted Date: July 2nd, 2026

DOI: https://doi.org/10.21203/rs.3.rs-9881411/v1

License: This work is licensed under a Creative Commons Attribution 4.0 International License.
Read Full License

Additional Declarations: No competing interests reported.

Abstract

Background: Weight regain (WR) after sleeve gastrectomy (SG) is an increasing concern, associated with maladaptive behaviors and insufficient follow-up (FU). Developing customized interventions is essential for effective management of WR.

Objective: To assess the effect of a 3-month remote intervention on physical and behavioral outcomes among SG patients experiencing WR.

Setting: A single-center specialized bariatric clinic, private hospital.

Methods: An open-label parallel randomized controlled trial among patients ≥2 years post-SG with WR≥10% from nadir. The intervention group received 3 months of remote multidisciplinary FU and weekly messages; the control group received one remote dietitian consultation. Anthropometrics, functionality, eating and lifestyle behaviors, and dietary intake were assessed at baseline and 3-months post-intervention, with adherence assessed 6- and 9-month post-intervention.

Results: Among 100 participants (76% women, mean age 49.7±11.6 years, mean time since SG 7.8±2.8 years), baseline BMI was 33.1±5.4 kg/m² and WR since nadir weight was 18.5±9.3 kg. Mean weight remained stable along the intervention with no differences between groups, while the intervention group showed a non-significant trend toward greater weight maintenance or loss. Both groups demonstrated significant improvement in functionality (p*time≤0.007) and most eating behaviors (p*time≤0.034) post-intervention. The intervention group demonstrated greater improvements in lower extremities strength (p time*group=0.036), some physical activity parameters (p time*group≤0.013), and grazing behavior (p time*group=0.001) post-intervention.

Conclusions: A 3-month remote multidisciplinary intervention did not achieve significant weight change, though it managed to improve several functional, physical activity, and eating-related outcomes compared to the control group. Further research is needed to develop tailored interventions for this population.

Clinical Trial Registry number and website where it was obtained: Registered under ClinicalTrials.gov Identifier no: NCT05122013

Key points

- A 3-month remote multidisciplinary intervention in SG patients with WR was tested
- Eating behaviors improved significantly in both groups
- Lower-limb strength, physical activity and grazing improved more among intervention
- Weight remained stable with no significant differences between groups

Introduction

Obesity is a complex chronic relapsing disease with significant public health implications (1, 2), and its global prevalence exceeds 14% and 18% among men and women aged≥20 years, respectively (3). Obesity treatment options include lifestyle modifications [e.g., eating behaviors, physical activity (PA), sleeping habits], pharmacotherapy, endoscopic bariatric procedures, and metabolic bariatric surgery (MBS). Although MBS is considered the most effective treatment for severe obesity (4), weight regain (WR) is a major concern (5, 6), with prevalence rates ranging between 49% to 76%, depending on its definition, time since surgery, and MBS type performed (7). WR mechanisms following MBS are multifactorial (8), while maladaptive eating and lifestyle behaviors seem to have a key role (5, 9). Following MBS, patients are expected to adhere to structured behavioral guidelines and engage in long-term multidisciplinary follow-up (FU) care, including lifelong nutritional monitoring and support (9, 10). A literature review found that nutritional and lifestyle education programs support weight loss post-MBS (11, 12), but only a few studies specifically address programs for patients experiencing WR following MBS (13-19). Remote eHealth interventions offer a suitable and potentially effective platform for behavioral changes and weight management in patients undergoing MBS (20, 21). The current study aimed to assess the effect of a 3-month remote comprehensive multidisciplinary intervention program, combined with weekly mobile text messages containing tasks to enhance well-being, on physical and behavioral parameters among patients after primary sleeve gastrectomy (SG) with a WR of ≥10% from nadir weight, compared to a control group receiving standard care consisting of a single remote consultation with a registered dietitian (RD). Specifically, the ***primary aim*** was to assess the intervention's effect on weight outcomes, and the ***secondary aims*** were to assess the intervention's effect on physical and behavioral parameters and their maintenance 3- and 6-month following the intervention completion.

Methods

Study type and participants

An open-label parallel randomized controlled trial (RCT(was conducted. Participants were recruited from Assuta Medical Center clinics and through an advertisement published on relevant social media networks. Inclusion criteriawere age≥18 years at MBS, primary SG, WR of ≥10% from nadir weight, Hebrew fluency and literacy, and owning a smartphone that supports video calls. Exclusion criteria were undergoing more than one MBS, use of obesity management medications (OMMs) at present or 1-month before trial entry, attending a weight loss program and losing >5% of weight during the last month, current pregnancy or giving birth in the last 6 months, and medical contraindications (e.g., active cancer, organ transplants or unbalanced psychiatric disorders). Participants who initiated OMMs or underwent a secondary MBS during the intervention and FU periods were excluded from the study. Participants were asked to sign an informed consent and then randomized into intervention or control groups using an online program, with stratification by gender using permuted blocks for every four participants (22). Group allocation was revealed only after baseline data collection was completed, after which both participants and the study team were aware of group assignment, and no blinding was maintained.

Study intervention protocol

Participants in the intervention group were enrolled in a 3-month remote care program delivered via DATOS, a customized digital remote care platform for patient management. The intervention included personalized nutritional and behavioral consultations along with a text message delivery protocol, as follows: (1) virtual consultations with an RD specializing in MBS with a 40-minute initial meeting followed by five 20-minute FU meetings; (2) three virtual consultations with a sleep consultant with a 30-minute initial meeting followed by two 15-minute FU meetings; (3) three virtual consultations with a PA consultant with a 30-minute initial meeting followed by two 15-minute FU meetings; (4) a total of 12 text messages, one sent each week, containing targeted tasks aimed at promoting overall well-being. Each consultation meeting included an evaluation, followed by setting measurable targets and providing practical strategies to enhance goal achievement, identifying barriers, and reinforcing achievements (see **Supplementary Figure 1** forthedetailed meetings protocol for each consultant**)**. The process of drafting and selecting the messages included a literature review (23-25), after which 22 task-oriented messages were chosen and pilot-tested among a sample of 30 post-MBS patients. Patients graded each message on a Likert scale from 1 (not at all) to 7 (to a very great extent) in response to the question: "*What are the chances that you would perform this activity if you knew it might improve your positive emotions and sense of joy*?". The 12 highest-rated messages were then selected (see **Supplementary Table 1)**.

Per-protocol compliance with the intervention was defined as participation in at least 50% of the scheduled remote sessions with each professional (RD, sleep consultant, and PA specialist). Per-protocol compliance with the text message component was defined as responding to at least 50% of the total 12 text messages sent during the intervention period. To assess the perceived impact of each message, a FU message was sent three days after the initial message, inquiring whether the participant had completed the suggested task and requesting a self-rating of its effect on their sense of joy and upliftment on a scale of 0 (not at all) to 10 (very much). The control group participants received standard care, consisting of one scheduled remote 40-minute RD consultation, accompanied by a recommendation to pursue ongoing FU as needed. Full details of the intervention are described according to the TIDieR checklist (26) (see **Supplementary table 2**). An overview of the study protocol is presented in **Supplementary Figure 2**.

Data collection

Preoperative data, including demographics, comorbidities, and anthropometrics before surgery, were collected from medical forms or self-reports, as available. Data on current demographic status, health condition, and behaviors were collected by a structured questionnaire. At study entry)T0) and at the end of the intervention program (T3), the following variables were measured.

Primary outcome

Weight change. Weight and height were measured on a digital medical scale, and body mass index (BMI), excess weight loss percentage (%EWL), and total weight loss percentage (%TWL) were calculated (27).

Additionally, participants were instructed to record their weight using their home scales on the morning of the T3 assessment, to verify the reliability of self-reported weight data subsequently collected via phone call interviews at 3-month (T6) and 6-month (T9) following the intervention completion.

Secondary outcomes

Anthropometrics. Waist circumference (WC) was measured twice at the level of the umbilicus (28) and an average was calculated, with cut-off points for high-risk of >102 cm for men and >88 cm for women (29). Body composition was measured using multi-frequency bioelectrical impedance analysis (BIA) (Inbody370S®, InBody Co., Ltd.), with cut-off points for excess adiposity defined as a fat mass percentage (%FM) of ≥25.0% for men and ≥35.0% for women (30).

Functionality. Upper extremities strength was measured by a digital hand dynamometer (Jamar plus digital®), with participants seated, elbows at 90 degrees, squeezing maximally with their dominant hand for three trials with 15-second breaks, and an average was calculated (31). Lower extremity strength was measured by the 30-second sit-to-stand test, with participants seated, feet flat, arms forward, repeatedly standing and sitting for 30 seconds, and the total number of repetitions was counted (32).

Compliance with eating behaviors. Participants were asked if they adhered to key MBS eating recommendations over the past month using a 0 to 2 scale (0=did not maintain, 1=partially maintained, 2=always maintained) (33).

Dietary intake. Participants were asked to complete a food diary for three consecutive weekdays. The 'Food Atlas' by the Ministry of Health and visual measurement tools were used to verify food identification and portion estimation (34). Average daily energy and macronutrient intake were calculated using the "Nutratio" software (35). Protein target of ≥60 g/day, and ≥1.5 g/ideal body weight (IBW) were calculated (4). Drinking habits were assessed based on self-reported daily cup consumption and liquid type.

Maladaptive eating behaviors. Grazing, characterized by the repetitive eating of small or modest amounts of food in an unplanned manner with or without loss of control (36, 37), was assessed by asking: "*Over the past month, do you tend to pick or nibble small amounts of food outside of planned meals in an unplanned way or on the go*?", while responses were rated on a 0 (never) to 4 (all the time) scale (38). Given the anatomical restrictions imposed by SG, which limit the physical capacity to consume objectively large quantities of food (39), the assessment of binge eating in this study focused on episodes subjectively perceived as excessive by participants (37). Therefore, participants were asked whether they had experienced episodes of "*eating subjectively large amounts of food while experiencing a sense of loss of control at least once a week in the last three months*", while responses were ranked as 0 (yes) or 1 (no) (39, 40). Food intolerance was assessed by asking: "*Are there any food items that you cannot consume due to intolerance (i.e., pain or discomfort after eating a small amount)*?", while responses were ranked as 0 (yes) or 1 (no).

The "Power of Food^{SM}" scale (PFS) was used to assess individuals' responsiveness to a food-abundant environment across three levels; (1) food available, (2) food present, and (3) food tasted (41). The questionnaire was translated into Hebrew according to a standardized language validation process (42), including forward-backward translation, expert review by a panel of seven bariatric RDs, and pilot testing with 20 patients with lived experience of MBS to assess face validity. Feedback from both the expert review and the pilot phase was incorporated to finalize the Hebrew version. The PFS was administered under a license agreement with the original developers.

Lifestyle habits. Participants reported their average nightly sleep duration separately for weekdays (n=5) and weekends (n=2) over the past month. A weighted weekly average was subsequently calculated. In addition, sleep quality was assessed using a self-reported rating scale ranging from 0 ('very good') to 3 ('very bad') (43). Participants were asked to report their PA regimen, including type, duration of each session, and frequency per week. This data was subsequently analyzed to determine whether participants adhered to the recommended guidelines of ≥150 aerobic moderate-intensity minutes per week and ≥2 sessions of anaerobic PA per week (4). Adherence to supplementation usage was defined as participants reporting daily intake of an adult multivitamin (MV), consistent with the recommended guidelines (4).

Happiness and subjective well-being. Happiness and subjective well-being were assessed by asking participants to rate their current life on a Likert scale from 0 ("worst possible life") to 10 ("best possible life"), while positive and negative emotions as well as meaningfulness were measured on a similar Likert-type scale of 0 ("not at all") to 10 ("very much") (44).

Structured phone call interviews were performed at T6 and T9 to collect data regarding weight, compliance with eating behaviors, lifestyle habits (i.e., night sleep hours, PA regimen, and MV daily intake), professional FU meetings with a multidisciplinary team outside of the study framework, current pregnancy, and receiving other treatments of obesity (e.g., OMM initiation). *Statistical Analyses*

Statistical analyses were conducted using the SPSS statistical package version 29. Continuous variables were presented as means ± standard deviation (SD) or median and interquartile range (IQR), depending on normal distribution. Dichotomous and categorical variables were expressed as proportions. Normality for continuous variables was assessed using several pathways, including Shapiro-Wilk, Q-Q plot, and histogram. If normality was rejected, non-parametric tests were employed. Between-group differences were tested by an independent T-test or Mann-Whitney U test for continuous variables and by chi-square test or Fisher's exact test for dichotomous variables, as appropriate. To assess differences in continuous and dichotomous variables within and between groups over time, linear mixed models and generalized linear mixed models were applied, respectively. The level of significance for all analyses was set at $p<0.05$, with Bonferroni correction applied to adjust for multiple comparisons.

Sample size calculation

The sample size was calculated using the G-power program version 3.1.9.7 to achieve 80% power for detecting a 3% difference in weight loss between groups, assuming an SD of 4.6 (45), a 0.05 two-sided alpha level, and a 1:1 group allocation ratio, with 25% additional recruitment to account for attrition or protocol violation. Accordingly, a sample size of 100 participants was calculated (n=50 per group).

The study protocol was approved by the ethics committee of the institutional review board of Assuta Medical Centers (ASMC-0046-21). The study was preregistered on the NIH registration website (*ClinicalTrials.gov number* NCT05122013). The study reporting adhered to the Consolidated Standards of Reporting Trials (CONSORT) statement (46). All participants who attended the T3 appointment received a participation reward, including a gift card for purchasing an MBS multivitamin ("Barimil" by TruForMe company).

Results

Flow of study participants and baseline comparison between groups. One hundred participants were recruited to the study, of whom 76% were women, with a mean age of 49.7±11.6 years and a mean time since SG of 7.8±2.8 years. Baseline characteristics of study participants by group are described in **Table 1**. Mean %EWL, %TWL and BMI at nadir were 94.6±20.4%, 37.2±7.3% and 26.4±3.7 kg/m^2, respectively. Median (IQR) %WR from nadir and current BMI at study entry were 22.1% (17.0, 31.5) and 32.2 (28.8, 37.2) kg/m^2, respectively, with 66% having a BMI of ≥30 kg/m^2. Out of 50 participants allocated to the intervention group, 8 withdrew or were lost to FU and 2 were excluded from the study due to pregnancy (n=1) or OMM initiation (n=1) at the T3 meeting. At the T3 meeting, 33 (66%) participated in all 12 professional FU meetings, 6 (12%) participated in 11 professional FU meetings, and 1 (2%) participated in only 8 professional FU meetings. Moreover, only 12 participants (24%) responded to ≥6 of the 12 messages sent, with a mean responding rate of 4.1±3.4 messages. Out of 50 participants allocated to the control group, 7 withdrew or were lost to FU and 6 were excluded from the study due to OMM initiation at the T3 meeting. A CONSORT flow chart of the study population is presented in **Supplementary Figure 3.**

A significantly higher proportion of participants from the control group initiated OMM treatment during the study period compared to the intervention group at all time points, with accumulative rates of 1/50 (2.0%) vs. 6/50 (12.0%) at T3, p=0.050, 1/50 (2.0%) vs. 11/50 (22.0%) at T6, p=0.002, and 3/50 (6.0%) vs. 12/50 (24.0%) at T9, p=0.012, for the intervention and control group, respectively.

Primary outcome

Weight change. Mean weight was stable throughout the study period in both study groups, with no differences between groups (see **Table 2** and **Supplementary Table 3)**. Nevertheless, there was a non-significant trend toward a higher proportion of participants in the intervention group maintaining or losing weight compared to the control group at T3 (59.0% vs. 47.2%, p=0.308), which was maintained at T9 (67.7% vs. 45.0%, p=0.107) (see **Supplementary Table 4**).

Secondary outcomes

Anthropometrics. WC, body composition parameters, and prevalence of WC and %FM exceeding normal range did not change significantly at T3 compared to T0 in both groups(see **Table 2**)**.**

Functionality. Both upper and lower extremities strength scores significantly improved in both groups at T3 (p*time=0.007 and p*time<0.001, respectively), with the intervention group showing greater improvement in lower extremities strength compared to the control group (p time*group=0.036) (see **Table 2**).

Compliance with eating behaviors. Both groups showed a trend toward improvement in most eating behaviors at T3 compared to T0, but the trend was more pronounced in the intervention group over time, and only some improvements were sustained at T6 and T9 (see **Figure 1** and **Supplementary Table 5)**.

Dietary intake. Mean kcal/day reduction was observed in both groups at T3 compared to T0 (p*time<0.001). The majority (≥51.4%) of participants reached the minimal protein target of ≥60 g/day, but only a minority (≤14.8%) reached the optimal protein target of ≥ 1.5 g/IBW among both groups at T3. Both groups improved their daily water consumption at T3 compared to T0 (p*time <0.001), with the intervention group showing a greater improvement (p time*group <0.001) (see **Table 3**).

Maladaptive eating behaviors. A significantly higher reduction in the proportion of participants who reported grazing was observed among the intervention group at T3 compared to T0 (p time*group=0.001), while within-group improvement in binge eating and food intolerance at T3 compared to T0 was observed only among the intervention group (p<0.001 and p=0.032, respectively) (see **Figure 2**).

Both groups demonstrated similar improvements in the total and all three PFS subscale scores at T3 compared to T0 (p<0.001 for all) (see **Supplementary Table 6)**.

Lifestyle habits. The intervention group demonstrated a significantly greater improvement in the proportion of participants who answered they engage in any PA (p time*group<0.001), aerobic minutes/week (p time*group=0.013), and anaerobic PA≥2 sessions/week (p time*group =0.008) at T3 compared to T0. Both groups presented significant improvements in daily MV intake during the study period (P*time<0.001), while no significant changes were observed in reaching recommended sleeping hours (see **Figure 3** and **Supplementary Table 5**)**.**

Happiness and subjective well-being. No significant changes in happiness, negative or positive emotions, or meaningful scores were observed at T3 compared to T0. Nevertheless, within the intervention group, weight maintenance or loss was associated with lower median negative emotion scores at T3 [1.7 (0.2, 3.1) vs. 4.1 (1.8, 6.4), p=0.015] compared to weight gain, while no such association was observed in the control group.

Discussion

WR following MBS and specifically SG is a growing phenomenon creating significant medical challenges for the healthcare system (5, 7). This necessitates the development of effective non-surgical interventions to stop and revert WR and to ensure long-term success in patient outcomes (7). This study evaluated the impact of a 3-month remote multidisciplinary intervention incorporating RD, sleep, and PA consultations, along with weekly mobile text messages containing tasks to enhance well-being, on physical and behavioral outcomes in patients with ≥10% WR since nadir weight after primary SG, compared to a control group receiving a single remote RD consultation as standard care. In the present study, anthropometric changes, including weight change, were small and did not reach statistical or clinical significance in any group. Nevertheless, the intervention group showed a trend toward higher rates of weight maintenance or loss throughout the study, although it did not reach statistical significance. These observations emphasize the potential efficiency of the study's intervention program in stopping and reverting WR. Moreover, low-level weight loss can provide clinically meaningful benefits by improving various health indicators, including cardiovascular markers, quality of life and psychosocial measures (47). Previous intervention studies among similar populations found mixed results, with some finding a minimal effect on weight outcomes (18, 19), and others showing a greater effect (13, 16, 17). A plausible explanation for the lower-than-expected results in terms of weight changes is the heterogeneity in time elapsed since SG (mean 7.8 years, range 2.1 to 16.2) and %WR from nadir weight (mean 25.7%, range 10.2% to 80.5%) among participants. Another plausible explanation could be that the control group was not entirely devoid of nutritional support, as they received one remote RD consultation, which may have motivated them to act. Indeed, 19.4% of the control group reported they scheduled at least one additional RD consultation outside the research framework.

Handgrip and sit-to-stand are widely accepted assessments of muscle function, representing key components of upper and lower extremity strength evaluation and overall patient health assessment (48). In this study, both groups showed post-intervention improvement, with the intervention group demonstrating superiority in the 30-second sit-to-stand test. Nevertheless, the lack of well-established cut-off points for these results in this specific population (48) poses a challenge in drawing definitive conclusions from these outcomes.

The present study demonstrated the superiority of the intervention group in enhancing various eating and lifestyle behaviors, as well as in reducing maladaptive eating behaviors, compared to the control group during the study period, though some changes occurred in both groups. Nutritional noncompliance is associated with inadequate weight loss and WR following MBS, thus improving adherence may benefit clinical outcomes, although data regarding the management of WR following MBS is lacking (49). When assessing patients' eating behaviors, it is crucial to consider not only 'what' they eat but also 'how' they eat. Interestingly, a greater improvement in preferring to eat solid foods as well as a greater reduction in grazing behavior was seen post-intervention among the intervention group compared to the control group, while subjective binge eating behaviors and food intolerance improved post-intervention only within the intervention group but not in the control group. These results are of high importance as grazing and binge eating are the most commonly identified maladaptive eating behaviors associated with WR (8, 50), and solid food preference promotes fullness and satiety, helping reduce

grazing behaviors and potentially lowering daily energy intake (9). The cascade of maladaptive eating behaviors leading to poor food choices may be reduced or even prevented with adequate behavioral counseling during the postsurgical period (51). Nevertheless, it remains unclear whether improving these maladaptive behaviors is enough to impact weight outcomes in patients experiencing WR following MBS, and it is also unclear at what point during the WR trajectory or at what magnitude of regain intervention is most effective. Moreover, regarding PFS, improvements were observed in both groups. This may suggest that while the intervention may have influenced some eating behaviors, it has less impact on food-related responsiveness, and that the mere presence of FU at varying levels may have influenced this measure.

Considering dietary intake in the present study, both groups reported a trend toward a reduction in energy intake post-intervention, although the decrease was statistically significant only within the intervention group. While the majority of participants in both groups met the minimum protein intake target of ≥60 g/day, only a minority reached the optimal intake of ≥1.5 g/kg IBW (52). Literature supports the importance of adequate protein consumption after MBS for lean body mass preservation and prevention of bone mineral density loss (53), although more research is needed to personalize protein requirements in the long term after MBS, especially for patients with WR (52).

Adherence to daily MV intake significantly improved post-intervention in both study groups. Lifelong MV supplementation is strongly recommended by international guidelines for all patients following MBS (4, 10), as it plays a critical role in preventing nutritional deficiencies and their associated complications (10, 53).

Concerning sleep habits, no changes were observed in average sleep hours or the proportion of participants meeting the recommended 7-9 hours of sleep per night for optimal daytime functioning in both groups (54). Although the literature supports a correlation between the quality, duration, and timing of sleep and weight status, the efficacy of sleeping interventions on weight outcomes is yet to be elucidated (54).

Regarding PA, the intervention group demonstrated significant improvements in overall PA engagement as well as in meeting the anaerobic PA recommendations of ≥2 sessions per week (4) along the study period. Growing evidence supports the benefits of a structured, supervised exercise intervention to enhance functional muscle strength, bone mineral density preservation, and improve weight maintenance among patients following MBS (55). One of the common barriers to PA post-MBS may be insufficient support (56), emphasizing the importance of incorporating PA professional support in structured intervention programs for WR, such as in the current study.

About well-being, no changes were observed in happiness, positive and negative emotions, and meaningfulness scores among both groups post-intervention. A plausible explanation for the lack of effect may be that our intervention targeting participants' well-being involved only weekly text messages, and the exposure rate to them was lower than expected, which may not have been enough to foster a notable improvement. The low exposure rate to these messages could be related to the delivery format

or frequency, which may imply a need for more personalized delivery approaches in future similar studies to enhance engagement and improve outcomes. WR after MBS represents a critical clinical challenge, prompting important considerations regarding the optimal timing and strategy for intervention. In our study, the leading cause of attrition was the initiation of OMM, which occurred significantly more often in the control group. Given that our intervention led to modest weight loss, compared to the weight reductions reported with the new generation incretin-based OMM (57), earlier integration of pharmacotherapy may be essential in certain cases.

Strengths and limitations of the study

This study innovates by developing a tailored, multidisciplinary remote intervention, providing the most recommended care for patients with WR (8). Our study expands lifestyle intervention beyond nutrition by including components of sleep and PA as well as text messages targeted to enhance wellbeing. Since FU rates are known to reduce over time following MBS (58), and the main reasons for attrition from FU include logistic constraints (59), there is an importance in reaching out to patients and offering them remote intervention programs (60). Other strengths include rigorous RCT methodology with high per-protocol engagement, a relatively large sample size, and single RD involvement in each group for consistency and reducing performance bias. Moreover, although chosen as the primary outcome, the study included various outcomes beyond weight loss, reflecting a patient-centered approach that considers the individual beyond the scale. Nonetheless, several limitations should be noted. First, dropout and loss to FU rates at T3 were aligned with the pre-study assumption of up to a 25% attrition rate, although significantly more participants among the control group withdrew or were excluded from the study compared to the intervention group, primarily due to OMM initiation. Second, weight measurements were taken on the study scale at T0 and T3, but on the participants' home scale at T6 and T9. To overcome this potential measurement bias, participants were asked to measure their home weight on the morning of the scheduled T3 study meeting, and a high correlation was found between both measurements ($r=0.999$, $P<0.001$, $n=59$). Nevertheless, providing personal weight scales should be considered in future similar studies. Third, some outcomes were self-reported, making reporting bias and social desirability bias optional. Fourth, due to time constraints and the need to minimize participant burden, some eating behaviors (i.e., grazing and subjective binge eating) were assessed using targeted questions adapted from existing literature, rather than using fully validated questionnaires.

Conclusion

A 3-month remote comprehensive intervention program, including a multidisciplinary team combined with mobile text messages containing tasks to enhance well-being demonstrated superiority in several parameters, including enhancing PA, improving lower extremity strength, adhering to multiple eating and lifestyle behaviors, and reducing maladaptive eating behaviors, compared to a control group that received a single remote RD consultation as usual care. Nevertheless, weight loss was minimal, though the intervention group showed better but not statistically significant weight maintenance trends. More

studies are needed to develop an effective intervention protocol adjusted to patients following MBS experiencing WR, which holds unique characteristics and challenges.

Abbreviations

ASMC: Assuta Medical Centers; BIA: Bioelectrical Impedance Analysis; BMI: Body Mass Index; CONSORT: Consolidated Standards of Reporting Trials; IQR: Interquartile Range; MBS: Bariatric Surgery; EWL: Excess Weight Loss; FM: Fat Mass; FU: Follow Up; IBW: Ideal Body Weight; MV: Multivitamin; OMM: Obesity Management Medication; PA: Physical Activity; PFS: Power of Food; RCT: Randomized Controlled Trial; RD: Registered Dietitian; RYGB: Roux-en-Y Gastric Bypass; SD: Standard Deviation; SG: Sleeve Gastrectomy; TWL: Total Weight Loss; WC: Waist Circumference; WR: Weight Regain

References

1. Bray G, Kim K, Wilding J, Federation WO. Obesity: a chronic relapsing progressive disease process. A position statement of the World Obesity Federation. Obesity Reviews. 2017;18(7):715-23.
2. Jastreboff AM, Kotz CM, Kahan S, Kelly AS, Heymsfield SB. Obesity as a disease: the obesity society 2018 position statement. Obesity. 2019;27(1):7-9.
3. World Obesity Federation, World Obesity Atlas 2023.
4. Mechanick JI, Apovian C, Brethauer S, Garvey WT, Joffe AM, Kim J, et al. Clinical practice guidelines for the perioperative nutrition, metabolic, and nonsurgical support of patients undergoing bariatric procedures–2019 update: cosponsored by american association of clinical endocrinologists/american college of endocrinology, the obesity society, american society for metabolic & bariatric surgery, obesity medicine association, and american society of anesthesiologists. Endocrine Practice. 2019;25(s2):1-75.
5. Lauti M, Kularatna M, Hill AG, MacCormick AD. Weight Regain Following Sleeve Gastrectomy-a Systematic Review. Obes Surg. 2016;26(6):1326-34.
6. El Ansari W, Elhag W. Weight regain and insufficient weight loss after bariatric surgery: definitions, prevalence, mechanisms, predictors, prevention and management strategies, and knowledge gaps—a scoping review. Obesity Surgery. 2021:1-12.
7. Noria SF, Shelby RD, Atkins KD, Nguyen NT, Gadde KM. Weight Regain After Bariatric Surgery: Scope of the Problem, Causes, Prevention, and Treatment. Current diabetes reports. 2023;23(3):31-42.
8. Cohen RV, Petry TB. How to address weight regain after bariatric surgery in an individualized way. Reviews in Endocrine and Metabolic Disorders. 2023;24(5):993-1002.
9. Benson-Davies S, Frederiksen K, Patel R. Bariatric nutrition and evaluation of the metabolic surgical patient: Update to the 2022 Obesity Medicine Association (OMA) bariatric surgery, gastrointestinal

hormones, and the microbiome clinical practice statement (CPS). Obesity Pillars. 2025;13:100154.

10. Sherf Dagan S, Goldenshluger A, Globus I, Schweiger C, Kessler Y, Kowen Sandbank G, et al. Nutritional recommendations for adult bariatric surgery patients: clinical practice. Advances in Nutrition. 2017;8(2):382-94.
11. Nijamkin MP, Campa A, Sosa J, Baum M, Himburg S, Johnson P. Comprehensive nutrition and lifestyle education improves weight loss and physical activity in Hispanic Americans following gastric bypass surgery: a randomized controlled trial. Journal of the Academy of Nutrition and Dietetics. 2012;112(3):382-90.
12. Kalarchian MA, Marcus MD, Courcoulas AP, Lutz C, Cheng Y, Sweeny G. Structured dietary intervention to facilitate weight loss after bariatric surgery: a randomized, controlled pilot study. Obesity. 2016;24(9):1906-12.
13. Bradley LE, Forman EM, Kerrigan SG, Goldstein SP, Butryn ML, Thomas JG, et al. Project HELP: a Remotely Delivered Behavioral Intervention for Weight Regain after Bariatric Surgery. Obes Surg. 2017;27(3):586-98.
14. Himes SM, Grothe KB, Clark MM, Swain JM, Collazo-Clavell ML, Sarr MG. Stop regain: a pilot psychological intervention for bariatric patients experiencing weight regain. Obesity surgery. 2015;25(5):922-7.
15. Stewart KE, Olbrisch ME, Bean MK. Back on track: confronting post-surgical weight gain. Bariatric Nursing and Surgical Patient Care. 2010;5(2):179-85.
16. Bradley LE, Forman EM, Kerrigan SG, Butryn ML, Herbert JD, Sarwer DB. A pilot study of an acceptance-based behavioral intervention for weight regain after bariatric surgery. Obesity surgery. 2016;26(10):2433-41.
17. Faria SL, de Oliveira Kelly E, Lins RD, Faria OP. Nutritional management of weight regain after bariatric surgery. Obesity surgery. 2010;20(2):135-9.
18. Lauti M, Kularatna M, Pillai A, Hill AG, MacCormick AD. A randomised trial of text message support for reducing weight regain following sleeve gastrectomy. Obesity surgery. 2018;28(8):2178-86.
19. Kalarchian MA, Marcus MD, Courcoulas AP, Cheng Y, Levine MD, Josbeno D. Optimizing long-term weight control after bariatric surgery: a pilot study. Surgery for Obesity and Related Diseases. 2012;8(6):710-5.
20. Wright C, Mutsekwa RN, Hamilton K, Campbell KL, Kelly J. Are eHealth interventions for adults who are scheduled for or have undergone bariatric surgery as effective as usual care? A systematic review. Surgery for Obesity and Related Diseases. 2021;17(12):2065-80.
21. Messiah SE, Sacher PM, Yudkin J, Ofori A, Qureshi FG, Schneider B, et al. Application and effectiveness of eHealth strategies for metabolic and bariatric surgery patients: A systematic review. Digital health. 2020;6:2055207619898987.
22. Suresh K. An overview of randomization techniques: an unbiased assessment of outcome in clinical research. Journal of human reproductive sciences. 2011;4(1):8.
23. Steptoe A. Happiness and health. Annual review of public health. 2019;40:339-59.

24. Das KV, Jones-Harrell C, Fan Y, Ramaswami A, Orlove B, Botchwey N. Understanding subjective well-being: perspectives from psychology and public health. Public Health Reviews. 2020;41(1):1-32.
25. Sherman A, Shavit T, Barokas G, Kushnirovich N. On the role of personal values and philosophy of life in happiness technology. Journal of Happiness Studies. 2020:1-16.
26. Hoffmann TC, Glasziou PP, Boutron I, Milne R, Perera R, Moher D, et al. Better reporting of interventions: template for intervention description and replication (TIDieR) checklist and guide. Bmj. 2014;348.
27. Brethauer SA, Kim J, El Chaar M, Papasavas P, Eisenberg D, Rogers A, et al. Standardized outcomes reporting in metabolic and bariatric surgery. Obesity surgery. 2015;25:587-606.
28. Obesity NAAftSo, Heart N, Lung, Institute B, Initiative NOE. The practical guide: identification, evaluation, and treatment of overweight and obesity in adults: National Institutes of Health, National Heart, Lung, and Blood Institute; 2000.
29. Sherf-Dagan S, Refaeli R, Buch A. Phenotyping of Obesity Treatment Candidates: A Narrative Review. Current Obesity Reports. 2024:1-10.
30. De Lorenzo A, Soldati L, Sarlo F, Calvani M, Di Lorenzo N, Di Renzo L. New obesity classification criteria as a tool for bariatric surgery indication. World journal of gastroenterology : WJG. 2016;22(2):681-703.
31. Sousa-Santos AR, Amaral TF. Differences in handgrip strength protocols to identify sarcopenia and frailty-a systematic review. BMC geriatrics. 2017;17:1-21.
32. STEADI—Older Adult Fall Prevention. Centres for Diseases Control and Prevention (CDC) [Available from: https://www.cdc.gov/steadi/media/pdfs/steadi-assessment-30sec-508.pdf.
33. Sherf-Dagan S, Biton R, Ribeiro R, Kessler Y, Raziel A, Rossoni C, et al. Nutritional and Lifestyle Behaviors Reported Following One Anastomosis Gastric Bypass Based on a Multicenter Study. Nutrients. 2023;15(6):1515.
34. Dao MC, Subar AF, Warthon-Medina M, Cade JE, Burrows T, Golley RK, et al. Dietary assessment toolkits: an overview. Public health nutrition. 2019;22(3):404-18.
35. NutRatio.com [Internet]. 2024 [cited 31.3.2024]. Available from: https://nutratio.com/.
36. Conceição EM, Mitchell JE, Engel SG, Machado PP, Lancaster K, Wonderlich SA. What is "grazing"? Reviewing its definition, frequency, clinical characteristics, and impact on bariatric surgery outcomes, and proposing a standardized definition. Surg Obes Relat Dis. 2014;10(5):973-82.
37. Conceição EM, de Lourdes M, Pinto-Bastos A, Vaz AR, Brandao I, Ramalho S. Problematic eating behaviors and psychopathology in patients undergoing bariatric surgery: The mediating role of loss of control eating. International Journal of Eating Disorders. 2018;51(6):507-17.
38. Lane B, Szabó M. Uncontrolled, repetitive eating of small amounts of food or'grazing': development and evaluation of a new measure of atypical eating. Behaviour Change. 2013;30(2):57.
39. Conceição EM, Utzinger LM, Pisetsky EM. Eating disorders and problematic eating behaviours before and after bariatric surgery: characterization, assessment and association with treatment

outcomes. European Eating Disorders Review. 2015;23(6):417-25.
40. Williams-Kerver GA, Steffen KJ, Mitchell JE. Eating pathology after bariatric surgery: an updated review of the recent literature. Current psychiatry reports. 2019;21(9):86.
41. Cappelleri JC, Bushmakin AG, Gerber RA, Leidy NK, Sexton CC, Karlsson J, et al. Evaluating the Power of Food Scale in obese subjects and a general sample of individuals: development and measurement properties. International journal of obesity. 2009;33(8):913-22.
42. Tsang S, Royse CF, Terkawi AS. Guidelines for developing, translating, and validating a questionnaire in perioperative and pain medicine. Saudi journal of anaesthesia. 2017;11(Suppl 1):S80.
43. Buysse DJ, Reynolds III CF, Monk TH, Berman SR, Kupfer DJ. The Pittsburgh Sleep Quality Index: a new instrument for psychiatric practice and research. Psychiatry research. 1989;28(2):193-213.
44. Lahav E, Sherman A, Shavit T. The Longitudinal Effect of Pre-war Investments in Hedonic Capital on Wartime Well-Being. Journal of Happiness Studies. 2025;26(1):11.
45. Polzien KM, Jakicic JM, Tate DF, Otto AD. The efficacy of a technology-based system in a short-term behavioral weight loss intervention. Obesity. 2007;15(4):825-30.
46. Hopewell S, Chan A-W, Collins GS, Hróbjartsson A, Moher D, Schulz KF, et al. CONSORT 2025 explanation and elaboration: updated guideline for reporting randomised trials. bmj. 2025;389.
47. Dhar D, Packer J, Michalopoulou S, Cruz J, Stansfield C, Viner RM, et al. Assessing the evidence for health benefits of low-level weight loss: a systematic review. International Journal of Obesity. 2025;49(2):254-68.
48. Prado CM, Batsis JA, Donini LM, Gonzalez MC, Siervo M. Sarcopenic obesity in older adults: a clinical overview. Nature Reviews Endocrinology. 2024;20(5):261-77.
49. Shukla AP, He D, Saunders KH, Andrew C, Aronne LJ. Current concepts in management of weight regain following bariatric surgery. Expert review of endocrinology & metabolism. 2018;13(2):67-76.
50. Lopes KG, Romagna EC, Mattos DMF, Kraemer-Aguiar LG. Disordered Eating Behaviors and Weight Regain in Post-Bariatric Patients. Nutrients. 2024;16(23):4250.
51. Johnson Stoklossa C, Atwal S. Nutrition care for patients with weight regain after bariatric surgery. Gastroenterology research and practice. 2013;2013.
52. Ben-Porat T, Lahav Y, Cohen TR, Bacon SL, Buch A, Moizé V, et al. Is There a Need to Reassess Protein Intake Recommendations Following Metabolic Bariatric Surgery? Current Obesity Reports. 2025;14(1):1-7.
53. Ben-Porat T, Elazary R, Sherf-Dagan S, Goldenshluger A, Brodie R, Mintz Y, et al. Bone health following bariatric surgery: implications for management strategies to attenuate bone loss. Advances in nutrition. 2018;9(2):114-27.
54. Golem DL, Martin-Biggers JT, Koenings MM, Davis KF, Byrd-Bredbenner C. An integrative review of sleep for nutrition professionals. Advances in nutrition. 2014;5(6):742-59.
55. Hansen D, Decroix L, Devos Y, Nocca D, Cornelissen V, Dillemans B, et al. Towards Optimized Care After Bariatric Surgery by Physical Activity and Exercise Intervention: a Review. Obesity surgery.

2020:1-8.
56. King WC, Bond DS. The importance of pre and postoperative physical activity counseling in bariatric surgery. Exercise and sport sciences reviews. 2013;41(1):26.
57. Haddad A, Suter M, Greve JW, Shikora S, Prager G, Dayyeh BA, et al. Therapeutic options for recurrence of weight and obesity related complications after metabolic and bariatric surgery: an IFSO position statement. Obesity Surgery. 2024;34(11):3944-62.
58. Freire RH, Borges MC, Alvarez-Leite JI, Correia MITD. Food quality, physical activity, and nutritional follow-up as determinant of weight regain after Roux-en-Y gastric bypass. Nutrition. 2012;28(1):53-8.
59. Goldenshluger A, Elazary R, Cohen M, Goldenshluger M, Ben-Porat T, Nowotni J, et al. Predictors for adherence to multidisciplinary follow-up care after sleeve gastrectomy. Obesity surgery. 2018;28(10):3054-61.
60. Bradley LE, Sarwer DB, Forman EM, Kerrigan SG, Butryn ML, Herbert JD. A survey of bariatric surgery patients' interest in postoperative interventions. Obesity surgery. 2016;26(2):332-8.

Tables

Table 1: Baseline characteristics of study participants by group

Control (n=50)	Intervention (n=50)	All population (n=100)	Parameter[1]
Demographics			
51.5±11.3	48.0±11.8	49.7±11.6	Age (years)
38 (76.0%)	38 (76.0%)	76 (76.0%)	Gender (% women) (n, %)
34 (68.0%)	34 (68.0%)	68 (68.0%)	Marital status (n, % married)
31 (62.0%)	33 (66.0%)	64 (64.0%)	Education (n, % with>12 years)
41 (82.0%)	40 (80.0%)	81 (81.0%)	Occupation (n, % work full-time or part-time)
7.5±2.4	8.2±3.1	7.8±2.8	Time elapsed since SG (years)
Health status			
3 (7.7%)	3 (8.8%)	6 (8.2%)	Type 2 Diabetes (n, %)[2]
3 (6%)	4 (8%)	7 (7%)	Hypertension (n, %)[3]
7 (7.0%)	6 (6.0%)	13 (13.0%)	Current smokers (n, %)
Anthropometrics			
117.3±16.4	117.4±21.1	117.3±18.8	Weight before SG (kg)
40.0 (38.2, 44.8)	41.7 (39.4, 45.0)	40.7 (38.3, 45.0)	BMI before SG (kg/m^2) (Median, IQR)
75.0 (65.9, 84.2)	69.0 (61.7, 83.5)	71.0 (64.0, 84.0)	Nadir weight (kg) (Median, IQR)
26.5±3.8	26.3±3.6	26.4±3.7	Nadir BMI (kg/m^2)
36.2±7.0	38.2±7.5	37.2±7.3	%TWL at nadir weight
94.4±21.1	94.9±19.9	94.6±20.4	%EWL at nadir weight
49 (98.0%)	50 (100.0%)	99 (99.0%)	EWL≥50% at nadir weight (n,%)
14.4 (12.0, 21.8)	15.8 (11.8, 24.0)	14.9 (12.0, 23.5)	WR since nadir weight (kg) (Median, IQR)
20.0 (15.5, 29.4)	22.3 (17.6, 31.9)	22.1 (17.0, 31.5)	WR since nadir weight (%) (Median, IQR)
92.0±16.9	90.6±17.7	92.0±16.6	Current weight (kg)
32.1 (28.7, 37.1)	32.6 (28.8, 37.2)	32.2 (28.8, 37.2)	Current BMI (kg/m^2) (Median, IQR)

Control (n=50)	Intervention (n=50)	All population (n=100)	Parameter[1]
34 (68.0%)	32 (64.0%)	66 (66.0%)	Current BMI≥30 (kg/m^2) (n, %)
20.2±9.6	22.6±10.2	21.4±9.9	Current %TWL
25 (50.0%)	30 (60.0%)	55 (55.0%)	Current %TWL≥20% (n, %)
52.8±26.1	56.2±26.2	54.5±26.1	Current %EWL
28 (57.1%)	28 (56.0%)	56 (56.6%)	Current EWL ≥50% (n, %)

Abbreviations: Sleeve Gastrectomy (SG), Interquartile Range (IQR), Body Mass Index (BMI), Total Weight Loss (TWL), Excess Weight Loss (EWL), Weight Regain (WR).

[1] All outcomes are presented as mean±SD or as n (%), unless otherwise stated.

[2] Defined by HbA1c≥6.5% or reported diabetes pharmacotherapy.

[3] Defined by reported hypertension pharmacotherapy.

Table 2: Changes in anthropometrics and functionality between groups at the end of the intervention

Outcome variable[1]	Group[a]	Baseline (T0)	Post intervention (T3)	P Time[2]	P Group[3]	P Time* Group[4]
Weight (kg)	Intervention	90.6±2.4	89.6±2.4	0.084	0.357	0.378
	Control	93.3±2.4	93.2±2.4			
WC (cm)	Intervention	107.7±1.9	105.8±1.9 [b]	0.069	0.204	0.350
	Control	110.1±1.9	109.7±2.0			
WC exceeding normal range[5] (n, %)	Intervention	46 (92.0%)	33 (89.2%)	0.099	0.735	0.504
	Control	46 (92.0%)	21 (84.0%)			
FM (kg)	Intervention	39.1±1.6	38.4±1.6	0.115	0.972	0.448
	Control	39.0±1.6	38.7±1.7			
FM (%)	Intervention	42.9±1.1	42.4±1.1	***0.045***	0.492	0.616
	Control	41.7±1.1	41.4±1.1			
%FM exceeding normal range (n, %)[6]	Intervention	45 (90.0%)	35 (94.6%)	0.272	0.181	0.914
	Control	40 (81.6%)	23 (88.5%)			
FFM (kg)	Intervention	51.4±1.4	51.4±1.4	0.956	0.316	0.685
	Control	53.4±1.4	53.5±1.4			
SMM (kg)	Intervention	28.3±0.8	28.3±0.9	0.673	0.330	0.754
	Control	29.5±0.9	29.5±0.9			
Handgrip (kg)	Intervention	29.3±1.3	30.4±1.3 [b]	***0.007***	0.952	0.558
	Control	29.4±1.3	30.1±1.3			
Sit and Stand 30 seconds (times)	Intervention	16.4±0.6	19.3±0.6 [b]	***<0.001***	0.289	***0.036***
	Control	16.2±0.6	17.7±0.7 [b]			

Abbreviations: Baseline (T0), post-intervention (T3), Body Mass Index (BMI), Fat Free Mass (FFM), Fat Mass (FM), Skeletal Muscle Mass (SMM), Waist Circumference (WC).

[1] Data are presented as estimated mean (±SE) according to the mixed model analysis.

[2] P Time= P value for changes over time in the two groups.

[3] P Groups= P value for between-groups differences over time.

[4] P Time*Group = P value for interaction between the trend of change over time and the group effect.

[5] WC>102 cm for men and WC>88 cm for women.

[6] ≥25% for men and ≥35% for women. [a] No between-group differences were found at baseline for any outcome variable ($p \leq 0.05$). [b] Within-group differences compared to baseline ($p \leq 0.05$).

Table 3: Changes in dietary intake between groups at the end of the intervention

Outcome variable[1]	Group	Baseline (T0)	Post intervention (T3)	P Time[2]	P Group[3]	P Time* Group[4]
Energy (kcal/day)	Intervention	1,541.6±64.4	1,318.6±74.3 [a]	***<0.001***	***0.011***	0.274
	Controls	1,697.4±64.4	1,599.3±83.0			
Protein (g/day)	Intervention	69.2±3.3	66.0±3.8	0.834	0.015	0.347
	Controls	77.7±3.3	79.7±4.2			
Protein≥60 g/day	Intervention	35.0 (70.0%)	18.0 (51.4%) [a]	0.161	0.063	0.175
	Controls	39.0 (78.0%)	21.0 (77.8%) [b]			
Protein intake ≥ 1.5 g/kg IBW[5] (n, %)	Intervention	4 (8.0%)	5 (14.3%)	0.435	0.521	0.524
	Controls	7 (14.0%)	4 (14.8%)			
Proteins (% daily intake)	Intervention	18.3±0.6	20.2±0.7 [a]	***0.003***	0.860	0.701
	Controls	18.6±0.6	20.1±0.8			
Carbs (g/day)	Intervention	169.2±9.0	142.6±10.4 [a]	***<0.001***	0.184	0.930
	Controls	185.8±9.0	157.8±11.5 [a]			
Carbs (% daily intake)	Intervention	43.8±1.3	43.1±1.4	***0.023***	0.248	0.122
	Controls	43.1±1.3	39.7±1.6 [a]			
Fats (g/day)	Intervention	64.9±3.3	54.8±3.8 [a]	0.078	***0.022***	0.066
	Controls	70.1±3.3	70.3±4.2			
Fats (% daily intake)	Intervention	37.7±1.0	37.4±1.1	0.203	0.594	0.103
	Controls	37.1±1.0	39.4±1.2			
Fibers (g/day)	Intervention	17.0±1.1	15.9±1.3	0.261	0.342	0.993
	Controls	18.4±1.1	17.4±1.4			
Water cups per day	Intervention	2.9±0.4	5.2±0.4 [a]	***<0.001***	0.603	***<0.001***
	Controls	4.1±0.4	4.5±0.4			

Abbreviations: Baseline (T0), post-intervention (T3), Ideal Body Weight (IBW).

[1] Data are presented as estimated mean (±SE) according to the mixed model analysis.

[2] P Time= P value for changes over time in the two groups.

[3] P Groups= P value for between-groups differences over time.

[4] P Time*Group = P value for interaction between the trend of change over time and the group effect.

[5] IBW defined using the BMI threshold of 25 kg/m², as follows: IBW (kg)=25×(height in meters)^2.

[a] No between-group differences were found at baseline for any outcome variable ($p \leq 0.05$).

[b] Within-group differences compared to baseline ($p \leq 0.05$).

Figures

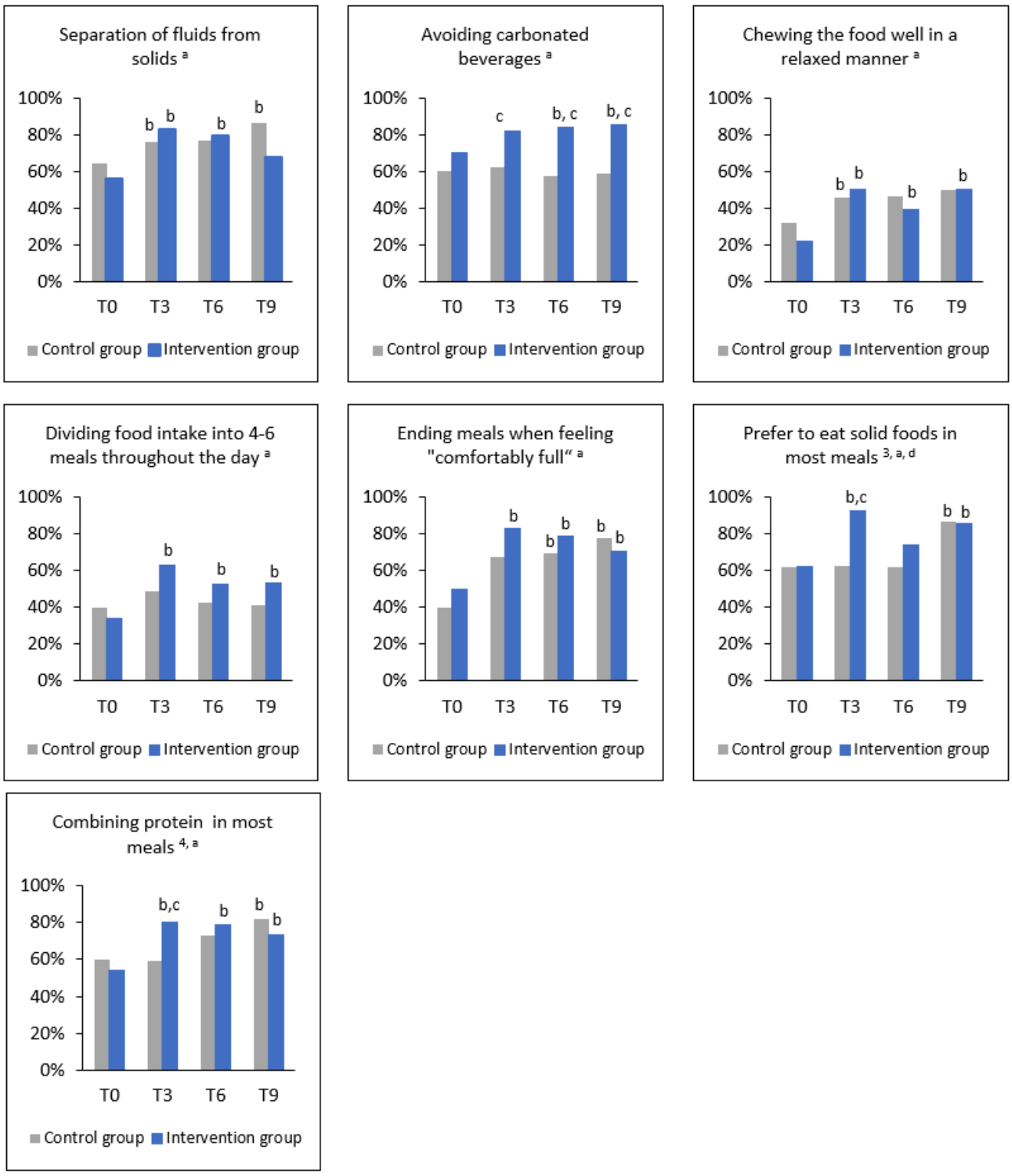
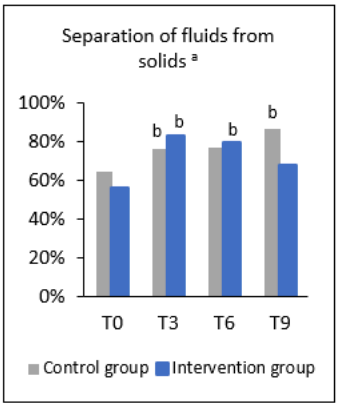
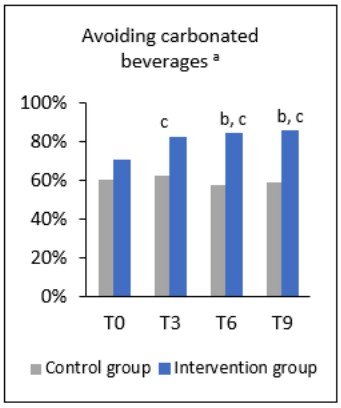
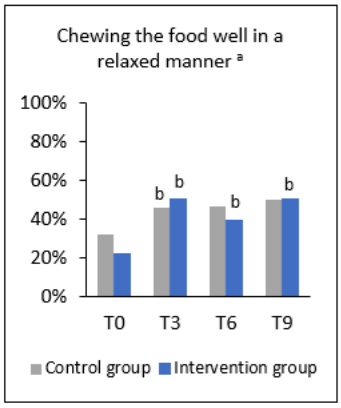


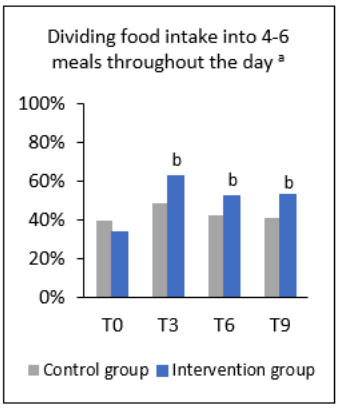
Figure 1

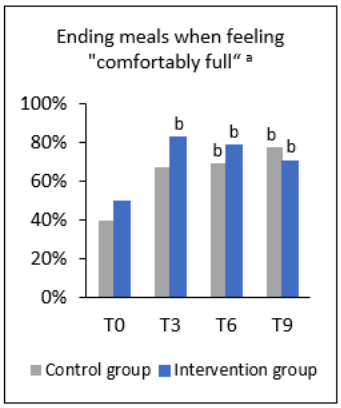
Adherence to eating behaviors over time [1,2]

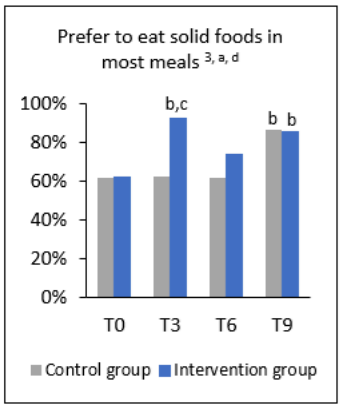


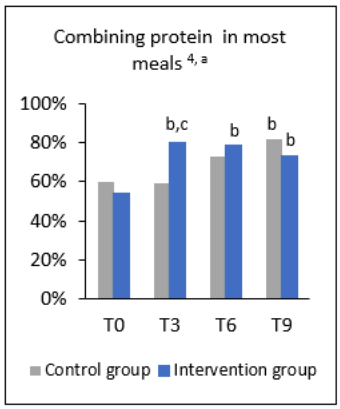












Abbreviations: Baseline (T0), post-intervention (T3), 3 months post-intervention follow-up (T6), 6 months post-intervention follow-up (T9).

[1] Data available for participants: n=50, n=40, n=38, n=34 for the intervention group and n=50, n=37, n=26, n=22 for the control group for T0, T3, T6, and T9, respectively.

[2] Patients were asked if they kept the following recommended behaviors during the last month (always maintained/partially maintained/did not maintain). The data represent the percentage of patients who answered that they always maintain this behavior.

[3] Preference to eat solid food items (e.g., boiled egg, chicken breast, salad) over soft or crunchy food items (e.g., ice cream, cookies, cakes, cookies) in most meals.

[4] Combining proteins (e.g., meat, poultry, fish, dairy, soy, lentils) in most meals.

[a] No between-group differences were found at baseline for any outcome variable ($p \leq 0.05$). [b] Within-group differences compared to baseline ($p \leq 0.05$). [c] Between-group differences at T3/T6/T9 ($p \leq 0.05$). [d] P Time*Group = $p \leq 0.05$ for interaction between the trend of change over time and the group effect.

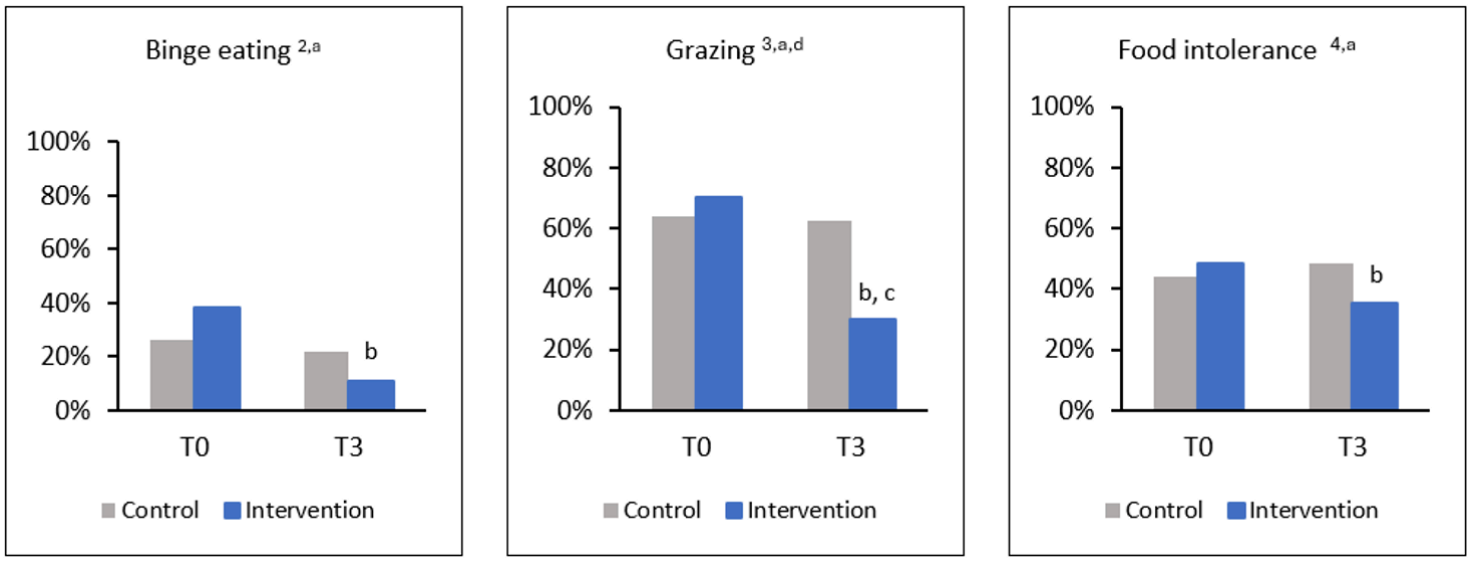


Figure 2

Reported maladaptive eating behaviors at the end of the intervention [1]

Abbreviations: Baseline (T0), post-intervention (T3), 3 months post-intervention follow-up (T6), 6 months post-intervention follow-up (T9).

[1] Data available for participants; Food intolerance: n=50 and n=40 for the intervention group and n=50 and n=37 for the control group for T0 and T3, respectively; Binge eating and grazing: n=50 and n=37 for the intervention group and n=50 and n=32 for the control group for T0 and T3, respectively.

[2] Patients were asked about having episodes of eating subjectively large amounts of food while experiencing a sense of loss of control at least once a week in the last 3 months. Data represents the percentage of patients who answered yes.

[3] Patients were asked if they tend to pick or nibble small amounts of food outside of planned meals in an unplanned way or on the go during the last month on a scale of 0 (never) to 4 (all the time). Data represents the percentage of patients who answered they do most or all the time.

[4] Patients were asked if there were any food items they could not consume due to intolerance (i.e., pain or discomfort after eating a small amount). The most common food intolerance items were red meat

(n=11), steak and pasta (n=9 each), fish (n=8), chicken and cuscus (n=5 each), and rice, potato, spicy and oily or fried food (n=4 each).

[a] No between-group differences were found at baseline for any outcome variable ($p \leq 0.05$).

[b] Within-group differences compared to baseline ($p \leq 0.05$).

[c] Between group differences at T3 ($p \leq 0.05$).

[d] P Time*Group = $p \leq 0.05$ for interaction between the trend of change over time and the group effect.

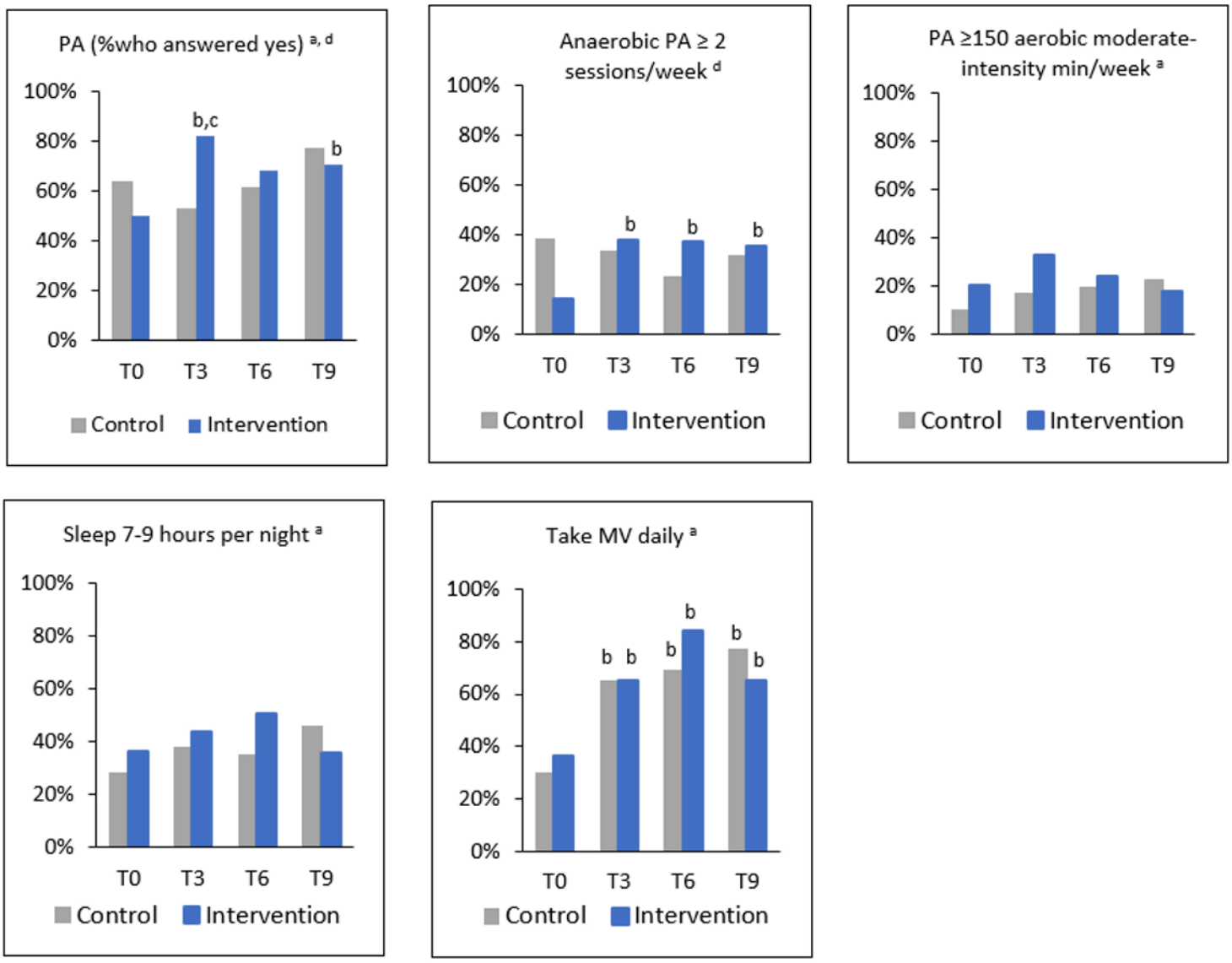
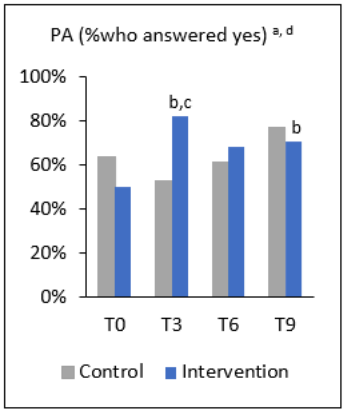
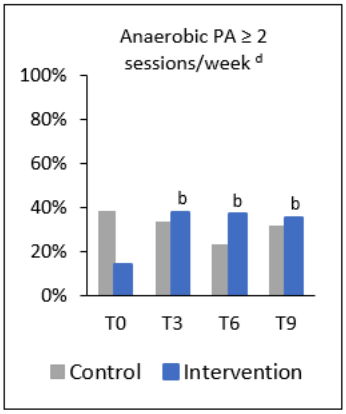
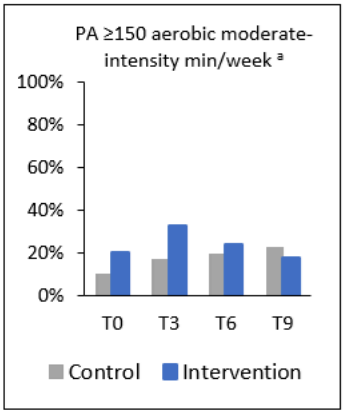


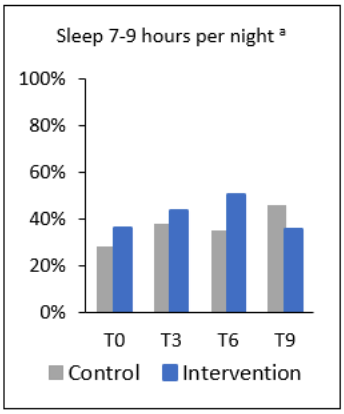
Figure 3

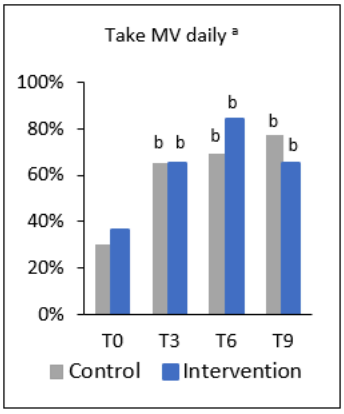
Adherence to lifestyle recommendations over time [1]











Abbreviations: Baseline (T0), post-intervention (T3), 3 months post-intervention follow-up (T6), 6 months post-intervention follow-up (T9), Physical Activity (PA), Multivitamin (MV).

[1] Data available for participants: n=50, n=40, n=38, n=34 for the intervention group and n=50, n=37, n=26, n=22 for the control group for T0, T3, T6 and T9, respectively.

[a] No between-group differences were found at baseline for any outcome variable ($p \leq 0.05$), except for anaerobic PA≥2 sessions/week. [b] Within-group differences compared to baseline ($p \leq 0.05$). [c] Between-group differences at T3/T6/T9 ($p \leq 0.05$). [d] P Time*Group = $p \leq 0.05$ for interaction between the trend of change over time and the group effect.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- SupplementaryFigure1.docx
- Supplementaryfigure2Detailedoverviewofthestudy.docx
- Supplementaryfigure3CONSORT.pdf
- SupplementaryTable2.pdf
- SupplementaryTable1.docx

- SupplementaryTable3.docx
- SupplementaryTable6Changesinthep.doc
- SupplementaryTable4.docx
- SupplementaryTable5.docx
- SupplementaryTable5.docx