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FULL LENGTH MANUSCRIPT

Adding Telephone and Text Support to an Obesity Management Program Improves Behavioral Adherence and Clinical Outcomes. A Randomized Controlled Crossover Trial

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Abstract

Background Behavioral treatment strategies improve adherence to lifestyle intervention for adults with obesity, but can be time and resource intensive when delivered via traditional face-to-face care. This study aimed to investigate the efficacy and optimal timing of using telephone calls and text message as adjunctive tools to support a community-based obesity management program.

Method This 8-month randomized controlled crossover trial recruited 61 adults with class III obesity (BMI > 40 kg/m^2) enrolled in a publicly funded obesity management service (OMS). Participants were randomly assigned to receive telephone and text message support in addition to standard OMS care, or standard OMS care alone. After 4 months, participants crossed over to the alternative sequence. The technological support was based on self-determination theory. Outcome measures included diet, physical activity, anthropometry, self-efficacy, and treatment self-regulation.

Results Telephone and text message support improved lifestyle intervention adherence and clinical outcomes when compared with standard care. Participants who received the intervention in the first 4-month period lost 4.87 kg, compared with no weight loss (+ 0.38 kg) in the standard care only group. There was no evidence to indicate an optimal timing of the intervention, with both groups achieving significant results by the end of the intervention.

Conclusion These results suggest a high degree of promise for the incorporation of telephone and text message support into community-based obesity management services. The findings have the potential to improve existing practices and reduce the burden on the health care system by demonstrating a resource-effective improvement to obesity management service delivery.

Keywords Obesity · Behavioral treatment · Technology · Text message · Telephone · mHealth · Telehealth · Adherence · Compliance · Weight loss

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Introduction

Reducing the prevalence of obesity remains a major public health challenge, demanding effective, broad-scale interventions to support weight management and health behavior change. The intensive approach to behavioral treatment seen within academic and commercial lifestyle intervention programs is often effective [1–3], but requires considerable resources, including time, money, and the availability of multiple health professionals with expertise in the behavioral treatment of obesity. It may therefore be considered too burdensome and expensive to be sustainable in a community environment [4, 5]. In order to translate the success of these interventions into community settings, we must explore innovative ways to adapt these approaches, while still maintaining the key features that led to their success.

Investigators are examining new modalities for delivering lifestyle intervention programs, and the use of technology has shown great promise in a variety of health domains, such as smoking cessation, hypertension, asthma, coronary heart disease, medication compliance, and diabetes [6–14]. While research on the use of technology in obesity management is in its infancy, it is an area that holds great promise as a mechanism for disseminating and supporting lifestyle intervention programs [10, 15–17]. Previous studies have shown that telephone calls and text messaging promotes weight loss, weight loss maintenance, and health behavior change in overweight and obese adults when investigated as stand-alone interventions [10, 18–31]. Little is known about whether telephone and text message support is an effective adjunct for patients with class III obesity (BMI > 40 kg/m^2) in addition to medically lead multidisciplinary specialist obesity care. This research is important and timely, as it has been suggested that technological approaches may be more useful as adjunct interventions, especially when the aim is long-term weight loss maintenance [30, 32].

Through telephone calls and text messaging, health professionals can offer continued support, motivation, accountability, reinforcement, and feedback between scheduled clinic visits. This form of technology therefore poses a unique opportunity for obesity management programs, and a range of health care services alike, to offer frequent patient-provider contact, prompting and reminders via a cost and time-effective platform [9, 10]. Additionally, it offers a convenient option of communication, which may be appealing to those who have difficulties accessing community clinics due to time, distance, or financial constraints [9, 16]. The convenient nature of technology-based communication is not only advantageous to the patient but also the health care service, affording potential benefits to patient access, flow, and human resource management.

The study was based on self-determination theory, with a range of behavioral treatment strategies targeted, including goal setting, self-monitoring, motivational interviewing, problem solving, relapse prevention, stimulus control, cognitive restructuring, and self-reinforcement. The intervention focused on promoting autonomous forms of dietary and exercise self-regulation and intrinsic motivation. Previous studies utilizing self-determination theory have shown that intrinsic motivation and autonomous self-regulation are reliably associated with improved diet and exercise adherence, improved attendance rates, greater weight loss and weight loss maintenance, and improved overall health outcomes [33]. Behavioral treatment strategies, such as motivational interviewing, problem solving, and self-monitoring, have also been shown to improve adherence to lifestyle intervention for adults with obesity [34]. Even without an intentional emphasis, regular telephone calls and text messages in themselves inherently tap important behavioral constructs such as reinforcement, social support, cues to action, stimulus control, and prompting. Individually tailoring the text messages was an important component of the study, as tailored messages have been shown to be more effective for health behavior change compared with generic messages [17, 35–37].

While the use of technology is a rapidly growing area, there has been insufficient research to date investigating the efficacy and feasibility of using telephone calls and text messaging as adjunctive tools within a community-based obesity management program. Exploring the use of technology among adults with class III obesity (BMI > 40 kg/m^2) is also imperative, as prior research involving this population group is extremely sparse [38]. This is the first study to explore the use of telephone calls and text messaging as adjunctive tools to support an established community-based obesity management program. The findings have the potential to improve existing practices, reduce the burden on the health care system, and increase accessibility to the millions of adults with obesity requiring long-term support.

Methods

Study Design

This 8-month randomized crossover trial was conducted between June 2017 and July 2018 in conjunction with a publicly funded, physician led, obesity management service (OMS). Participants were randomly assigned to receive 4 months of telephone and text support in addition to standard OMS care (tech-support), or standard OMS care alone (control). After 4 months, participants crossed over to the alternative sequence for four additional months. One group therefore received the tech-support intervention first, followed by the control condition (TS-C group), while the other group received the control condition first, followed by the tech-support intervention (C-TS group). No washout was included within the study design,

as a washout period would do little to remove the carry-over effect present for participants in the TS-C group. Rather, the carry-over effects have been accounted for within the analysis and interpretation of the findings. Figure 1 shows the study design from recruitment to 8 months. The study received approval from the ACT Health Human Research Ethics Committee (ETH.4.17.081) and the University of Canberra Human Research Ethics Committee. The study has been registered with the Australian New Zealand Clinical Trials Registry, ACTRN: 12617000459325. The conduct and reporting of this research follows the guidelines outlined by the Consolidated Standards of Reporting Trials (CONSORT) statement.

Subjects

Participants were recruited on a rolling basis from the pool of patients entering the OMS from June to December 2017. Patients of the OMS complete a 4-week education group at the beginning of the OMS program. The lead investigator recruited study participants by attending these education groups and introducing the research within this group setting. Interested patients provided their contact details and were later contacted via telephone to discuss the study in more detail and be screened for eligibility. All of the interested patients spoken to via telephone were deemed eligible to participate and were willing to do so.

Written informed consent was obtained from all study participants and no stipend was provided for participation. The OMS is available to self-managing adults (> 18 years of age) with class III obesity (body mass index > 40 kg/m^2) and comorbidity. Additional inclusion criteria were (a) access to a mobile phone; (b) sufficient technological literacy and English skills; (c) willing and able to receive three weekly texts and one monthly phone call over a period of 4 months; and (d) willing and able to attend follow-up assessments over a period of 8 months. Exclusion criteria were (a) psychiatric or medical condition that would preclude full participation in the

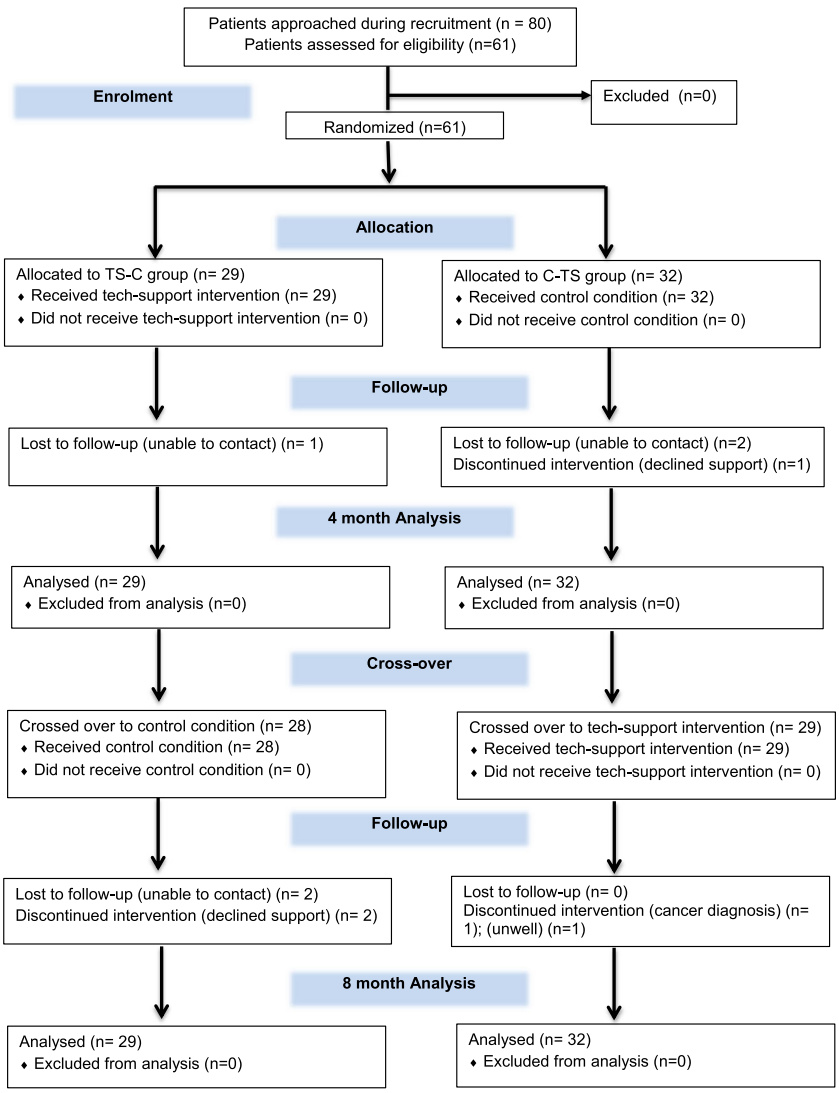

Fig. 1 Study design and participation from recruitment to 8 months

treatment. Participants were stratified based on age and gender and entered sequentially into four computer-generated randomization lists (female > 50 years; male > 50 years; female < 50 years; male < 50 years) by a trained researcher with no involvement in the study. Block randomization with randomly selected block sizes of either four, six, or eight were used to achieve balance within the intervention groups. Preliminary calculations indicated that a total of 50 participants were required for this trial to be adequately powered ($B = 0.80$) to detect a treatment difference at a two-sided 0.05 significance level [39]. This calculation takes into account an attrition rate of 25%, a figure commonly seen in this type of intervention [32, 40].

Interventions

Tech-Support Intervention

Telephone calls lasting 10–30 min (average call duration 21 min) were provided monthly throughout the intervention period. Motivational interviewing, goal setting, problem solving, stimulus control, and self-reinforcement were all targeted within these telephone calls, and participants were guided to set goals to work toward over the following month. These goals were highly individual, and varied month to month for every participant. Goals were generally related to physical activity (e.g., a daily walk), diet (e.g., reducing soft-drink intake), stress/mood (e.g., including a daily meditation practice), and sleep and lifestyle related habits (e.g., creating healthy habits such as meal planning, leaving work on time, going to bed at a reasonable hour). Participants were encouraged to self-monitor their chosen goals each month using their preferred self-monitoring method (e.g., paper or phone application). The behavioral treatment strategies utilized within the telephone calls were based on self-determination theory, and aimed to promote autonomous self-regulation, intrinsic motivation, and self-efficacy for behavior change. This was achieved by encouraging and supporting participants to develop their own individualized goals, as well as to problem solve and strategize around potential barriers to behavior change. The information gathered within these calls was then used to tailor and individualize the subsequent month of text messages. Three text messages were sent each week, aimed to remind or prompt participants to strive toward their goals, as well as foster a sense of support and accountability. The text messages aimed to endorse the autonomous motivation that was being promoted during the telephone calls, and strengthen it over the course of the month. The primary investigator conducted all of the telephone calls and text messages. Table 1 shows example text messages.

Control

The control sequence involved standard OMS care. The OMS uses a chronic disease care model and is a physician led program. It offers a holistic range of services delivered by a multidisciplinary team of health professionals, including doctors, nurses, psychologists, exercise physiologists, and dietitians. It is available to self-managing adults with class III obesity. Patients receive an initial appointment with a medical staff specialist where they are assessed for medical complications of obesity. They then attend a 4-week education group that includes education with an exercise physiologist, dietitian, psychologist, nurse, and doctor. These groups offer information regarding lifestyle management of obesity, pharmacotherapy, and surgery. Patients are then provided with individualized case management support. Case managers assess readiness to change, assist the patient to construct a self-management plan involving realistic and achievable goals, and arrange for ongoing allied health and medical appointments. Available lifestyle intervention strategies include dietary assessment and intervention, exercise physiology assessment and provision of exercise prescription (including optional weekly on-site physical activity classes), and a 6-week education group with the psychology team focusing on strategies to manage non-hungry eating. Patients are assessed by their OMS physician at 6 monthly intervals or more frequently if medically necessary. More intensive interventions such as very low energy diets and pharmacotherapy are prescribed where necessary, and a select number of patients are eligible to receive publicly funded bariatric surgery.

Outcome Measures

Outcome measures were obtained at baseline, 4, and 8 months by the primary investigator. Dietary adherence was measured using changes in dietary habits via the Fat and Fibre Behavior Questionnaire (FFBQ) [41, 42]. Physical activity adherence was measured by change in energy expenditure and steps using activity monitors worn for seven consecutive days. The SenseWear Pro3 Armband Mini was the chosen activity monitor due to its strong validity as an accurate and reliable tool to estimate energy expenditure during multiple activities, especially those of low-to-moderate intensity [43]. Participants were asked to wear the armband 24 h a day for seven consecutive days, only removing the armband when in water. Anthropometrical changes were measured using weight, body mass index (BMI), and waist circumference. Waist circumference was measured in the horizontal plane mid-way between the lowest rib and the iliac crest [44]. Eating self-efficacy was measured using the Weight Efficacy Lifestyle Questionnaire – Short Form (WEL-SF), an eight item self-report measure used to assess changes in weight management self-efficacy [45, 46]. Exercise self-efficacy

Table 1 Example text messages

Behavioral treatment strategy targeted	Example text message
Goal setting	How are you going with your exercise this week Joy? Have you done your 2*30min walks this week yet? Emily
Goal reminders/prompts	Are you remembering to pack your lunch this week Michael? Do not forget your goal to pack lunch 3 times this week. Emily
Preparatory and planned behavior prompts	Have you laid out your clothes for tomorrow's walk yet Prue? Remember you thought this would motivate you in the morning. Emily
Stimulus control	Have you planned your meals and done a grocery shop for this week yet Greg? If not get onto it tonight! Emily
Self-monitoring	How are you today Paul? Have you been recording in your food and exercise diary? Emily
Barrier identification and problem solving	Have you had to work late this week Trent? If so, remember your plan to go for a walk at lunch on the days you know you are working late. Emily

was measured using the Physical Activity Assessment Inventory (PAAI), a 13-item scale that asks respondents to rate how confident they are that they can perform their usual physical activity in a variety of circumstances [47]. Treatment self-regulation, a construct within Self-Determination Theory, was measured using the Treatment Self-Regulation Questionnaire (TSRQ) for diet and exercise [48, 49]. Both aim to assess the degree to which a person's motivation for a particular behavior or set of behaviors is relatively autonomous or self-determined.

Statistical Analysis

To account for the complex 2 × 2 crossover design, the data were analyzed with mixed-effects linear models using the R package lmer [50, 51]. A random intercept for subjects was included to account for intra-individual dependencies and inter-individual heterogeneity. This also allowed for individual baseline adjustments. Fixed effects were included for sequence (TS-C vs C-TS) and time (0, 4, 8 months). The sequence factor was a combination of the conditions and the order in which they were administered. By including this order effect and its interaction with time, the carry-over effect present for participants in the TS-C sequence was accounted for [52]. At no stage were the conditions pooled to assess treatment effect. All models were estimated using Restricted Maximum Likelihood. Visual inspection of residual plots did not reveal any obvious deviations from homoscedasticity or normality. *P* values were obtained using Type II Wald F tests with Kenward-Roger degrees of freedom as implemented in the R package car [53]. The significance levels were set to 0.05 and all significance testing was two-sided. Results are reported as mean estimates and 95% confidence intervals. No post hoc testing was performed which made multiple testing corrections unnecessary.

Results

A total of 80 OMS patients were approached during the recruitment phase of the trial. Of the 80 patients approached, a total of 61 patients posed interest in the trial and were assessed for eligibility. All 61 were deemed eligible and participated in the trial. The participants (women: $n = 47$, men: $n = 14$) had a mean age of 49 years ± 12.6 (25–74 years) and a mean BMI of 47.8 kg/m^2 ± 8.4 (31.2–79.2 kg/m^2). Baseline characteristics did not differ significantly between the two groups (Table 2). Of the 61 adults who began the trial, 93% ($n = 57$) completed the 4-month outcome measures, and 84% ($n = 51$) completed the 8-month outcome measures. There was an equal dropout rate between the two groups. All participants completed all four of their monthly telephone calls throughout the intervention period.

Anthropometric Variables

Significant time by condition interactions were seen for all of the anthropometric variables (Table 3). Within both groups, participants obtained greater reductions in weight, waist circumference, and BMI and achieved higher percentage weight

Table 2 Baseline characteristics by group

Variable	TS-C ($n = 29$) Mean (range)	C-TS ($n = 32$) Mean (range)
Age (years)	49 (25–72)	50 (31–74)
Gender (F:M)	23:6	24:8
Weight (kg)	138.4 (96.7–244.6)	126.1 (72.1–207.3)
BMI (kg/m^2)	49.7 (37.5–79.2)	46.1 (31.2–62.7)
Steps (daily)	4565 (751–10,520)	4688 (144–10,996)

TS-C, tech-support intervention followed by control period; *C-TS*, control period followed by tech-support intervention

Table 3 Estimated mean change and 95% confidence interval, time by condition interactions, and group comparisons for the TS-C and C-TS groups from baseline to 8 months

Variable	TS-C group Estimated mean change [95% CI]		C-TS group Estimated mean change [95% CI]		Time × condition interaction	Group comparison Estimated mean change [95% CI]
Weight (kg)						
4 months	TSC	−4.87 [−7.28; −2.47]	CTS	0.38 [−1.98; 2.74]	F (2,104.1) = 4.68, p = 0.01	8.93 [−6.72; 24.59]
8 months		−6.14 [−8.69; −3.59]		−2.76 [−5.19; −0.33]		
Waist circumference (cm)						
4 months	TSC	−3.84 [−5.93; −1.75]	CTS	1.68 [−0.36; 3.73]	F (2,104.3) = 6.76, p = 0.001	3.58 [−5.16; 12.32]
8 months		−4.78 [−6.99; −2.57]		−2.35 [−4.45; −0.24]		
BMI (kg/m^2)						
4 months	TSC	−1.74 [−2.55; −0.93]	CTS	0.10 [−0.69; 0.90]	F (2,104.2) = 4.94, p = 0.009	2.55 [−1.45; 6.55]
8 months		−2.11 [−2.97; −1.25]		−1.10 [−1.91; −0.28]		
Percentage weight loss (% kg)						
4 months	TSC	3.25 [1.54; 4.95]	CTS	−0.43 [−2.11; 1.25]	F (1,50.2) = 6.71, p = 0.01	1.44 [−1.01; 3.88]
8 months		3.61 [1.84; 5.36]		2.17 [0.47; 3.87]		
Diet (score)						
4 months	TSC	0.45 [0.31; 0.60]	CTS	0.32 [0.18; 0.46]	F (2,106.4) = 6.54, p = 0.002	0.06 [−0.18; 0.30]
8 months		0.41 [0.26; 0.56]		0.66 [0.52; 081]		
Steps (n)						
4 months	TSC	874 [84; 1663]	CTS	−575 [−1348; 197]	**F** (2,105.9) = 3.98, p = 0.02	−41.51 [−1495.77; 1408.59]
8 months		658 [−176; 1494]		1151 [353; 1949]		
Energy expenditure (calories)						
4 months	TSC	15 [−521; 551]	CTS	−494 [−1020; 31]	F (2,104.6) = 2.93, p = 0.05	458.80 [−1171.64; 2092.36]
8 months		−366 [−935; 201]		595 [53; 1136]		
Eating self-efficacy (score)						
4 months	TSC	15 [10; 20]	CTS	1 [−4; 6]	F (2,106.0) = 8.05, p = 0.000	7.14 [−1.79; 16.09]
8 months		13 [8; 19]		11 [6; 16]		
Exercise self-efficacy (score)						
4 months	TSC	259 [157; 361]	CTS	9 [−91; 108]	F (2,107.2) = 9.52, p = 0.000	98.77 [−49.00; 245.69]
8 months		203 [96; 311]		264 [162; 366]		
Diet self-regulation (score)						
4 months	TSC	0.69 [0.15; 1.24]	CTS	−0.12 [−0.65; 0.41]	F (2,107.2) = 2.17, p = 0.11	0.11 [−0.68; 0.90]
8 months		0.36 [−0.22; 0.93]		0.07 [−0.47; 0.62]		
Exercise self-regulation (score)						
4 months	TSC	0.36 [−0.16; 0.87]	CTS	−0.01 [−0.52; 0.49]	F (2,106.9) = 0.67, p = 0.51	0.56 [−0.22; 1.34]
8 months		0.34 [−0.20; 0.88]		−0.04 [−0.56; 0.47]		

TS-C, tech-support intervention followed by control period; *C-TS*, control period followed by tech-support intervention; *TS*, tech-support; *C*, control; *CI*, confidence interval

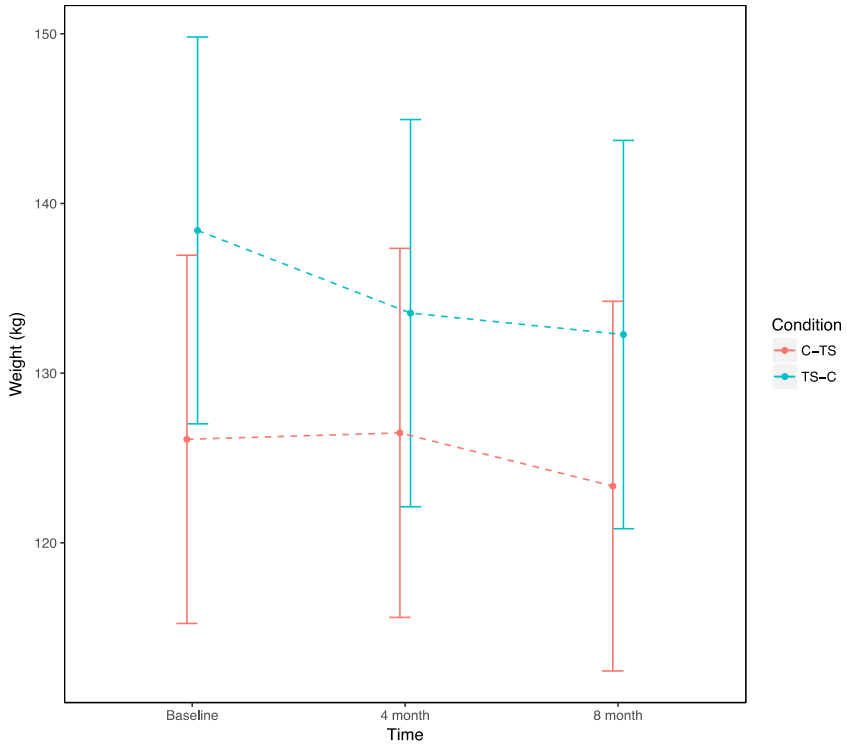

Fig. 2 Time by condition interaction for weight

losses while receiving the telephone and text support. Participants starting with the tech-support intervention (TS-C) achieved significant decreases in weight (− 4.87 kg), waist circumference (− 3.84 cm), and BMI (− 1.74 kg/m^2) at 4 months, maintaining these losses after crossing over to the control condition. For participants who started with the control condition (C-TS), no significant anthropometric changes were seen at 4 months. After crossing over to the tech-support intervention, significant reductions in weight (− 2.76 kg), waist circumference (− 2.35 cm), and BMI (− 1.1 kg/m^2) were achieved by 8 months. Figure 2 shows the time by condition interaction for weight.

Behavior Change Variables

A significant time by condition interaction was seen for dietary and physical activity adherence, with both groups achieving greater improvements in diet and physical activity while receiving the telephone and text support. Participants in the TS-C group significantly increased their steps (874 steps/week) and score on the FFBQ at 4 months, maintaining the increase in FFBQ at 8 months after crossing over to the control condition. Participants in the C-TS group significantly increased their FFBQ score within both time periods. No significant changes in physical activity were seen for the C-TS group at 4 months; however, after crossing over to the tech-support intervention, significant increases in both steps (1151 steps/week) and energy expenditure were achieved. Figure 3 shows the time by condition interaction for steps.

Psychological Variables

A significant time by condition interaction was seen for exercise and eating self-efficacy, with both groups improving their self-efficacy to a greater extent while receiving the telephone and text support. Participants in the TS-C group significantly increased their scores on the PPAI and WEL at 4 months, maintaining these increases after crossing over to the control condition. For participants in the C-TS group, there were no significant changes in self-efficacy at 4 months, but after crossing over to the tech-support intervention, this group significantly increased both PPAI and WEL scores. Figure 4 shows the time by condition interaction for eating self-efficacy. No time by condition interactions were seen for treatment self-regulation for diet or exercise.

Direct comparisons between the two groups revealed no significant differences for any of the outcome variables from baseline to 8 months. There is therefore no evidence to indicate an optimal timing of the intervention, with both groups achieving significant results by the end of the trial.

Discussion

The addition of telephone and text message support to a community-based obesity management program improved behavioral adherence and clinical outcomes when compared with standard care. Within both groups, participants achieved greater improvements in their diet, physical activity, and self-

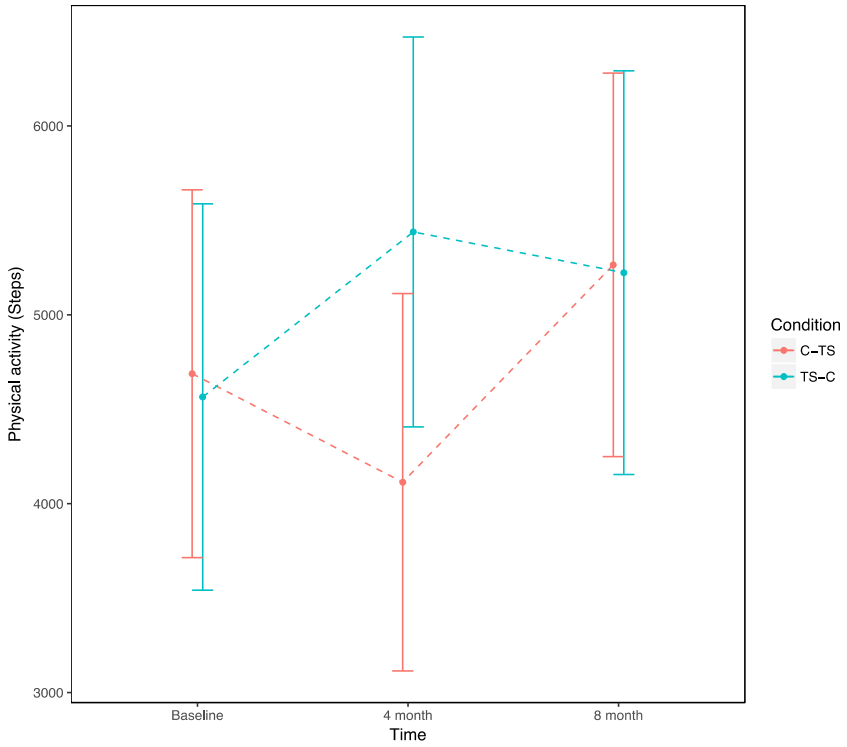

Fig. 3 Time by condition interaction for physical activity (steps)

efficacy and lost more weight while receiving the telephone and text support. The group who received the telephone and text support within the first 4-month period continued to lose weight after crossing over to the standard care period. This ability to maintain weight loss once the tech-support had ceased is an important finding. The behavioral treatment strategies incorporated within the intervention aimed to provide participants with long-term skills to self-manage their weight and lifestyle [34]. The results suggest this aim was successful, albeit over a short maintenance period. The early weight loss

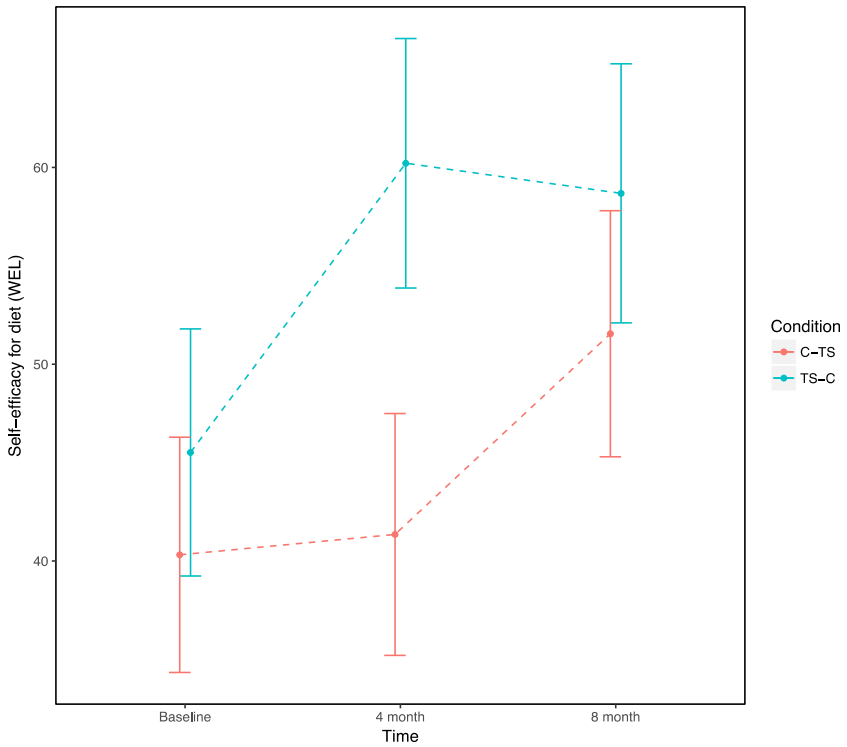

Fig. 4 Time by condition interaction for eating self-efficacy

achieved by this group may have boosted motivation and improved adherence and engagement with the OMS, with a recent systematic review finding that early weight loss success was one of the most prominent predictors of adherence to behavior change for adults with obesity [54]. The improvements seen for diet and self-efficacy were also maintained throughout the control period, which may have further contributed to the ongoing weight loss success. Achieving significant time by condition interactions across diet, physical activity, self-efficacy, and weight offers services confidence in the holistic implications of the intervention. Lastly, the results reveal that the timing of the telephone and text message support was not important, with both groups achieving similar outcomes by 8 months. This allows services to select the most appropriate timing of implementation according to their model of care.

Despite the rising prevalence of obesity worldwide, research focusing on obesity, specifically class II and III obesity, is surprisingly sparse. Much of the literature targets a population group with both overweight and obesity (e.g., inclusion criteria of BMI > 25 kg/m^2), and as a result, the average weight under investigation tends to fall within the overweight category. More commonly, researchers actively exclude participants with a BMI over a certain threshold (e.g., inclusion criteria of BMI > 25 kg/m^2 < 35 kg/m^2) [38]. Adults with obesity are therefore an under-represented group within the literature, in spite of widespread agreement that obesity is one of the major health epidemics of our time [55, 56]. This study investigates adults with class III obesity exclusively (inclusion criteria BMI > 40 kg/m^2). There have been a number of prior studies exploring lifestyle intervention, bariatric surgery, and pharmacotherapy in this population group [57–62]. However no prior research has investigated the efficacy of using telephone and text message support within a lifestyle intervention, weight loss, or obesity management program in adults with class III obesity [38]. The findings of this research are therefore novel and contribute significantly to the existing literature; however, we are unable to compare our results with prior research of the same nature. The positive findings are nevertheless consistent with previous research in adults with overweight and obesity that compare the use of telephone and text message support to no contact or self-directed controls, in extended contact maintenance interventions or to in-person treatment. Specifically, the improvements this study identified in regard to weight loss, physical activity adherence, and self-efficacy through the use of technology-based support have been demonstrated within prior research [10, 18–31]. For example, in a 1-year mobile phone operated weight loss program among 125 overweight individuals aged 25–44 years, the participants receiving diet education and support via text message lost significantly more weight and had a greater reduction in waist circumference, both short-term and over 12 months, than a no contact control group [21]. Similarly, in a randomized controlled trial among overweight adults, intervention participants who received exercise guidance and support via mobile phone engaged in over 2 h more physical activity per week than a control condition that received no support [23].

There are a number of important limitations of this study to consider. Although these results suggest a high degree of promise for the use of adjunct technological support, they arise from relatively small participant numbers. It will be necessary to study the use of this approach in a larger population within a variety of public health facilities. The study duration is comparable to many mHealth interventions looking at weight loss, although relatively short compared with trials investigating obesity management. More clinically significant results may be obtained with trials of a longer duration. A strength of the study was its ability to retain 93% and 84% of participants at the mid-way and final assessments, respectively. These figures are far better than those seen within previous research [63], and are a testament to participant's satisfaction with the trial.

In order for community and public health services to be viable long term, they must look at intervention feasibility, sustainability, and accessibility just as closely as intervention effectiveness. This study highlights the efficacy of using telephone calls and text messaging to support a face-to-face obesity management service; however, it is just one proposal with many more innovative ideas to be explored. Further research could look at other forms of technology, such as email, phone application, and website support. A rigorous cost benefit analysis is pertinent for all forms of technological support, especially in regard to contact frequency, duration, and level of text personalization. The way in which a text message is framed is another crucial consideration, with a person's receptiveness varying significantly depending on the wording, information, and tone [64]. A poorly framed text message may even act in detriment to encouraging behavior change. Individually tailoring text messages must involve ethical, socio-economic, education, sex, and age considerations. Stage of change must also be closely assessed in order for the support to be tailored appropriately. Care must be taken when treading the fine and constantly shifting line between supportive and intrusive. Further research exploring the appropriate framing of text messages for given population groups and stage of change is therefore warranted.

Researchers investigating the use of technology are encouraged to narrow their research focus to obesity exclusively (BMI > 30 kg/m^2), as well as including those with class II (BMI > 35 kg/m^2) and III (BMI > 40 kg/m^2) obesity. They are also encouraged to examine the use of technology when applied in conjunction with a lifestyle intervention or obesity management program. The majority of research to date has focused on the use of technology in extended contact interventions to promote the maintenance of lost weight, or on the

use of technology in comparison to standard care or a no contact control. While established obesity management programs may take interest in this existing mHealth literature, they require further research on the efficacy, feasibility, and practicality of implementing technology into their existing model of care.

Given the real-world context of the study, the findings make an important contribution to both research and clinical realms by informing possible improvements to obesity management service delivery, as well as to the broader field of services targeting health behavior change.

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Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflict of interest.

Ethical Approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

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