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The impact of Dietary Weight loss, Aerobic Exercise, and Daylong Movement on Social Cognitive Mediators of Long-term Weight loss

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Abstract

This report contrasts the impact of a dietary weight loss intervention (WL) paired with aerobic exercise (EX) and/or sitting less and moving throughout the day (SL) on self-efficacy for walking (hereafter walking self-efficacy) and satisfaction with physical functioning (hereafter satisfaction). Additional analyses examined dose-response associations between change in weight and changes in these key outcomes. Older adults (N = 112; age = 70.21 ± 4.43) were randomized to 6 months of WL+EX, WL+SL, or WL+EX+SL followed by a 12-month maintenance period. All groups reported increases in walking self-efficacy at month 6 with greater improvements in WL+EX and WL + EX+SL. Only WL+SL demonstrated improved walking self-efficacy at month 18. All conditions demonstrated improved satisfaction scores at both time points. Changes in walking self-efficacy and satisfaction were negatively associated with change in weight over the 6-month intervention and after the maintenance period. These results support the utility of WL + SL for improving key social cognitive outcomes in aging.

Keywords Obesity · Behavioral weight loss · Physical activity · Aging · Behavioral maintenance

Introduction

Obesity in older adults constitutes an enormous burden on the health care system and society in that it predisposes individuals to physical disability, a host of chronic diseases, and premature mortality (Gill et al., 2015; Houston et al., 2009; Rejeski et al., 2010). While it is well-recognized that state-of-the-art behavioral weight loss programs include physical activity to sustain maintenance of lost weight (Bergouignan et al., 2016; Physical Activity Guidelines Advisory Committee 2018; Piercy et al., 2018), in this context it is unclear how physical activity should be prescribed for older adults, since structured exercise often leads to a compensatory increase in sedentary behavior (Thompson et al., 2014) and the exercise behavior is rarely sustained upon termination of formal treatment (McEwan et al., 2022). In a recently completed randomized-controlled trial of weight regain in older adults with obesity (REDACTED), we compared caloric restriction for behavioral weight loss (WL) when it is coupled with one of three physical activity interventions: structured exercise (WL + EX), sitting less and moving more across the day (WL + SL), or a treatment involving both exercise and moving across the day (WL + EX + SL). Participants engaged in a 6-month "intensive" intervention comprising weekly in-person group meetings and a suite of self-monitoring tools. This was followed by a 12-month minimal contact period. All groups demonstrated a significant 6-month reduction in body weight, with no group differences. Groups that received SL improved total activity time and those who received EX improved moderate-to-vigorous activity time. Over the 12-month follow-up period, where there was minimal contact to examine weight regain, those who received WL + EX demonstrated greater weight regain relative to WL + SL. This secondary analysis examines the extent to which two social cognitive constructs that are central to the promotion of physical activity and quality of life in older adults—self-efficacy for walking and satisfaction with physical functioning—changed as a function of the three treatments. Finally, because the dose (i.e., amount) of weight loss has been found to be directly related

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to change in numerous health outcomes (Atukorala et al., 2016; Georgoulis et al., 2022; Wang et al., 2022) we also examine the associations between change in each outcome (self-efficacy for walking, satisfaction with physical functioning) and change in body weight.

A strong body of evidence indicates that well-designed structured exercise interventions increase older adults' self-efficacy and satisfaction with their physical functioning, and these are important social cognitive outcomes closely linked with quality of life and health behavior change (REDACTED; Katula et al., 2004; McAuley & Blissmer, 2000). However, the effects of these interventions quickly dissipate with the end of formal program support (McAuley et al., 1993, 2011). As a result, some researchers have worked to integrate physical activity into the lifestyle of older adults with a focus on accumulating recommended levels of physical activity throughout the day via an array of enjoyable activities, hereafter referred to as "daylong movement" (REDACTED; Sallis et al., 2006).

It is not surprising that long-term adherence to dietary weight loss and structured exercise is poor (McEwan et al., 2022). Both behaviors are highly complex and subject to dynamic physiological, psychological, social, and environmental influences. Social cognitive theory (Bandura 1986, 1997) outlines several constructs that drive both uptake and maintenance of challenging behaviors. The central construct in social cognitive theory is self-efficacy, which consistently emerges as a key cause and consequence of older adults' activity (McAuley & Blissmer, 2000) and eating behaviors (Ames et al., 2012) and can be defined as an individual's perceived ability to execute a very specific course of action (Bandura, 1997). Importantly, self-efficacy is modifiable through well-designed behavioral interventions—especially those that include goals that progress in difficulty, provide immediate and specific feedback, and that are social in nature (McAuley et al., 2011). In addition to driving adoption and maintenance of targeted eating and activity behaviors, self-efficacy perceptions are also closely related to numerous valued outcomes in aging including health-related quality of life (McAuley et al., 2006). A second social cognitive construct that is informed by self-efficacy perceptions, affects quality of life, and drives behavioral uptake and maintenance is outcome expectations (Bandura, 2004; Rejeski et al., 2001). In the context of a weight loss and physical activity intervention, weight loss and enhanced activity contribute to better physical functioning and in turn feelings of satisfaction with one's physical functioning (hereafter referred to as *satisfaction*). As a result, the individual is likely to develop positive attitudes toward weight loss and activity participation. Deficits in satisfaction are associated with physical disability and limitations to daily activities (Blalock et al., 1988; Katz & Neugebauer, 2001) and well-designed weight loss and exercise trials consistently produce improvements in satisfaction (Brawley et al., 2012; Rejeski et al., 2014). We previously demonstrated that a 6-month group-mediated intervention targeting weight loss paired with structured walking exercise among older adults produced significant improvements in self-efficacy for walking (hereafter referred to as *walking self-efficacy*) for extended durations and in satisfaction versus a weight loss only condition. These effects persisted across a one-year period of minimal contact (REDACTED).

In recent years, increased attention in the physical activity literature has been directed toward increasing physical activity via daylong movement as compared to structured exercise (Physical Activity Guidelines Advisory Committee 2018). A daylong movement approach to activity promotion is one that emphasizes achieving physical activity recommendations through frequent bouts of activity; indirectly breaking up sustained sitting time. For instance, one might engage in active commuting, chores around the home, or walking the dog while self-monitoring progress toward a daily step goal (Nicklas et al., 2014). Such an approach may present one method for addressing the limitations of structured exercise interventions. For example: (a) exercise programs do not train individuals to flexibly alter activity regimens in the face of boredom or daily barriers; (b) participation in structured exercise often contributes to compensatory sitting and reductions of activities of daily living; and (c) exercise is often not intrinsically enjoyable and is therefore difficult to sustain once behavioral supports are removed on completion of a program (Bonomi et al., 2013; Deci & Ryan, 2008; Martin et al., 2011; Melanson et al., 2013; Redman et al., 2009). This approach to activity promotion is also supported by the most recent Physical Activity Guidelines for Americans, which emphasizing moving more and more often and removed a recommended minimum bout duration for physical activity (Piercy et al., 2018). In one 12-week pilot study, older adults with chronic pain were randomized to receive dietary weight loss in combination with a daylong movement intervention or to a waitlist control (REDACTED). Those who received the active intervention demonstrated moderate improvements in walking self-efficacy and large improvements in satisfaction (REDACTED). To date, there are no data comparing dietary weight loss combined with either structured exercise and/or daylong movement on walking self-efficacy or satisfaction. Moreover, few researchers have published on the relationships between changes in these key constructs and changes in weight in the context of a weight loss intervention for older adults.

The primary purpose of this secondary analysis is to investigate changes in walking self-efficacy and satisfaction after the 6-month intensive phase of the intervention.

Additionally, we will investigate changes in self-efficacy and satisfaction at the final 18-month assessment, which followed 12 months of minimal contact with the research team. Notably, we have previously reported that participants in each condition lost a similar amount of weight over 6 months, but those in WL + EX regained significantly more weight during the 6- to 18-month maintenance phase as compared to WL + SL (REDACTED). Because of mounting evidence related to the favorable dose-response effects of weight loss on health outcomes (Atukorala et al., 2016; Georgoulis et al., 2022; Wang et al., 2022), we also examine the associations between weight loss and change in these outcomes.

The specific hypotheses included the following. First, at 6 months, all three treatment groups would experience improvement in each outcome. However, because WL + EX and WL + EX + SL trained in walking for exercise, we expect improvements in self-efficacy for walking to be greater in these groups relative to WL + SL. Second, as WL + SL demonstrated the best maintenance of weight loss over the 12-month minimal contact period (REDACTED), we expect better maintenance of walking self-efficacy and satisfaction across this period relative to WL + EX and WL + EX + SL.

Methods.

Participants.

The Empowered with Movement to Prevent Obesity and Weight Regain (EMPOWER) study was an 18-month, three-group, single-blind randomized trial (NCT02923674). Study design and detailed methods and CONSORT for the EMPOWER trial were previously published (REDACTED). Participants were recruited in six waves between 2016 and 2019 from Forsyth County and surrounding areas in North Carolina. The first five waves completed the 6-month intensive phase of the intervention prior to the onset of the COVID-19 pandemic in the United States and the implementation of local stay-at-home orders. As such we have restricted our analyses to these participants.

Eligible participants were aged 65–85 years, classified as having obesity with a body mass index (BMI) of 30–45 kg/m^2; not participating in regular resistance training and/or >20 min/day of other structured exercise in past 6 months; nonsmoking for at least 1 year; <5% weight change in past 6 months; and no insulin-dependent or uncontrolled diabetes, osteoporosis as verified via dual-energy x-ray absorptiometry scan, cognitive impairment (i.e., Montreal Cognitive Assessment < 22), clinical depression, anemia, heart disease, cancer, liver, renal, or chronic pulmonary disease, uncontrolled hypertension, major physical impairment, or any contraindication for weight loss or exercise. Additionally, participants were asked about their access to a personal smartphone device and willingness to use it for the study. Those without a device were given one for the duration of the study (18% of all randomized participants).

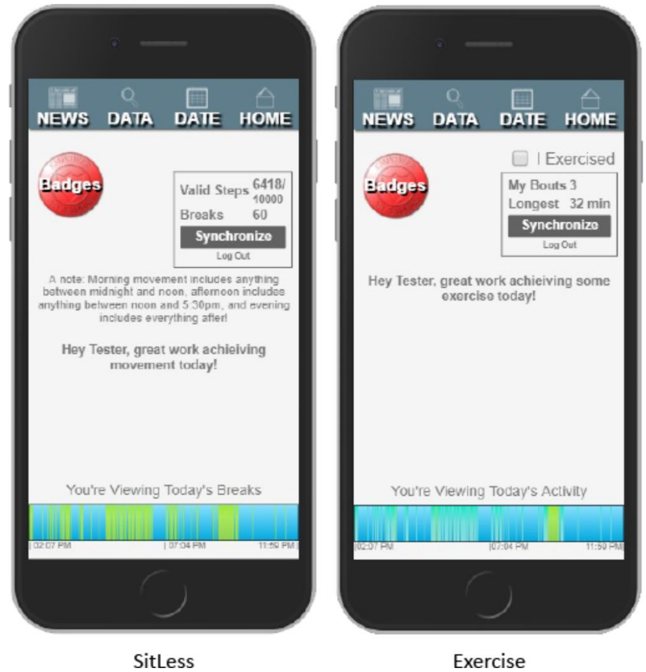

Fig. 1 Example EMPOWER Companion app screens. The bar across the bottom depicts patterns of Fitbit-based non-movement (blue) and movement (green/teal). For those who received the exercise component, sporadic movement in bouts < 10 min are displayed in teal and sustained movement in bouts of at least 10 min are displayed in green

Randomization.

In total, 1,655 participants were pre-screened via telephone, 183 participants were randomized in a 1:1:1 fashion to one of the three study treatment arms: WL + EX, WL + SL, or WL + EX + SL. A total of 151 participants were randomized in the first 5 waves of EMPOWER.

Interventions.

During the initial 6-month intensive intervention phase, all participants met once weekly in group-mediated dietary weight loss sessions. Each participant received a Fitbit Alta activity monitor, which was paired with a custom EMPOWER "Companion" smartphone app (see Fig. 1 for example screens). This app displayed condition-specific feedback on physical activity (see below), reinforced success through group-specific "mastery" badges (REDACTED) and facilitated contact between group members and group leaders during the week (REDACTED). After the initial intensive period, participants transitioned to a 12-month maintenance period, which included a 3-month transition phase wherein participants met twice monthly, and a 9-month no-contact period. Participants retained access to study technologies throughout the full 18-month study period.

Dietary Weight Loss (WL).

All participants aimed to achieve 7 −10% weight loss from baseline body mass through a weekly caloric restriction goal of approximately 400 kcal/day from weight maintenance requirements. Participants aimed to consume approximately 25–30% of energy from protein, 20–35% from fat, and 45–55% from carbohydrates, and participants tracked progress toward daily dietary goals via paper or digital food log. To support adoption and adherence to these goals, participants met each week in the first 6 months of the program in small peer groups led by a behavioral interventionist and registered dietician. These sessions were designed using principles of social cognitive theory (Bandura, 1997) and group dynamics (Brawley et al., 2000) with an emphasis placed on developing self-regulatory skills, strengthening social support, developing knowledge and awareness, and experiencing the interplay between physical activity, mindfulness, and eating. The content of these sessions was further tailored to each group's unique activity recommendation (see reference (REDACTED) for details on the weight loss component of the interventions).

Aerobic Exercise (EX).

Participants randomized to the WL + EX and WL + EX + SL conditions engaged in walking at a moderate-to-vigorous intensity on 4–5 days per week (65–70% heart rate reserved as calculated from a graded maximal exercise test). This was accomplished primarily as supervised treadmill walking. Duration of exercise progressed to 40–50 min by the sixth week of the program. Each session completed with a 3–5-minute cooldown followed by 5 min of large muscle flexibility stretches. During the initial 6-month intensive phase of EMPOWER, participants aimed to attend supervised exercise sessions at least 3 times weekly, with the remaining sessions conducted in the home or community. Participants received guidance on self-monitoring exertion using Rating of Perceived Exertion with a target rating of 13–15 (Borg, 1973).

As a self-monitoring tool, participants self-reported exercise by selecting "I exercised" within the Companion app. Additionally, given the focus on sustained aerobic exercise, the participant's Companion app highlighted activity bouts of at least 10 min in two ways. First, a timeline bar displayed on the bottom of the screen depicted patterns of movement throughout the day in near real time based upon data from the Fitbit device. Inactive minutes (0 steps) were displayed in blue, non-bouted minutes of stepping activity (i.e., those lasting less than 10 min) were marked in pale green, and bouts lasting at least 10 min were marked in bright green. Additionally, the app displayed minutes spent in activity bouts of at least 10 min. See (REDACTED) for more information.

SitLess (SL).

Those randomized to the WL + SL and WL + EX + SL conditions aimed to increase the amount of time they spent in physical activity while indirectly breaking up sitting time by engaging in frequent bouts of activity. In addition to weight loss, the SL group content focused on finding ways to engaging in light and moderate-to-vigorous intensity lifestyle activities across the day. This was reinforced by several feedback mechanisms within the Companion app. As with the EX condition, SL participants were instructed to view their patterns of activity using the timeline bar within the app. However, this timeline bar simply marked all movement (i.e., minutes with > 0 steps) as green, and all non-movement minutes in blue. Participants were instructed to attempt to achieve a "tree rings" profile. That is, participants sought to have stripes of green evenly dispersed throughout the day. This was further supported by a "periodic step goal." Participants aimed to increase their daily step goal by up to 25% each week, and these goals were set in collaboration with the group leader with a maintenance limit of 10,000 daily steps. To disincentivize engaging in a single bout of sustained walking followed by prolonged sedentary behavior, participants could earn up to 45% of their daily steps prior to 12:00pm, 45% could be earned between 12:00pm and 5:30pm, and 45% could be earned after 5:30pm. Thus, achieving a daily step goal required movement during each period of the day. See (REDACTED) for more detail.

Outcomes.

Blinded research staff collected measures at baseline prior to randomization and again at 6 months. Body weight was assessed on the same calibrated scale within the clinical research center. Satisfaction with physical functioning was assessed using a 6-item scale developed originally by Ray and colleagues (Ray et al., 1996). Individuals were cued to rate their satisfaction with various components of physical function. Example items include "currently, how satisfied are you with your overall level of physical fitness?" or "currently, how satisfied are you with your overall level of energy?". Responses are provided on a 7-point scale ranging from −3 (very dissatisfied) to + 3 (very satisfied), and the final satisfaction score is an average of these 7 items. Reboussin and colleagues (2000) demonstrated that all six items loaded on a single dimension with a Cronbach alpha of 0.94. Rejeski and colleagues demonstrated that the satisfaction had a 1-3-week test-retest reliability of 0.73, and we have previously demonstrated it is responsive to change in the context of physical activity and weight loss randomized trials (REDACTED). Walking self-efficacy was assessed using an 8-item scale that queried participants on their perceived ability to walk at a moderate pace without stopping for 5, 10, 15, 20, 25, 30, 35, and 40 min. Responses were provided on an 11-point scale such that 0 indicated "not at all confident" and 10 indicated "high confidence". The final

Table 1 *Participant characteristics. Notes: M = mean; SD = standard deviation; BMI = body mass index, kg/m²; Peak VO2 (mL/kg/min), self-efficacy and satisfaction scores are baseline values; WL = dietary weight loss; EX = aerobic exercise;*[a]*Complete* peak VO2 data available on 104 participants (WL + EX n = 36, WL + EX + SL n = 30, WL + SL n = 38)

	WL + EX (n = 40)	WL + SL (n = 33)	WL + EX + SL (n = 39)	All (N = 112)
Age; M(SD)	70.49 (4.08)	69.66 (5.04)	70.54 (4.15)	70.21 (4.43)
BMI; M(SD)	35.76 (3.87)	35.77 (3.73)	34.66 (3.62)	35.44 (3.75)
Race; n(%)				
White	33 (82.5)	28 (71.8)	23 (69.7)	84 (75)
Black	5 (12.5)	10 (25.6)	10 (30.3)	25 (22.3)
More than one	2 (5.0)	1 (2.6)	0 (0.0)	3 (2.7)
Sex; n(%)				
Male	9 (22.5)	11 (28.2)	8 (24.2)	28 (25)
Female	31 (77.5)	28 (71.8)	25 (75.8)	84 (75)
Hypertension; n(%)	28 (70)	22 (66.7)	24 (61.5)	74 (66.1)
Diabetes; n(%)	3 (7.5)	4 (12.1)	7 (17.9)	14 (12.5)
Arthritis; n(%)	27 (67.5)	25 (75.8)	26 (66.7)	78 (69.6)
Peak VO2; M (SD)[a]	19.3 (3.1)	20.6 (4.0)	19.6 (5.1)	19.8 (4.2)
Self-Efficacy; M(SD)	6.7 (2.11)	6.11 (3.11)	7.22 (2.44)	6.65 (2.61)
Satisfaction; M(SD)	-0.93 (1.52)	-0.91 (1.54)	-0.40 (1.53)	-0.77 (1.54)

walking self-efficacy score is computed as an average of these 8 items. This scale was developed based on Bandura's methodology (1986, 2006) and we have previously demonstrated it is amenable to change in the context of a physical activity weight loss intervention (REDACTED).

Statistical Analyses.

Descriptive statistics, including mean and standard deviation for continuous variables and N (%) for categorical variables, are presented to describe the sample at baseline. To determine whether changes in satisfaction and self-efficacy differ by intervention assignment, we first conducted separate analyses of covariance, including group assignment as a between-subjects factor, the outcome of interest (self-efficacy or satisfaction) at 6- or 18-months as the dependent variable, and the baseline value of the dependent variable and participant sex as covariates. Post-hoc paired samples t-tests conducted within each group were used to investigate whether scores changed over time. Levene's test was utilized to verify homogeneity of variances and normality of residuals was confirmed via skewness Z scores. Raw walking self-efficacy data were negatively skewed, which was improved by applying a reflected natural log transformation to measures at each timepoint. The sign for each resulting regression or correlation coefficient has been inverted in text to assist in interpretation. Finally, to examine whether change in self-efficacy and satisfaction were associated with change in weight, we conducted a series of Pearson correlations between residualized change in body weight and residualized change in self-efficacy and satisfaction at month 6 and 18, each accounting for baseline values. Within each analysis, significance was established at $p \leq 0.05$. Additionally, as a sensitivity analysis, we repeated all analyses following multiple imputation with five imputations across the waves of participants who received EMPOWER prior to COVID-related stay-at-home orders. As interpretation was not meaningfully altered by this approach, results from original non-imputed analyses are presented herein.

Results

Participant Characteristics.

In total, 112 participants engaged in the first 5 waves of EMPOWER and provided data at baseline, month 6, and month 18. Participant characteristics at baseline are displayed in Table 1. The average age at baseline was 70.21 ± 4.43 years. The majority of participants were white (75.0%), female (75%), and had obesity (35.44 ¬± 3.75 kg/m²). A table comparing demographic characteristics and baseline self-efficacy and satisfaction scores in those with and without complete data is provided in Supplemental Table 1. Note there were no statistically significant differences identified in these comparisons.

Intervention-related changes in self-efficacy for walking and satisfaction with physical function.

Marginal means for each ANCOVA model, alongside results of within-group post-hoc paired t-tests are found in Table 2; Fig. 2. An ANCOVA controlling for baseline values and sex revealed a significant main effect for group assignment on transformed self-efficacy for walking scores at month 6; $F(2,107) = 6.137$, $p < .05$, $\eta^2 = 0.103$. Post-hoc analyses indicated that both WL + EX and WL + SL+EX demonstrated significantly higher self-efficacy at month 6 relative to WL + SL (*p*s < 0.05). Notably, paired t-tests indicated that all groups improved significantly from baseline to month 6 (*p*s < 0.05). Regarding satisfaction with function, ANCOVA models revealed no significant group effects at month 6. A series of paired t-tests revealed significant improvements in satisfaction scores in each group from baseline to month 6 (*p*s < 0.05).

Table 2 Marginal means [M (95%CI)] for self-efficacy for walking and satisfaction with function, adjusted for baseline values and sex. Notes: due to a negative skew and heterogeneous variances, self-efficacy scores were reflected, and log transformed. Back-transformed scores are presented here. [a]=significant within-group change from baseline to month 6; [b]=significant within-group change from baseline to month 18; [c]=significant within-group change from month 6 to 18; WL = dietary weight loss; EX = aerobic exercise; SL = the SitLess daylong movement program

	Self-Efficacy		Satisfaction with Function	
	Month 6	Month 18	Month 6	Month 18
WL + EX	9.41 (9.07, 9.69)[a]	8.19 (7.45, 8.78)[c]	0.83 (0.43, 1.23)[a]	0.14 (-0.36, 0.64)[bc]
WL + SL + EX	9.43 (9.06, 9.73)[a]	8.15 (7.30, 8.79)[c]	1.10 (0.65, 1.54)[a]	0.50 (-0.05, 1.05)[bc]
WL + SL	8.57 (8.05, 9.00)[a]	8.35 (7.64, 8.91)[b]	0.71 (0.30, 1.11)[a]	0.12 (-0.38, 0.63)[bc]

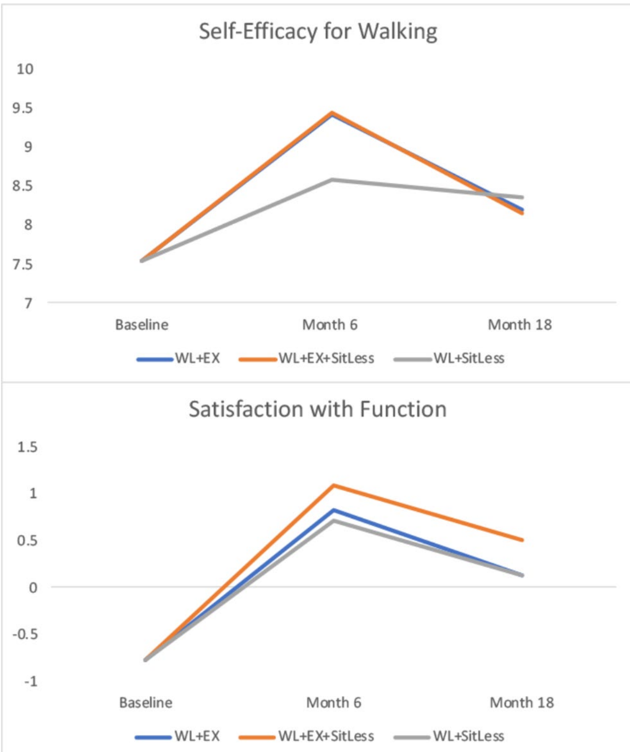

Fig. 2 Marginal means for self-efficacy for walking (top panel) and satisfaction with function (bottom panel), adjusted for baseline values and sex. Note: self-efficacy for walking values were reflected and transformed due to non-normality and heterogeneous variances; the data presented here have been back transformed

Changes in self-efficacy for walking and satisfaction with physical function during the minimal contact phase.

At month 18, an ANCOVA revealed there was no longer a significant difference in self-efficacy between conditions. A series of paired t-tests indicated that WL + EX and WL + EX + SL both decreased significantly from 6 to 18 months (*p*s < 0.05) such that scores at month 18 were not significantly different from baseline. WL + SL did not decrease during this period, and scores at 18 were significantly higher than baseline ($p < .05$). Regarding satisfaction with function, there was no significant difference between groups at month 18. Paired t-tests revealed significant improvements in satisfaction scores in each group from baseline to month 18 (*p*s < 0.05), though scores did decrease during the maintenance period (*p*s < 0.05).

Relationships between changes in body weight and change in self-efficacy for walking and satisfaction with physical function.

Relationships between residualized change in body weight at month 6 and 18 and residualized change in self-efficacy and satisfaction are depicted in Fig. 3. and Table 3. Change in body weight following the intensive 6-month intervention period was negatively and weakly related to change in transformed walking self-efficacy (r = -.23, $p < .05$) and moderately, negatively associated with satisfaction (r =-.36, $p < .05$). These relationships strengthened at month 18 such that change in self-efficacy (r=-.43, $p < .05$) and satisfaction (r=-.54, $p < .05$) were both moderately negatively associated with change in body weight.

Discussion

Our results support the first study hypothesis: regardless of group assignment, participants demonstrated improvements in self-efficacy and satisfaction following the 6-month intervention weight loss and physical activity intervention. Additionally, as expected, participants who received an exercise intervention focused on sustained walking demonstrated significantly better self-efficacy for walking relative to those who did not (WL + SL). The second study hypothesis was only partially supported: where both WL + EX and WL + EX + SL regressed to baseline levels of self-efficacy for walking by month 18, only WL + SL did not significantly decrease self-efficacy scores, sustaining a significant increase over baseline. Interestingly, counter to our hypotheses, all groups demonstrated maintenance in satisfaction scores. This is the first study to directly compare the impact of structured exercise and/or a program involving daylong movement on two key social cognitive outcomes associated with health behavior change and health-related quality of life in older adults. That a daylong movement program yielded significant improvements in self-efficacy and satisfaction is promising, since such an approach is likely to be more feasible and sustainable for a larger segment of the older adult population. As our data suggest, this is most

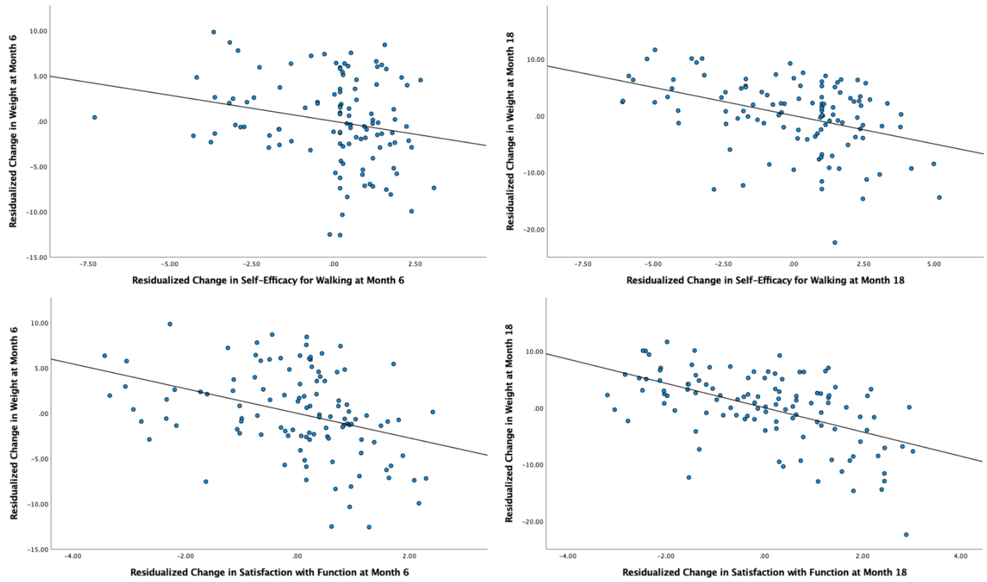

Fig. 3 Relationships between residualized change in body weight, and self-efficacy for walking and satisfaction with function at 6 and 18 months

Table 3 Correlations between residualized change in body weight and residualized change in self-efficacy for walking and satisfaction with physical functioning

	Residualized Change in Body Weight (Month 6)	Residualized Change in Body Weight (Month 18)
Residualized Change in Self-Efficacy for Walking	−0.23	−0.43
Residualized Change in Satisfaction with Physical Function	−0.36	−0.54

evident once the intensive social and infrastructural supports of a structured intervention are removed. To this end, as we have previously published (REDACTED), individuals who received WL + SL regained the least weight after the 6-month intensive intervention period.

Finally, in support of our third hypothesis we demonstrated that weight loss during the initial 6-month intervention was inversely associated with change in self-efficacy and satisfaction. Perhaps more interesting was the finding that relationships between change in weight and change in walking self-efficacy and satisfaction strengthened at the 18-month time point. This followed 12 months of minimal contact wherein participants sought to sustain their weight loss without the structural benefits of the 6-month intervention period (e.g., weekly meetings with feedback from the intervention staff). One explanation for this effect may be that program-related weight loss resulted in individuals feeling more confident in and satisfied with their physical functioning. However, counter to this interpretation is evidence from a previous clinical trial (REDACTED) demonstrating that participation in dietary weight loss plus exercise yields significantly better walking self-efficacy and satisfaction with function scores relative to a group who achieved their weight loss only via dietary means. More likely is that these relationships operate bidirectionally. This notion is supported by social cognitive theory wherein Bandura (1997) notes that better perceptions of self-efficacy and more positive outcome expectancies drive future participation in a behavior such as activity for weight management. Conversely, success resulting from this behavior drives improvements in self-efficacy to continue the behavior, and when that behavior results in notable physical and psychological outcomes (e.g., weight loss, improved mood), individuals are likely to expect future participation to yield similar benefits. Our findings suggest that these relationships may strengthen in the absence of more external forms of regulation, such as accountability to a coach or peers.

Strengths and Limitations.

There are several notable strengths to this study. EMPOWER included a fairly long intervention period (6 months) and a year-long follow-up, providing highly valuable data on ratings of self-efficacy and satisfaction following cessation of the structured intervention period. It employed a novel intervention designed to promote the accumulation of physical activity throughout the day. Such an approach indirectly breaks up prolonged sedentary time and aligns closely with recent revisions to the Physical Activity Guidelines for Americans, which emphasize a "move more, more often" approach to achieving sufficient levels of activity and for combatting obesity (Piercy et al., 2018). Each condition was supported by an evidence-based mHealth app, which aimed to support self-efficacy through immediate and specific feedback, and we provided smartphone devices for participants who did not own a device.

There are also several notable limitations that must be acknowledged. Due to the onset of the COVID-19 pandemic and associated stay-at-home orders, only 151 individuals were eligible to participate and 112 provided sufficient data for the present analysis. Of these individuals, 22.3% were Black, which is a lower percentage than the community in which the program was delivered (34.9%; (*REDACTED*), and 75% were female. This limits the generalizability of our findings and warrants replication in samples with greater male and non-White representation. Additionally, the design of this study neither permitted us to test mechanistic hypotheses, such as whether changes in weight loss and maintenance were driven by changes in walking self-efficacy or satisfaction, nor was there a no treatment control group for comparison. These represent exciting areas for future research for those conducting daylong movement interventions. Finally, we restricted our study sample to community-dwelling older adults with no contraindications to dietary weight loss or participation in physical activity. Additional work should investigate the health effects of a weight loss and daylong movement intervention among clinical populations who may benefit from more frequent activity such as those with diabetes or undergoing cancer treatment.

Conclusion

Perceptions of confidence in and satisfaction with one's physical function are highly important outcomes for older adults. Self-efficacy and satisfaction with function are closely tied to the adoption and maintenance of health behaviors as well as perceptions of health-related quality of life. Our findings add to recent public health guidance that health promotion professionals should demonstrate flexibility in the ways in which physical activity is prescribed for older adults. While some may resonate with the experience of traditional structured exercise, many do not. For these individuals, programs focused on daylong movement may contribute to improved self-efficacy and satisfaction, which in turn is associated with both short-term weight loss and the maintenance of lost weight. Future work should focus on better understanding the key behavior change techniques required to promote the accumulation of physical activity as a means of obesity treatment and weight management in large and diverse populations.

Tables.

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Conflict of interest The authors declare no conflicts of interest.

Ethics approval **, human and animal rights, and informed consent.** All procedures performed herein 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 standard. Informed consent was obtained from all individual participants included in the study.

Consent for publication N/A.

Data Availability Data may be made available upon request at discretion of the authors.

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