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BRIEF REPORT

Improvement in 6-min Walk Test Distance Following Treatment for Behavioral Weight Loss and Disinhibited Eating: an Exploratory Secondary Analysis

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Abstract

Background Poor functional exercise capacity is common among those with obesity; however, objective measures of exercise capacity are rarely examined in behavioral treatments targeting obese individuals. We examined whether a 4-week acceptance and commitment therapy (ACT) intervention for disinhibited eating or a behavioral weight loss (BWL) intervention improved exercise capacity and explored demographic and disinhibited eating variables related to exercise capacity.

Methods Veterans ($n = 61$), randomized to receive ACT or BWL, completed an assessment of exercise capacity via the 6-min walk test (6MWT) at baseline and 6-month follow-up. Measures of disinhibited eating patterns and body mass index (BMI), at baseline and post-treatment, were also collected. Change in 6MWT distance and treatment group differences were examined using mixed ANOVAs. Characteristics related to baseline 6MWT and predictors of improvement in 6MWT at 6 months were examined with hierarchical multiple regression.

Results There were overall significant improvements on the 6MWT from baseline to 6-month follow-up ($F(1,59) = 11.14$, $p = .001$, $\eta_p^2 = .159$) but no differences between the ACT and BWL groups. Baseline BMI ($\beta = -.33$, $p = .005$) was the only variable related to baseline 6MWT. Improvements on the 6MWT were related to younger age ($\beta = -.41$, $p = 0.001$), female gender ($\beta = .36$, $p = .001$), and treatment-related increases in dietary restraint behaviors ($\beta = .42$, $p = .001$).

Conclusions Functional exercise capacity improved among participants completing behavioral interventions for weight and disinhibited eating. Improvements in dietary behavior regulatory skills may have generalized to improved regulation in other behavioral domains associated with exercise capacity.

Keywords Disinhibited eating · Exercise capacity · Obesity · Restraint eating

Introduction

Functional exercise capacity, a person's exercise-related ability in a controlled laboratory setting, is thought to underlie physical activity [1], mobility [2], disability [3], and overall physical functioning [2, 4]. Functional exercise capacity is often diminished among individuals with obesity [5] and lower among individuals with obesity who engage in binge eating when compared to those with obesity alone [4]. There is also evidence that functional exercise capacity can be improved through changes to diet and exercise leading to weight loss and improved physical activity independent of weight loss [6–9].

Increasing physical activity is a cornerstone of behavioral treatments that target obesity and weight loss maintenance [10, 11]. However, improvements in functional exercise

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capacity are rarely assessed, especially during weight loss maintenance. The 6-min walk test (6MWT), a common measure of functional exercise capacity [12], is frequently used to assess response to treatment for the pulmonary and cardiac disease [12]. Many studies report relationships between 6MWT distance and physiological measures such as peak oxygen capacity [13] but limited research has examined how it relates to health behaviors or psychosocial constructs. As functional exercise capacity relates to many components of physical function [1–4], it is an important, but less utilized outcome in behavioral medicine interventions. The 6MWT is a relatively low burden, safe, and easy to administer assessment of functional exercise capacity [12]. Determining relationships among the 6MWT and psychosocial constructs may help to better understand the mechanisms involved in our study and help refine future intervention development.

Current Study

The current study examines changes in 6MWT outcomes following two different adjunctive behavioral treatments for veterans with overweight or obesity and disinhibited eating. In a previous study designed to address disinhibited eating [14], we examined acceptance and commitment therapy (ACT) compared to continued behavioral weight loss (BWL) treatment in veterans who had recently completed the Veterans Health Administration (VHA) standard behavioral weight loss intervention but endorsed continued disinhibited eating. Disinhibited eating was defined as objective binge eating, subjective binge eating, binge eating of low frequency and/or limited duration, overeating without loss of control, and emotional eating [15]. We found significant improvements at post-treatment on measures of binge eating, other disinhibited eating patterns, and BMI, with minimal differences between groups [14]. The purpose of the current study was to conduct exploratory secondary analyses to (1) examine if there were improvements in 6MWT distance from baseline to 6 months and whether these differences varied by treatment group, (2) identify participant characteristics associated with 6MWT distance at baseline, and (3) explore disinhibited eating outcome variables in relation to change in functional exercise capacity following treatment. Research questions were exploratory and we did not make formal hypotheses.

Methods

Participants

Participants were US military veterans who had completed the aforementioned ACT and BWL interventions following participation in MOVE!©, the VHA's evidence-based multidisciplinary weight management and health promotion program. Inclusion criteria were ages 18–75, BMI > 25 kg/m^2, and participation in at least 5 of 8 MOVE!© sessions. Those with serious or unstable medical or psychiatric illness, psychosocial instability, conditions in which exercise or weight loss could be detrimental to health, suicidality, other interventions for obesity or disinhibited eating, or previous experience with ACT were excluded. Participants were assessed at baseline, post-4-week treatment (post-treatment), and 6 months post-treatment. Of the 88 participants who were randomized into the study, 61 completed the 6MWT at baseline and 6-month follow-up. Participants were not eligible to participate in the 6MWT if they used an ambulatory aide, had a heart rate above 120 BPM, blood pressure greater than 180/100 mmHg, or reported experiencing chest pain, shortness of breath, or fainting. The local Institutional Review Board and the Research and Development Committee approved the study. Informed consent was obtained from participants.

Measures

Demographic Variables Participants reported demographic characteristics including age, sex, race, ethnicity, education, and income at baseline.

Body Mass Index At baseline, weight and height were measured by study assessors and used to calculate baseline BMI. BMI at follow-up was calculated using either self-reported or lab-measured weight and height.

Functional Exercise Capacity The 6MWT was used to assess functional exercise capacity. Using a standardized protocol, participants were asked to walk on a point-to-point flat track for 6 min. Results of the test are reported as total distance in feet. The 6MWT has been shown to be valid and reliable among people with obesity [16, 17]. There is variability in reported clinically significant cutoffs [16, 18], and to our knowledge, no standard cutoff for the current population (veterans with obesity and disinhibited eating behavior) has not been established. However, an increase of 100 ft is considered a minimally clinically meaningful increase among individuals with medical issues [18].

Disinhibited Eating Disinhibited eating behavior was assessed using the Binge Eating Scale (BES) [19] and the Dutch Eating Behavior Questionnaire (DEBQ) [20]. The BES is a 16-item self-report measure that assesses the behavioral, cognitive, and emotional features of binge eating in adults with overweight and obesity; higher scores indicated greater binge eating. The BES has good internal consistency and test-retest reliability in overweight and obese individuals [19]. The DEBQ is a 33-item self-report scale containing 3 subscales: *emotional eating* (13 items; e.g., "Do you have a desire to eat when you are irritated?"), *external eating* (10 items; "Do you

eat more than usually when you see others eating?"), and *restraint* (10 items; "Do you deliberately eat less in order not to become heavier?") [20]. Higher scores indicate greater endorsement of the eating behavior. The DEBQ has good internal consistency in overweight and obese individuals [21].

Data Analyses

All analyses were conducted using IBM SPSS Statistics, version 25 (IBM Corp., Armonk, N.Y., USA). A two-way mixed ANOVA was used to examine differences in the 6MWT difference between baseline and 6 months as well as potential group differences in improvement in 6MWT distance. Partial eta-squared effect sizes were estimated to express the magnitude of effects. Values of 0.04, 0.25, and 0.64 were considered minimal, moderate, and strong effect sizes, respectively [22]. Because results of the two-way mixed ANOVA indicated a non-significant group by time interaction, the remaining analyses were conducted on the 2 groups combined. Hierarchical multiple regression analyses were used to examine demographic- and eating-related predictors of 6MWT distance at baseline. Demographic variables (age, sex, baseline BMI) were entered on the first step and disinhibited eating predictors were entered on the second step. To examine demographic and disinhibited eating predictors of change in 6MWT, change scores were computed by subtracting 6MWT at 6 months from 6MWT at baseline. Treatment-related changes in disinhibited eating predictors were computed by subtracting post-treatment scores from baseline scores. Hierarchical multiple regression analyses were then used to examine whether demographic variables and changes in BMI and disinhibited eating patterns from baseline to post-treatment predicted improvements in 6MWT from baseline to 6-month follow-up. Demographics were entered at the first step, then change in disinhibited variables in the second step. Disinhibited eating predictors were entered on the second step in order to understand the relationships of these variables to 6MWT distance after accounting for demographic characteristics that are established predictors of 6MWT distance. For all regression models, 95% confidence intervals for coefficients were reported. Significance level was set at .05.

Results

On average, participants were 56.7 years (SD = 10.9). The majority of participants were male (82.0%). Further, the majority of participants were identified as White (68.9%), followed by African American/Black (19.7%). About half of the participants (49.2%) were married, and most participants completed some college or technical school (60%) or had a graduate degree (25%).

Means and standard deviations of study variables at baseline and post-treatment for the entire sample are presented in Table 1. At baseline, participants achieved an average of 1457 ft on the 6MWT. Following treatment, the average 6MWT distance was 1523 ft, representing an average improvement of 66.76 ft (SD = 156.25); 38% of participants had increased 6MWT distance by 100 ft or more. On average, participants' baseline BMI (37.07 kg/m^2) fell within the category of class 2 obesity. On average, participants' baseline BES score (15.62) was below the proposed clinical cutoff of 17 for binge eating disorder [23]; 45.7% of participants had BES scores of 17 or higher. Participants' average scores for restrained eating (M = 3.01), emotional eating (M = 3.00), and external eating (M = 3.15) at baseline were higher than what has been previously reported in a sample of obese men and women (M = 2.66, M = 2.11, and M = 2.17, respectively) [20].

The results of the two-way mixed ANOVA showed that there was a significant main effect of time ($F(1,59) = .11.14$, $p = .001$, $\eta_p^2 = .159$), indicating an increase in 6MWT distance from the baseline to 6 months, with a minimal to moderate effect. The main effect of treatment group ($F(1,59) = .45$, $p = .505$, $\eta_p^2 = .008$), and the interaction between time and treatment group ($F(1,59) = .18$, $p = .674$, $\eta_p^2 = .003$) were not significant.

Summaries of the hierarchical multiple regression models for predicting 6MWT distance at baseline and change in 6MWT are presented in Table 2. The total model for predicting 6MWT distance at baseline explained 53% of the variance in the 6MWT distance, $F(7,53) = 2.93$, $p < .001$, $R^2 = .53$. Only baseline BMI was significantly related to baseline 6MWT.

The total model for predicting a change in 6MWT distance explained 63% of the variance in the 6MWT distance, $F(7,53) = 4.88$, $p < .001$, $R^2 = .63$. Improvements on the 6MWT were related to younger age, and female sex, but not change in BMI from baseline to post-treatment. Accounting for the variance explained by age and sex, pre- to post-treatment improvement on restrained eating independently predicted a change in 6MWT distance from the baseline to 6 months.

Discussion

There were significant improvements in 6MWT distance from the baseline to 6 months in a sample of veterans who completed a short-term behavioral treatment for disinhibited eating. At baseline, lower BMI was the only study variable related to 6MWT distance. Improvement in 6MWT distance from the baseline to 6-month follow-up was predicted by younger age, female sex, and treatment-related improvements in restrained eating behavior.

Table 1 Means and standard deviations of study variables at baseline and post-treatment for entire sample ($N = 61$)

Variable (units/scale range)	Baseline	Post-treatment‡	Post-treatment change‡
	Mean (standard deviation)		
6 min walk test distance (feet)	1456.55 (260.67)	1523.31 (234.03)	66.76 (156.25)*
Body mass index (kg/m^2)	37.07 (6.80)	36.48 (6.80)	− 0.59 (0.82)
Binge eating[a] (0–32)	15.62 (8.60)	12.54 (8.58)	− 3.08 (6.54)*
Restrained eating[b] (1–5)	3.01 (0.56)	3.17 (0.69)	0.16 (0.54)*
Emotional eating[b] (1–5)	3.00 (0.91)	2.73 (0.92)	− 0.28 (0.55)**
External eating[b] (1–5)	3.15 (0.54)	2.93 (0.57)	− 0.22 (0.46)**

[a] Binge Eating Scale

[b] Dutch Eating Behavior Questionnaire

Difference from baseline as indicated by paired samples t test:*$p < .05$ **$p < .001$

‡Represents 6 months post-treatment and change from baseline to 6 months for 6 min walk test distance and immediately after treatment (4 weeks) and change from baseline to 4 weeks for all other variables

Despite significantly increased distance walked, our results indicate that even after completing a comprehensive lifestyle intervention for weight management (MOVE!©) and adjunctive behavioral intervention for disinhibited eating, participants in the sample demonstrated lower exercise capacity than what has been reported among both healthy adults (2290 ft) [24] and in people with obesity (1751 ft) [16]. However, those in the previous study of participants with obesity (mean BMI = 40) were younger (mean age = 47) on average than participants in the current study, which may explain the greater distance achieved [25, 26]. However, our finding is in line with other research indicating that veterans have poorer physical health compared to civilians [27]. Nonetheless, 38% of the sample achieved clinically significant improvement per one reported cutoff [18], suggesting that it is possible for obese veterans to obtain meaningful improvements in functional exercise capacity.

We did not find any associations between self-reported disinhibited eating and functional exercise capacity at baseline but found that lower BMI was the only variable associated with 6MWT distance at baseline. This BMI finding for our sample of mostly male, overweight or obese veterans is similar to those reported in other populations [15, 24]. In terms of change, however, we found that younger age and female

Table 2 Summary of hierarchical linear regression models ($N = 61$)

	B	SE_B	β	95% CI for B	p
6-min walk distance at baseline (final model)					
Body mass index (kg/m^2)	− 19.38	4.56	− .51	− 28.54, − 10.23	< .001
Age	− 2.44	2.87	− .10	− 8.18, 3.31	.399
Sex (1 = male, 2 = female)	− 129.29	81.48	− .19	− 292.71, 34.14	.119
Binge eating[a]	− 2.35	4.72	− .08	− 11.81, 7.11	.620
Restrained eating[b]	24.00	11.17	.05	− 86.65, 134.65	.665
Emotional eating[b]	63.76	51.51	.22	− 39.55, 167.08	.221
External eating[b]	− 16.85	76.98	− .04	− 171.26, 137.55	.828
Change in the 6-min walk distance from baseline to 6 months (final model)*					
Age	− 5.21	1.61	− .36	− 8.44, − 1.93	.002
Sex (1 = male, 2 = female)	160.26	48.08	.40	63.82, 256.70	.002
Change in BMI (kg/m^2)	− 26.23	22.76	− .14	− 71.87, 19.41	.254
Change in binge eating[a]	− .464	3.04	− .02	− 6.57, 5.64	.879
Change in restrained eating[b]	98.40	31.94	.34	34.34, 162.46	.003
Change in emotional eating[b]	18.22	38.58	.06	− 59.15, 95.60	.639
Change in external eating[b]	10.45	47.65	.03	− 85.13, 106.02	.827

[a] Binge Eating Scale

[b] Dutch Eating Behavior Questionnaire

*Aside from age and sex, all predictor variables were change scores reflecting change from baseline to post-treatment. *BMI*, body mass index; *B*, unstandardized coefficient; SE_B, standard error of the coefficient; *CI*, confidence interval; β, standardized coefficient

gender, but not change in BMI, predicted improvement in 6MWT distance. These results are only somewhat consistent with previous findings showing that improvement in exercise capacity achieved on a treadmill test following a cardiovascular rehabilitation program was associated with younger age and lower BMI, as well as improvement in self-report physical functioning and bodily pain [26]. The lack of a relationship between change in BMI and changes in 6MWT in our study may be due to the restricted range of change in BMI [14]. It is also noteworthy that female gender was associated with a greater increase in the 6MWT distance at 6 months. This finding should be interpreted with caution as the sample size of women in the current study was small ($n = 11$).

To our knowledge, this is the first study to explore the relationship between disinhibited eating patterns and changes in the 6MWT distance among veterans with obesity. We found that improvements in dietary restraint were the only treatment target that predicted improvement in 6MWT distance. Similarly, a previous study found that following an intervention for promoting physical activity and internal motivation for exercise and weight loss, general and exercise-specific self-determination fully mediated the relationship between physical activity and eating self-regulation [28]. These authors concluded that they may have been a motivational "spill-over" effect between physical activity behavior and eating behavior [28]. Other previous findings have demonstrated a high correlation between physical activity and dietary behaviors and those individuals who engage in one behavior at an optimal level are motivated to increase related behaviors previously at suboptimal levels [29]. There is some evidence of a carry-over mechanism involving cognitive transfer from physical activity behaviors and nutritional behaviors [29] rather than from nutritional behaviors to physical activity as the results of the current study suggests. Other shared mechanisms, such as self-regulation [30] or executive functioning [31], may also account for the relationship between eating restraint and functional exercise capacity.

This study has limitations. The findings are from secondary data analyses of a treatment study which was not designed to answer the specific questions examined. The small sample size limits the reliability and generalizability of the results. Therefore, the results should be interpreted with caution and additional larger studies are necessary to replicate these findings. The schedule of assessments is also a limitation, and a design with more frequent assessments over a longer period of time would allow for a more precise examination of the "spill-over" hypothesis as well as other alternative mechanisms. Further, it is unclear whether study participants achieved improvement on the 6MWT that is clinically meaningful. There is variability in reported clinically significant cutoffs [16, 18], and some research has indicated a possible "learning effect," in which participants increase their distance in walking across multiple trials administered on the same day by an average of 30 m [24]. Given the paucity of research on obesity, disinhibited eating, and functional exercise capacity, especially in veterans, the current study enhances understanding of these domains and establishes directions for further study.

Future research could focus on directly examining the "spill-over" hypothesis in a larger sample, using daily physical activity measurement by an accelerometer, and ecological momentary assessment for physical activity, eating behavior, and other psychosocial variables. A larger sample would also enable tests of the potential mediating role of restrained eating. Future research may develop and test intervention strategies specifically targeting older male veterans with obesity who engage in disinhibited eating behavior. For example, techniques for gradually increasing low-impact physical activity could be incorporated in treatment with the goal of increasing functional exercise capacity. Common mechanisms, such as behavioral restraint, may underlie multiple health behaviors and continued effort to identify these factors will contribute to the development of more effective clinical interventions.

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Compliance with Ethical Standards

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.

This article does not contain any studies with animals performed by any of the authors.

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

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