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Testing Mediator Variables in a Resistance Training Intervention for Obese Adults with Type
2 Diabetes

Running title: Resistance Training Mediation

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Abstract

A poor understanding of behavior change mechanisms has hindered the development of effective physical activity interventions. The aim of this study was to identify potential mediators of change in a home-based resistance training (RT) program for obese individuals with type 2 diabetes. Obese individuals with type 2 diabetes ($N = 48$) were randomly allocated to either an RT intervention ($n = 27$) or a control group ($n = 21$) for the 16-week study period. The study sample included 16 men and 32 women and the mean age of participants was 54.4 (± 11.7) years. Participants in the RT group received a multi-gym and dumbbells and home supervision from a certified personal trainer. RT behavior was measured using a modified Godin Leisure Time Questionnaire. Social-cognitive constructs were measured and tested in a mediating variable framework using a product-of-coefficients test. The intervention had a significant effect on RT behavior ($p < 0.001$) and muscular strength ($p < 0.001$). The intervention had a significant effect on RT planning strategies ($p < 0.01$), which mediated the effect of the intervention on RT behavior. The home-based RT program successfully targeted participants' RT planning strategies which contributed to their exercise adherence.

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Key Words: Intervention; Resistance Training; Mediation; Obesity; Strength Training.

A chronic imbalance between energy expenditure and energy intake at the population level has contributed to increased levels of obesity in many western countries (Flegal, Carroll, Ogden, & Curtin, 2010; Rennie & Jebb, 2005; Thorburn, 2005). Obesity is associated with a range of serious co-morbidities including insulin resistance and type 2 diabetes (Flegal, et al., 2010). Both resistance training and aerobic exercise have been found to improve body composition and improve glycemic control among individuals with type 2 diabetes (Eves & Plotnikoff, 2006; Sigal, et al., 2007; Zanuso, Jimenez, Pugliese, Corigliano, & Balducci, 2010). Exercise interventions promote increases in muscular and aerobic fitness; both of these outcomes are highly correlated with improved glucose tolerance (Hills, et al., 2010). A recent systematic review and meta-analysis concluded that structured exercise programs consisting of aerobic exercise, resistance training, or both combined are more effective in reducing HbA(1c) than physical activity advice interventions in this population (Umpierre, et al., 2011). Individuals living with diabetes often have difficulty adopting and maintaining physical activity behavior changes (Sweet, et al., 2009; Tudor-Locke, et al., 2004) and improving exercise adherence in this group is clearly a research priority. As obese individuals are at a higher risk of injury and pain-related intolerance in weight bearing aerobic activity (Hills, et al., 2010), resistance training interventions may be particularly attractive for this group.

Physical activity interventions developed in reference to a theory of behavior change (e.g. Theory of Planned Behavior, Social Cognitive Theory, Transtheoretical Model) appear to be more successful in changing behavior than atheoretical ones (Dishman, Oldenburg, O'Neal, & Shephard, 1998; Michie & Abraham, 2004). Theory-based interventions are hypothesized to impact upon relevant cognitions, which in turn influence behavior (Hardeman, et al., 2005). Mediation analysis can be used to explore these hypothesized pathways, which may help to improve our understanding of behavior change (Baranowski,

Anderson, & Carmack, 1998). Testing mediator variables allows researchers to determine which components of an intervention were associated with behavior change (Bauman, Sallis, Dziewaltowski, & Owen, 2002). However, few studies have successfully identified mediators of behavior change in physical activity interventions (Lubans, Foster, & Biddle, 2008; Rhodes & Pfaeffli, 2010).

Mediation analyses can be conducted using a variety of statistical methods (e.g., Baron Kenny causal steps, product-of-coefficients and difference-in-coefficients), but they generally involve an action theory test, a conceptual theory test and a significance test of the mediated effect (MacKinnon, 2008). The action theory test examines the impact of the intervention on the hypothesized mediators (e.g., self-efficacy). The conceptual theory test explores the association between changes in hypothesized mediators (e.g., self-efficacy) and changes in the targeted behavior (e.g., frequency of exercise bouts) controlling for the intervention effect. Finally, a simultaneous test of both action and conceptual theory tests is conducted to test the significance of the mediated effect.

Few studies have explored mediators of behavior change in interventions among clinical populations and to the authors' knowledge, no previous study has examined potential mediators in a RT intervention for obese adults with type 2 diabetes. In their systematic review of mediators in physical activity interventions in non-clinical populations, Rhodes and Pfaeffli (2010) concluded that self-regulatory processes, such as goal setting and self-monitoring have the most effect on changes in physical activity. However, they expressed concern over the general null findings and identified the need for increased innovation and intervention fidelity. Even less is known about the mechanisms of behavior change among individuals with type 2 diabetes. A recent short-term study (i.e. 1-month) found that self-efficacy mediated the effects of a print-based physical activity intervention in this population (Dutton, et al., 2009). The Alberta Diabetes Home-based Exercise Resistance Training Study

(ADHERES) evaluated the effects of a home-based resistance training (RT) program for obese patients with type 2 diabetes based on Social Cognitive Theory (Bandura, 2004). The primary aim of the present manuscript is to identify mediators of RT behavior change in ADHERES.

Measurement issues might explain why few studies have successfully identified mediators of behavior change in physical activity interventions (Lubans, et al., 2008; Rhodes & Pfaeffli, 2010). Physical activity is difficult to assess accurately (Sirard & Pate, 2001) and mediation analyses that include physical activity as the targeted outcome are limited by the reliability and validity of the measures used. Unlike habitual physical activity measures, physical activity recall questionnaires require participants to report their activity over a recent period of time (typically 3-7 days) (Trost, 2007). This method relies heavily on the assumption that the period of assessment is an accurate reflection of their usual activity or their physical activity throughout the intervention period. However, studies have found substantial seasonality (Plasqui & Westerterp, 2004; Reilly & Peiser, 2006) and intra-individual variation in physical activity (Levin, Jacobs, Ainsworth, Richardson, & Leon, 1999; Mattocks, et al., 2007), both of which might contribute to null findings. Alternatively, in exercise-based interventions, such as resistance training and aerobic programs, improvements in muscular fitness and cardiorespiratory fitness may be considered the targeted outcomes and both provide a reflection of exercise adherence over the study period. Consequently, a secondary aim of this study was to determine if the same psychosocial mediators could also explain changes in muscular fitness in the study sample.

Methods

Study Design

This study reports secondary data from the Alberta Diabetes Home-based Exercise Resistance Training Study (ADHERES) (Plotnikoff, et al., 2010). In brief, ADHERES

involved a prospective, two-armed, randomized controlled trial. Following baseline screening and testing, participants were randomized to the RT group ($n = 27$) or a non-training control group ($n = 21$). All testing procedures were repeated following the 16-week intervention. Assessments were conducted by trained research assistants who were blinded to participants' group allocation at baseline and posttest assessments. Following the 16 week intervention, the adjusted difference between intervention and control groups for bench press was 9.3 kg (95% CI 3.7 to 15.0, $P = 0.002$), leg press was 41.0 kg (95% CI 15.1 to 67.0, $P = 0.003$) and upright row was 12.4 kg (95% CI 7.3 to 17.5, $P < 0.001$) (Plotnikoff, et al., 2010).

Primary Outcome and Power Calculations

The primary outcomes of the ADHERES study were muscular strength and improved glycemic control (A1C). The study was adequately powered to detect a 33% increase in strength and 12.6% relative decrease in A1C, with 80% power and an alpha level of $p < 0.05$. The study was sufficiently powered to detect medium to large mediation effects using the distribution of the PROduct Confidence Limits for INdirect effects (PRODCLIN) program (Fritz & MacKinnon, 2007).

Participants and Screening Procedures

Sedentary, obese individuals [body mass index (BMI) $\geq 30 \text{ kg/m}^2$] with physician-diagnosed type 2 diabetes were recruited from diabetes clinics at the University of Alberta Hospital, Edmonton, Canada and the local community. Patients were excluded if they had a BMI $< 30 \text{ kg/m}^2$; uncontrolled blood pressure ($> 160/90 \text{ mmHg}$); known, unstable cardiovascular disease; severe osteoporosis and/or musculoskeletal limitations to RT. Individuals performing RT in the last 6 months were also excluded. Ethics approval received from the institutional review board and informed consent was obtained from all study participants. A detailed description of participation recruitment, screening and retention, along with a study flow diagram have been reported previously (Plotnikoff, et al., 2010). In

summary, 162 obese patients were screened, however 114 were excluded due to a variety of reasons (e.g. BMI <30, did not return follow-up call, already doing resistance training, musculoskeletal problems). There were no statistically significant differences between the groups at baseline for any of the study variables or between completers and the seven participants (control = 3 and intervention = 4) who dropped out of the study.

Intervention

Details of the intervention have been provided elsewhere (Plotnikoff, et al., 2010). In summary, individuals randomized to the RT group were provided with a multi-gym apparatus and dumbbells. The theoretical framework of intervention and the behavior change strategies employed are described in Table 1. Participants' baseline scores were used to determine training intensity, which progressed throughout the 16-week program. A certified personal trainer supervised training in the early stages of the program to provide social support and ensure that all exercises were performed safely and within the prescribed intensity range. The frequency of sessions supervised by the exercise specialist reduced over the intervention period, with 18 of the 48 sessions being supervised.

Measures

The following assessments were conducted by trained research assistants:

Muscular strength. Muscular strength was assessed using standardized procedures (American College of Sports Medicine, 2000). After being familiarized with correct lifting technique, the participants performed the 1RM tests- seated chest press, seated row and a leg press. The three strength tests were performed using standardized commercial weight machine (Apex Fitness Equipment, Saanichton, British Columbia, Canada). Chest press, seated row and leg press 1RMs were added together to create a total strength score which was used in the analyses.

Resistance training behavior. Participants were asked to report the number and duration of

RT sessions completed in an average week using a modified version of the Godin Leisure Time Questionnaire (Godin & Shephard, 1985). The number and duration of RT sessions were multiplied to create the outcome variable mean minutes in RT/week.

Social cognitive variables. Validated measures assessing the following social-cognitive RT constructs were used: intention (Plotnikoff, Courneya, Trinh, Karunamuni, & Sigal, 2008), planning intentions (Ziegelmann, Lippke, & Schwarzer, 2006), task self-efficacy (Rodgers & Sullivan, 2001), scheduling self-efficacy (Rodgers & Sullivan, 2001), barrier self-efficacy (Plotnikoff, Trinh, Courneya, Karunamuni, & Sigal, 2009), outcome expectations (Plotnikoff, et al., 2009) and social support (Plotnikoff, et al., 2008). The constructs along with a description of the scales, number of items, sample items, psychometrics and published sources are reported in Table 2.

Analysis

Statistical analyses were completed using PASW Statistics 17 (SPSS Inc. Chicago, IL) software and alpha levels were set at $P < 0.05$. Marginally significant ($0.05 < P < 0.10$) results are noted. Analyses were conducted using the intention-to-treat principle and baseline observation carried forward was used for data missing at 16-week posttests. Unstandardized regression coefficients are reported in the results section. A product-of-coefficients test was used to assess single mediator models using ordinary least squares regression. The product-of-coefficients test involves an action theory test, a conceptual theory test and a significance test of the mediated effect and has good statistical power in small samples (MacKinnon, Fritz, Williams, & Lockwood, 2007). Change in the variables of interest (i.e. RT behavior, muscular strength and potential mediators) were computed by regressing posttest values onto their respective baseline values to create residualized change indices.

An overview of mediation analysis is provided in Figure 1. In the first step, the total effect of the intervention on RT behavior was estimated by regressing RT behavior onto

treatment condition (intervention or control) (C coefficient). The second step was the action theory test which involved regressing the potential mediators onto treatment condition (A coefficient). The third step was the conceptual theory test which involved regressing RT behavior onto treatment condition (C' coefficient) and mediators (B coefficient). Finally, the asymmetric confidence intervals were used to test the significance of the product-of-coefficients (AB) using Mackinnon and colleagues PRODCLIN program (MacKinnon, et al., 2007). For a variable to satisfy the criteria for mediation, it must be associated with the treatment condition and RT behavior and the 95% confidence intervals (CI) for the product-of-coefficients (AB) must not include zero. The proportion of the total effect that was mediated was also calculated ($AB/(C'+AB)$). Bivariate correlation was used to examine the relationship between changes in RT behavior and muscular fitness.

Results

Overview

The study sample included 16 men and 32 women. The mean age of participants was 54.4 (11.7) years (Table 3). Means and standard deviations for raw scores are reported in Table 4. Unstandardized coefficients and 95% CIs are reported in the results section. After 16-weeks, the intervention was found to have a significant effect on RT behavior ($C = 110.99$, 95% CI = 78.28 to 143.72, $P < 0.001$) and overall strength ($C = 63.83$, 95% CI = 33.40 to 94.26, $P < 0.001$). The relationship between changes in muscular fitness and changes in RT behavior was statistically significant ($r = .51$, $p < .001$).

Action Theory Test

Participants in the intervention group significantly increased their RT planning strategies ($A = 0.72$, 95% CI = 0.22 to 1.22, $P < 0.01$) (Table 5). Changes in scheduling self-efficacy for RT were significantly associated with treatment condition ($A = 19.24$, 95% CI = 2.54 to 35.94, $P < 0.05$). The relationship between treatment condition and barrier self-

efficacy was approaching statistical significance ($A = 0.56$, 95% CI = -0.08 to 1.20 , $P = .083$).

The intervention did not impact upon RT intentions, task-self-efficacy, outcome expectations and social support.

Conceptual Theory Test

Controlling for the intervention effect, there was a positive association between changes in RT behavior and changes in RT planning strategies was statistically significant ($B = 31.35$, 95% CI = 14.44 to 48.27 , $P < 0.05$) (Table 5). Changes in task self-efficacy ($B = 0.57$, 95% CI = 0.08 to 1.06 , $P = 0.023$) and barriers self-efficacy ($B = 16.63$, 95% CI = 2.27 to 30.98 , $P = 0.024$) were also associated with changes in RT behavior. The association between changes in total strength and changes in RT planning strategies was statistically significant ($B = 18.98$, 95% CI = 0.94 to 37.02 , $P < 0.05$) (Table 6). Changes in task self-efficacy ($B = 0.43$, 95% CI = -0.03 to 0.89 , $P = 0.064$), scheduling self-efficacy ($B = 0.47$, 95% CI = -0.06 to 1.00 , $P = 0.078$) and barriers self-efficacy ($B = 13.57$, 95% CI = -0.53 to 27.67 , $P = 0.059$) marginally significant.

Mediated Effects

Based on the product-of-coefficients test and the PRODCLIN asymmetric confidence intervals, changes in RT planning strategies mediated the effects of the intervention on RT behavior ($AB = 22.57$, 95% CI = 6.09 to 44.53) (Table 5). The proportion of the intervention effect mediated by RT planning strategies was 20%. The mediated effect attributable to task self-efficacy ($AB = 6.15$, 95% CI = -1.54 to 18.64), scheduling self-efficacy ($AB = 9.04$, 95% CI = -0.47 to 23.85), and barriers self-efficacy ($AB = 7.60$, 95% CI = -0.93 to 21.46), all approached statistical significance. Changes in RT planning strategies mediated the effects of the intervention on strength gains ($AB = 13.67$, 95% CI = 0.10 to 33.27) (Table 6). The proportion of the intervention effect mediated by RT planning strategies was 21%. The mediated effect attributable to task self-efficacy ($AB = 6.15$, 95% CI = -1.54 to 18.64),

scheduling self-efficacy ($AB = 9.04$, 95% $CI = -0.47$ to 23.85), and barriers self-efficacy ($AB = 7.60$, 95% $CI = -0.93$ to 21.46), were not statistically significant.

Discussion

The primary aim of this study was to explore mediators of RT behavior in a home-based resistance training (RT) program for obese patients with type 2 diabetes. The intervention resulted in increases in RT planning strategies which in turn, mediated the effect of the intervention on behavior. Changes in task self-efficacy and barrier self-efficacy were associated with changes in RT behavior, but could not satisfy the criteria for mediation. A secondary aim was to determine if the same psychosocial mediators could also explain changes in muscular fitness in the study sample. The mediation results for muscular fitness were almost identical to those for RT behavior, identifying the potential for using muscular strength as the dependent variable in mediation analyses in RT programs.

RT planning strategies was the only variable that satisfied the criteria for mediation in the study sample. In the current study, participants in the intervention group increased their concrete planning for RT, including their strategies for overcoming barriers to training, which mediated the effect of the intervention on behavior. This finding is consistent with a recent review of mediators in physical activity interventions, which concluded that self-regulatory processes had the most evidence for mediation (Rhodes & Pfaeffli, 2010). For example, a recent study by Napolitano et al (2008) found that changes in behavioral processes mediated the effect for both print and telephone interventions on physical activity behavior in a sample of inactive adults.

Changes in scheduling self-efficacy were positively associated with the intervention and changes in barrier self-efficacy approached statistical significance. However, none of the self-efficacy variables could satisfy the criteria for mediation as the posttest scores decreased in both control and intervention groups (decreases were larger in the control group) over the

study period. As recommended, participants completed the questionnaires before physical assessments to prevent the actual process of assessment influencing their responses. This may have contributed to inflated baseline values and may explain the lower values reported at posttest. According to response shift theory (Sprangers & Schwartz, 1999), changes in a measured variable (e.g. physical activity) are accompanied by changes in an individual's self-evaluation and/or internal standard (e.g. self-efficacy) (Vallance, Courneya, Plotnikoff, & Mackey, 2008). Participants in the current study were obese individuals living with type 2 diabetes and the 1RM testing protocols involved maximal efforts which may have been uncomfortable and unfamiliar to sedentary individuals. Therefore, when both intervention and control group individuals were assessed at posttest, their efficacy beliefs about completing RT reduced due to a more accurate understanding of the difficulty of training. Dutton and colleagues (2009) found that changes in self-efficacy completed mediated the effect of a physical activity intervention for patients with type 2 diabetes. However, unlike the current study, their study did not include physical assessments that could influence participants' ratings of the difficulty of completing the behavior.

Alternate explanations for our failure to identify significant mediation effects in the ADHERES intervention include the following. First, the intervention strategies were not effective in changing the targeted constructs. While the intervention involved providing participants with a multi-gym and dumbbells, these were removed at the completion of the study. This might explain the reductions in self-efficacy observed among participants in the intervention group. Second, it is possible the targeted mediators were not the most appropriate mechanisms of change for the study population. There is a need to further explore the influence of socio-ecological mediators on behavior change and these were not explored in the current study. Third, the null findings could be attributed to lack of variability in the measures and/or lack of sensitivity to detect change in the targeted constructs. Finally, our

small sample size prevented us from detecting small mediation effects.

The mediation results for RT behavior and muscular strength were almost identical and RT planning strategies mediated 20% and 21% of the intervention effect on behavior and fitness, respectively. Muscular strength is a better measure of intervention effect in RT programs and evidence from the current study suggests strength could be used as the dependent variable in the mediation regression models. Rhodes and Pfaeffli (2010) identified the need for novel approaches to examining mediators and including muscular strength as the dependent variable has a number of advantages. Muscular strength is not influenced by respondent bias and the precision of measurement is generally higher with good test-retest reliability (Harmon, Garhammer, & Pandorf, 2000). Furthermore, self-report and objective behavioral data do not always reflect behavior throughout an intervention period, while muscular strength gains will be directly related to the volume and intensity of training completed by the participants.

The intervention did not impact upon outcome expectations. This is not surprising as all participants would have volunteered for the study believing that RT was a worthwhile behavior that could improve their health. Consequently, the baseline values for RT outcome expectancy were high for both control and intervention groups ($>4.3/5$). There is little evidence to suggest that changes in outcome expectancies mediate behavior change in physical activity interventions (Rhodes & Pfaeffli, 2010). Beliefs about the benefits of physical activity may to certain extent, explain behavior in cross-sectional studies, but individuals who have volunteered for a physical activity intervention may already be convinced of the value of such behavior.

In the current study, a certified personal trainer supervised training in the early stages of the program to provide social support and ensure that all exercises were completed safely. In addition, participants were encouraged to elicit social support from significant others.

While these strategies combined to enhance exercise adherence in the intervention, they were not successful in changing participants' perceptions of the social support they received from significant others. Identifying strategies to increase social support among sedentary individuals is challenging and novel techniques to achieve this outcome are clearly warranted. Task, scheduling and barriers self-efficacy might be important for behavior change, but could not satisfy the criteria for mediation. Modeling RT behavior and graded tasks were two behavior change strategies used in the ADHERES intervention to enhance self-efficacy. A personal trainer supervising the sessions in participants' homes may be an expensive strategy; however, the health care costs of treating obese adults with type 2 diabetes is substantial and arguably warrants this intervention component (Plotnikoff, et al., 2010).

While it is difficult to determine which intervention strategies were the most important for behavior change in the ADHERES intervention, consistent with previous literature (Rhodes & Pfaeffli, 2010), teaching participants self-monitoring techniques holds considerable promise. More specifically, encouraging participants to formulate plans and identify techniques to overcome potential barriers are important skills and should be considered for future interventions. These behavior change techniques are consistent with the concept of implementation intentions, whereby individuals consider in advance when, where and how they will achieve their stated goals (Gollwitzer, 1999), including, contingency plans when problems and barriers arise. In the current study, a certified personal trainer supervised training in the early stages of the program to provide social support and ensure that all exercises were completed safely. In addition, participants were encouraged to elicit social support from significant others. While these strategies combined to enhance exercise adherence in the intervention, they were not successful in changing participants' perceptions of the social support they received from 'significant others'. Identifying strategies to increase

social support among sedentary individuals is challenging and novel techniques to achieve this outcome are clearly warranted. Task, scheduling and barriers self-efficacy might be important for behavior change, but could not satisfy the criteria for mediation. Modeling RT behavior and graded tasks were two behavior change strategies used in the ADHERES intervention to enhance self-efficacy. A personal trainer supervising the sessions in participants' homes may be an expensive strategy; however, the health care costs of treating obese adults with type 2 diabetes is very substantial and arguably warrants this intervention component (Plotnikoff, et al., 2010).

This study has several strengths that should be noted. First, this was a novel intervention that was evaluated with a unique population. Second, this was a high quality trial that adhered to the CONSORT statement (Moher, et al., 2010). Third, mediation effects were explored using both behavior and muscular strength as outcomes, helping to improve our understanding of the mechanisms of change in an RT program. Finally, MacKinnon and colleagues PRODCLIN program (MacKinnon, et al., 2007) was used to identify potential mediators in the study sample. Few studies have successfully identified mediators of behavior change in physical activity interventions and product of coefficients tests, such as the PRODCLIN program, have been recommended for use in small samples (Fritz & MacKinnon, 2007). Despite these strengths, we acknowledge the relatively small sample size that prevented us from detecting small mediation effects and testing multiple mediator models. In addition, the measurement of both behavior and mediators relied on self-report, which may be biased by social desirability and limited due to lack of measurement sensitivity. The direction of causality cannot be determined in the current study and it is possible that behavior influenced the mediators. Finally, the current intervention could be improved by the inclusion of a lifestyle physical activity component. Self-monitoring with pedometers has emerged as an efficacious strategy for increasing physical activity and

improving weight status in adults (Bravata, et al., 2007) and could be easily incorporated into the ADHERES intervention. This would provide additional opportunities for participants to engage in physical activity with significant others and may contribute to the sustained effectiveness of the program.

Conclusions

Our study has shown that a home-based RT program for obese participants with type 2 diabetes resulted in increased RT behavior and muscular strength which were mediated by changes in RT planning strategies. These findings suggest that individuals working with obese individuals with type 2 diabetes should encourage them to make concrete plans and identify strategies to overcome barriers to training. Our study has also shown that including muscular fitness as the outcome variable is an appropriate strategy for identifying mediation effects in RT programs.

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Figure 1. Overview of mediation including pathways and coefficients

Table 1

Theoretical framework of intervention and behavior change strategies

SCT construct	Explanation of how intervention targeted construct	Behavior change strategies included in intervention ¹
Intention to RT	Participants were asked and encouraged to plan their RT sessions by the PTs. Goal setting was established with qualified PTs.	* Prompt specific goal setting * Prompt intention formation
RT planning strategies	PTs encouraged participants to plan their RT sessions and self-monitor their behavior to ensure that they completed all necessary sessions. This included the identification of strategies to overcome barriers and the formation of plans to overcome barriers.	* Provide information about behavior health link * Prompt self-monitoring of behaviors * Barrier identification
Task self-efficacy	Participants performed RT sessions with PTs, who also demonstrated the target behaviors. PTs corrected participants' technique and provided feedback on performance.	* Model or demonstrate the behavior * Graded tasks
Scheduling self-efficacy	In addition to the scheduled PT visits, participants were asked and encouraged to schedule their own RT sessions and self-monitor their behaviors. Training logs were kept by the participants, and the qualified PTs checked and ensured the completion of the logs during home visits.	* Prompt self-monitoring of behaviors
Barrier self-efficacy	Participants were encouraged to identify barriers to RT and were offered strategies to overcome these barriers by PTs. The PTs also provided advice on injury prevention and modification of the exercises if participants experienced pain/soreness or injury.	* Barrier identification
Outcome expectations	Participants were provided with information of the benefits of RT by the PTs. PTs prompted self-reflection on RT performance and potential benefits.	* Provide information about behavior health link * Information on consequences
Social support	PTs provided social support and encouragement for participants. PTs encouraged participants to elicit social support from significant others.	* Plan social support or social change * Model or demonstrate the behavior

Note. SCT = Social Cognitive Theory; RT = resistance training, PT = personal trainer.

¹Adapted from behavior change taxonomy developed by Abraham and Michie (2008)

Table 2

Description and psychometric properties of hypothesized mediator scales

Hypothesized mediators	Description of scale	Range (No. of items)	Source	α
Intention to RT	Participants reported their intention to RT by responding to the following question: <i>On a scale of 0% to %100, how likely is it that you will weight train/resistance train regularly over the next 4 months?</i>	0 to 100 (1)	Plotnikoff et al. (2008)	N/A
RT planning strategies	Participants reported their concrete plans for a RT schedule. Example item: <i>I already have concrete plans on what to do if I miss a weight training session.</i> Scale: 1 = <i>Hardly true at all</i> to 4 = <i>Exactly true</i>	1 to 4 (4)	Adapted from Ziegelmann, et al (2006)	0.92
Task self-efficacy	Participants reported their confidence to complete RT sessions. Example item: <i>On a scale of 0% to %100, how confident are you in your ability to weight train once a week?</i>	0 to 100 (3)	Adapted from Rodgers & Sullivan (2001)	0.95
Scheduling self-efficacy	Participants reported their confidence to overcome barriers and complete RT sessions they have missed: <i>On a scale of 0% to %100, how confident are you that you can make up a missed weight training session?</i>	0 to 100 (3)	Adapted from Rodgers & Sullivan (2001)	0.91
Barrier self-efficacy	Participants reported their confidence about RT on a regular basis in a variety of adverse circumstances. Using the common stem: <i>In the next 4 months I am confident that I can weight training three times per week.</i> Example item: <i>When I am a little tired.</i> Scale: 1 = <i>Not at all confident</i> to 5 = <i>Extremely confident</i>	1 to 5 (13)	Plotnikoff et al. (2009)	0.97
Outcome expectations	Participants reported the extent to which potential outcomes of RT would influence their decision to weight train regularly. Example item: <i>Weight training regularly will lead to better control of my blood sugar.</i> Scale: 1 = <i>Not at all</i> to 5 = <i>Very much</i>	1 to 5 (6)	Plotnikoff et al. (2009)	0.96
Social support	Participants reported their level of social support for RT from significant others. Example item: <i>Most people in my social network want me to weight train regularly in the next 4 months.</i> Scale: 1 = <i>Strongly disagree</i> to 5 = <i>Strongly agree</i>	1 to 5 (3)	Plotnikoff et al. (2008)	0.79

Note. RT = Resistance training; α = Cronbach's alpha derived from study sample. In all scales higher numbers represent more positive responses.

Table 3

Baseline characteristics of participants

Characteristics	Control (<i>n</i> = 21)		Intervention (<i>n</i> = 27)		Total (<i>N</i> = 48)	
	Mean	SD	Mean	SD	Mean	SD
Age (years)	54	± 12	55	± 12	54	± 12
Gender						
Male, <i>n</i> (%)	8	38.1%	8	29.6%	16	33.3%
Female, <i>n</i> (%)	13	61.9%	19	70.4%	32	66.7%
Weight (kg)	100	± 18	97	± 27	99	± 23
Height (m)	1.67	± .11	1.65	± .10	1.66	± .10
BMI (kg/m ²)	36	± 5	35	± 8	36	± 7
Chest press (kg)	45	± 16	46	± 22	46	± 19
Seated row (kg)	55	± 19	56	± 21	55	± 20
Leg press (kg)	99	± 61	128	± 86	116	± 77
Total strength (kg)	200	± 92	230	± 124	217	± 111
RT behavior (mins/week)	13	± 29	5	± 16	8	± 22

Note. Means ± standard deviations reported; BMI = Body Mass Index; RT = Resistance training; Total strength = seated chest press + seated row + leg press.

Table 4

Baseline and 16-week posttest scores for strength and hypothesized mediators

Variables	Control group		Intervention group		Total	
	Baseline	16 weeks	Baseline	16 weeks	Baseline	16 weeks
<i>Behavior</i>						
RT behavior (mins/week)	13 ± 29	12 ± 27	5 ± 16	124 ± 68	8 ± 22	75 ± 78
<i>Muscular strength</i>						
Seated chest press (kg)	45 ± 16	45 ± 16	46 ± 22	55 ± 26	46 ± 19	51 ± 23
Seated row (kg)	55 ± 19	57 ± 21	56 ± 21	70 ± 28	55 ± 20	64 ± 26
Leg press (kg)	99 ± 61	94 ± 63	128 ± 86	175 ± 141	116 ± 77	140 ± 121
Total strength (kg)	200 ± 92	195 ± 94	230 ± 124	300 ± 190	217 ± 111	256 ± 134
<i>Social-cognitive constructs</i>						
Intention to RT	57 ± 34	48 ± 37	63 ± 40	58 ± 39	60 ± 38	54 ± 38
RT planning strategies	2.08 ± .84	1.92 ± .89	2.12 ± 1.11	2.67 ± 1.12	2.10 ± .99	2.34 ± 1.08
Task self-efficacy	72 ± 30	53 ± 35	80 ± 24	71 ± 35	77 ± 27	63 ± 36
Scheduling self-efficacy	64 ± 30	37 ± 29	74 ± 26	63 ± 35	70 ± 28	51 ± 35
Barrier self-efficacy	3.50 ± .86	2.69 ± .99	3.69 ± .96	3.36 ± 1.32	3.61 ± .91	3.07 ± 1.22
Outcome expectations	4.30 ± .90	3.84 ± 1.31	4.76 ± .41	4.19 ± 1.25	4.56 ± .70	4.03 ± 1.27
Social support	3.44 ± .95	3.09 ± .88	3.47 ± 1.31	3.05 ± 1.20	3.46 ± 1.15	3.07 ± 1.06

Note. Means ± standard deviations reported; Baseline observation carried forward for missing data; Total strength = sum of 1RMs for seated chest press + seated row + leg press.

Table 5

Action theory test, conceptual theory test and significance of the mediated effect on RT behavior

Hypothesized mediators	Action theory test		Conceptual theory test		Significance of mediated effect		Proportion (%)
	A (SE)	95% CI	B (SE)	95% CI	AB	95% CI ¹	AB/(C' + AB)
Intention to RT	6.89 (9.85)	-12.96 to 26.74	.43 (.25)	-.07 to .94	2.96	-5.01 to 13.77	3%
Intention to plan for RT	.72 (.25)**	.22 to 1.22	31.35 (8.39)**	14.44 to 48.27	22.57	6.09 to 44.53	20%
Task self-efficacy	14.31 (9.46)	-4.73 to 33.35	.57 (.24)*	.08 to 1.06	8.16	-1.75 to 23.04	7%
Scheduling self-efficacy	19.24 (8.30)*	2.54 to 35.94	.53 (.28)	-.04 to 1.10	10.20	-.21 to 26.41	9%
Barrier self-efficacy	.56 (.32)	-.08 to 1.20	16.63 (7.12)*	2.27 to 30.98	9.31	-.70 to 24.83	8%
Outcome expectations	-.15 (.30)	-.76 to .46	7.20 (7.84)	-8.59 to 22.99	-1.08	-7.09 to 3.35	<1%
Social support	-.06 (.26)	-.59 to .48	3.07 (9.02)	-15.11 to 21.25	-.18	-2.39 to 1.81	<1%

Note. Control and intervention groups were coded as 0 and 1, respectively; RT = Resistance training; A = estimate of unstandardized regression coefficient of treatment condition predicting hypothesized mediators; B = estimate of the unstandardized regression coefficient of the hypothesized mediator predicting RT behavior, with treatment condition included in the model; SE = standard error; 95% CI = 95% confidence interval; AB = product-of-coefficients estimate; C' = effect of treatment on RT behavior accounting for effect of mediator.

¹95% asymmetric confidence intervals of the mediated effect calculated using the PRODCLIN program.

* $p < 0.05$; ** $p < 0.01$.

Table 6

Action theory test, conceptual theory test and significance of the mediated effect on muscular strength

Hypothesized mediators	Action theory test		Conceptual theory test		Significance of mediated effect		Proportion (%)
	A (SE)	95% CI	B (SE)	95% CI	AB	95% CI ¹	AB/(C' + AB)
Intention to RT	6.89 (9.85)	-12.96 to 26.74	.29 (.24)	-.19 to .77	2.00	-3.55 to 10.09	3%
Intention to plan for RT	.72 (.25)**	.22 to 1.22	18.96 (9.95)*	.94 to 37.02	13.67*	.10 to 33.27	21%
Task self-efficacy	14.31 (9.46)	-4.73 to 33.35	.43 (.23)	-.03 to .89	6.15	-1.54 to 18.64	10%
Scheduling self-efficacy	19.24 (8.30)*	2.54 to 35.94	.47 (.26)	-.06 to 1.00	9.04	-.47 to 23.85	14%
Barrier self-efficacy	.56 (.32)	-.08 to 1.20	13.57 (7.00)	-.53 to 27.67	7.60	-.93 to 21.46	12%
Outcome expectations	-.15 (.30)	-.76 to .46	4.24 (7.53)	-10.93 to 19.42	-.64	-4.78 to 2.54	<1%
Social support	-.06 (.26)	-.59 to .48	-2.72 (8.44)	-19.73 to 14.29	.16	-1.64 to 2.15	<1%

Note. Control and intervention groups were coded as 0 and 1, respectively; RT = Resistance training; A = estimate of unstandardized regression coefficient of treatment condition predicting hypothesized mediators; B = estimate of the unstandardized regression coefficient of the hypothesized mediator predicting muscular strength, with treatment condition included in the model; SE = standard error; 95% CI = 95% confidence interval; AB = product-of-coefficients estimate; C' = effect of treatment on muscular fitness accounting for effect of mediator.

¹95% asymmetric confidence intervals of the mediated effect calculated using the PRODCLIN program.

* $p < 0.05$; ** $p < 0.01$.

Figure 1

Overview of mediation including pathways and coefficients