Improvements in Cardiometabolic Risk Markers, Aerobic Fitness, and Functional Performance Following a Physical Therapy Weight Loss Program

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Running Head: PT, Weight Loss and Cardiometabolic risk

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Acknowledgements

We acknowledge and thank Randy Frieser, the staff, and patients at Revolution Physical Therapy and Weight Loss clinics (Chicago, IL) for assistance and participation in this study.

Word count: Abstract = 228, Text = 4155
Abstract

Objective: The objectives of this study were to determine the efficacy of a current physical therapy and weight loss program model on exercise performance, physical function, and cardiometabolic risk factors in obese patients. Design: Retrospective pre-post design. Subjects: A total of 192 patients who previously underwent testing of anthropometric measurements, cardiovascular biomarkers, and lower extremity function scale (LEFS) were included. Results: There was a significant reduction in body weight [5.91 ± 3.47 (95% CI, 5.4 to 6.4) kg; p<0.001; n=187] and waist circumference [7.1 ± 5 (95% CI, 6.3 to 7.9) cm; p<0.001; n=187]. Submaximal exercise capacity (VO2ex) increased by [5.29 ± 4.74 (95% CI, 4.38 to 6.19) ml/kg/min; p<0.001; n=107], and lower extremity functional scale (LEFS) improved by [9 ± 11 (95% CI, 7 to 12) scale points; p<0.001; n=75]. Both systolic (pre SBP: 125.7±15 vs. post SBP: 118.4±12 mmHg; p<0.001; n=150) and diastolic (pre DBP: 78.5 ± 10 vs. post DBP: 74 ± 8.5 mmHg; p<0.001; n=150) blood pressures as well as fasting blood glucose (pre FBG: 112.8±37 vs. post FBG: 99±18 mg/dL; p<0.001; n=132) were significantly reduced. Conclusions: This study indicates the importance and significance of weight loss in improving physical function and cardiometabolic risk profiles across a cohort of outpatient physical therapy patients. Our study also suggests that weight loss can be achieved in a comprehensive exercise intensive physical therapy program for obese patients.

Keywords: Physical Therapy; Obesity; Weight loss; Risk factors; Biomarkers.
List of Tables

Table 1. Demographic, Cardiometabolic, and functional performance outcomes before and after weight loss. All data are reported as mean ± standard deviation.

Table 2. Dependent t-test results for pairs of data. BW: body weight (kg) BMI: body mass index (kg/m\(^2\)), Waist (cm), W2H: waist to hip ratio, SBP: systolic blood pressure (mmHg), DBP: diastolic blood pressure (mmHg), FBG: fasting blood glucose (mg/dL), PU: push-ups, LEFS: lower extremity functional scale.
Introduction

Over the past years the epidemic of obesity has probably received more attention in the United States (US) and other countries around the world than most other pathological conditions. Obesity trends have been climbing at frightening rates of almost eight percentage points between 1976 and 1994, and a similar increase between 1994 and 2000 (Flegal, Carroll, Kit, & Ogden, 2012; Flegal, Carroll, Ogden, & Curtin, 2010). By 2030, forecasts predict that 86.3% of the American adult population would be classified as overweight or obese, 51% will be classified as obese and 11% as severely obese (Mozaffarian et al., 2015; Wang, Beydoun, Liang, Caballero, & Kumanyika, 2008). This predicted forecast represents an increase of 33% for obesity and 130% for severe obesity (Mozaffarian et al., 2015). According to the 2015 American Heart Association (AHA) statistical update, 69% of the current adult American population is classified as overweight or obese (Mozaffarian et al., 2015). Concerning health care expenditures, if current obesity growth trends continue at similar rates, it is expected that by 2030 healthcare costs related to obesity could account for 16-18% of US health expenditures (compared to 9.1% in 1998) (Wang et al., 2008).

Obesity contributes to a multitude of health disorders and consequences including, but not limited to, cardiovascular (CV) disorders, metabolic disorders, stroke, and musculoskeletal ailments (Anandacoomarasamy, Caterson, Sambrook, Fransen, & March, 2008; Racette, Deusinger, & Deusinger, 2003). These consequences may have a direct relationship with physical therapy interventions and goals to such an extent that full rehabilitation potential may not be achieved unless the condition of overweight/obesity is corrected.

In addition, in the effort to control the obesity epidemic, it would seem wise to recruit all qualified medical and healthcare professionals to assist with obesity treatment
and guidance whenever feasible. In 2007, 9 million adults (>18 years old) received ambulatory physical therapy services (Machlin, Chevan, Yu, & Zodet, 2011). Assuming that the prevalence of overweight/obesity is identical across the general population and the physical therapy patient population, that would account for over 6 million overweight/obese patients seeking PT services. Taking into consideration the direct relationship between obesity and a great multitude of orthopedic (Anandacoomarasamy et al., 2008) and CV (Deshpande, Dodson, Gorman, & Brownson, 2008; Klein et al., 2004) impairments that often lead to significant functional deficits, it is crucial that therapists embrace a more active role towards obesity management.

In this study, we aim at evaluating the efficacy of a current physical therapy and weight loss program model on exercise performance, physical function and cardiometabolic risk factors in obese patients.

**Methods**

This study was designed to investigate the efficacy of a physical therapy centered practice in the management of weight loss. Anthropometric measurements, CV biomarkers, and lower extremity functional scale scores were obtained at baseline and post an 8-10 week weight loss and exercise intervention. Data were collected from 192 patients who completed the 8-10 week exercise intensive physical therapy program for analysis. The study protocol and data safety and monitoring plans were approved by the institutional review board of the respective university.

**Inclusion and Exclusion Criteria**

Patients undergoing outpatient physical therapy (n=192) at multiple office locations were enrolled in the study. All participants 18 years of age or older, and overweight [Body mass index (BMI) > 25 kg/m²] were included in our analysis. Exclusion was limited to patients with known anorexia or bulimia, any use of non-topical steroids, known pituitary
tumors, known thyroid disorders, known chromosomal abnormality, anemia, or body weight under 68 kg (150 lbs).

Weight Loss Program Model – General Overview

Before initiation of the weight loss program, all patients participated in initial motivational counseling and interview sessions with a behavioral counselor (overseen by a clinical psychologist). These sessions were developed with the goal of identifying individual aims and concerns as well as identifying obstacles and means to overcome them. Next, patients participated in a baseline biomarker collection visit after an overnight fast. All patients then received nutritional counseling with a registered dietitian (RD) to formulate an individualized nutritional plan for each patient. Participants were required to attend once a week meetings with the behavioral counselor and once a week meetings with the RD throughout the 8-10 week intervention. Each patient performed three-times-per-week physical therapy exercise sessions for up to 26 visits. Biomarker data were also collected at the completion of the program. Figure 1 summarizes the treatment program and follow-up.

Baseline Assessments

*Anthropometric measurements*

Body weight and height measurements were assessed using a standard physician beam scale and stadiometer. Weight was recorded in pounds (lbs) to the nearest ¼ pound and then converted to kilograms (kg). Body mass index (BMI) was calculated as the weight in kg divided by the square of the height in meters. Patients were instructed to remove shoes and wear minimal clothing during weight measurements. Waist circumference measures were taken as an average of 3 readings midway between the lower rib margin and iliac crest as previously described (Flegal & Graubard, 2009; Lemieux, Prud’homme, Bouchard, Tremblay, & Després, 1996). Hip circumference
measures were also taken as the average of 3 readings across the widest area at the hips (Flegal & Graubard, 2009; Lemieux et al., 1996). Waist to hip circumference was calculated as the ratio between the two measurements (Flegal & Graubard, 2009; Lemieux et al., 1996).

Cardiometabolic assessments

Blood pressure was measured manually using standard auscultatory methods (Pickering et al., 2005). Fasting blood glucose levels were measured using a blood glucose meter (TRUEtrack®, NIPRO Diagnostics™, Ft. Lauderdale, FL).

Physical function

Physical function was determined via a group of measures. Muscle strength measures were made testing squats and push-ups. The maximum number of squats (resistance free), to 90-degree knee flexion, performed in 30 seconds was recorded. Standard push-up tests were performed to determine composite upper extremity strength. Push-up tests were administered to exhaustion. Lower extremity functional scale (LEFS) scores (Binkley, Stratford, Lott, & Riddle, 1999) were used to assess functional impairment. Aerobic exercise capacity (VO_{2max}) was determined (CardioCoachCO_{2™}; KORR Medical Technologies; Inc., Salt Lake City, UT) (Dieli-Conwright, Jensky, Battaglia, McCauley, & Schroeder, 2009; Sun et al., 2009) using a graded submaximal treadmill test composed of speed and grade increments of 0.5 mph (0.81 km/h) or 2% grade every two minutes to volitional fatigue.

Resting Metabolic Rate

RMR was calculated using indirect calorimetry (ReeVue™; KORR Medical Technologies, Inc., Salt Lake City, UT) (Sun et al., 2009). Results of the RMR were used to formulate an individual nutritional plan in order meet specific weight loss goals.
Intervention

After baseline assessment measures have been completed, patients participated in their exercise, nutrition, and behavioral counseling program.

Exercise training

The initial exercise prescription for all patients consisted of five total bouts of structured therapeutic exercise for eight weeks. Of these five bouts: three were supervised under a licensed physical therapist and exercise physiologist. The other two bouts were performed independently by patients and comprised of only aerobic exercise.

Supervised sessions started with a 5-minute CV warm up utilizing the treadmill, stationary bike, or dynamic flexibility exercises according to patient ability and preference. Patients then performed an individualized group of upper and lower body resistance exercise composed primarily of compound movements aiming to recruit large muscle groups. Resistance therapeutic exercise consisted of 15-20 repetitions at 50-60% 1-repetition maximum (RM) performed primarily in circuit format. One-RM for resistance exercise was estimated via push-up and squat test, along with physical therapist recommendations following clinical evaluation. Large muscle group exercises included, but were not limited to; push, squat, pull, step/lunge, and trunk movements. Resistance modalities varied from bands, machines, free weights, and body weight (both modified and via suspension systems according to patient ability). Exercise progression was accomplished by increases in load (approximately 10-20% every two-weeks) and decreases in recovery time between sets (8-10% every two weeks, 1:4, 1:3, 1:2). For a detailed description of resistance exercises performed see appendix A. Aerobic intervals (5-8 minutes of 60-70% VO$_{2max}$) were interspersed throughout the circuit.

Independent aerobic exercise bouts (45-60 minutes, 60-70% VO$_{2max}$) were prescribed twice a week. Patients were given the option of interval therapeutic exercise or
steady state intensity to achieve prescribed intensity zones. Intensity was monitored via heart rate monitors (Polar Heart Rate Monitor FT7™, Polar, USA) for both adherence and efficiency. Although patients were allowed to choose modality, they were urged to choose mode that best fit orthopedic limitations and personal preference. Intensity of independent aerobic exercise was increased at four-weeks to account for improvements in aerobic fitness and weight loss results.

Nutrition Counseling

After the readiness evaluation and initial biomarkers had been performed, the participants underwent an initial nutrition assessment by an RD. In this session, the RD gathered information regarding the patient's eating patterns, nutrition-related medical complications, nutritional strengths and challenges, and history of weight loss attempts. The RD and patient determined nutritional areas of knowledge that need further development and established three nutrition-focused goals. Goals included a numerical weight goal, a nutrition educational goal and the final goal was to meet the resting metabolic rate for caloric needs with a recommendation to eat to the RMR which was calculated at the first visit. There was no allowance for activity factor in this recommendation and there was no adjustment over time based on weight loss.

The nutrition arm included eight sessions consisting of evaluation of client's intake by examining the patient's daily food diary. Each session also included educational objectives. Education topics included macronutrient balancing, fueling for exercise, label reading, portion sizing, restaurant dining, cooking alternatives, menu planning, nutrition and disease, nutrition while traveling and contingency planning. At each session, the RD determined one area of improvement for that week.

Behavioral Counseling
The goals of the counseling were to understand the general approach to food and identify the behaviors that impacted weight gain, and at times, uncontrolled or mindless eating. Behavioral counselors helped determine triggers and cravings and strategize with the patient healthy coping skills that help deter overconsumption or mindless eating. Main tools utilized during these sessions included motivational interviewing (Levensky, Forcehimes, O’Donohue, & Beitz, 2007), acceptance and commitment therapy (ACT) (A-Tjak et al., 2015), and cognitive behavioral therapy (CBT) (Murphy, Straebler, Cooper, & Fairburn, 2010).

Program Completion and Re-assessment

The program was considered to be complete after the patient completed 26 physical therapy office visits, eight nutritional counseling visits, and nine behavioral counseling visits over an 8-10-week duration. Follow-up tests were collected in the same fashion as described for the baseline measures.

Statistical Analysis

Data were analyzed using SPSS software (IBM SPSS Statistics, Version 22.0. Armonk, NY: IBM Corp). Data are presented as mean ± SD unless mentioned otherwise. Dependent t-tests were performed to evaluate pre and post changes. Statistical significance was determined at P < 0.05.

Results

Patient characteristics

A total of 192 patients were eligible and enrolled in this study. Data on five participants could not be found. Of the participants 36.5% (n=70) were male while 63.5% (n=122) were female. Mean BMI at baseline was 35.7 ± 7.1 kg/m². Seventy-five patients (39%) received a complete set of biomarker testing. The total number for each biomarker
along with mean, SD, and range is presented in table 1. For a group of subjects, pre and post LEFS measures have been collected (n=75) to determine the effects of weight loss and exercise on lower extremity function.

**Intervention results**

Our results show that enrolled patients lost 5.91 ± 3.47 (95% CI, 5.4 to 6.4; p<0.001) kg following treatment completion. BMI was reduced by 2 ± 1.2 (95% CI, 1.8 to 2.2; p<0.001) points, and waist circumference decreased by 7.1 ± 5 (95% CI, 6.3 to 7.9; p<0.001) cm (figure 2). Measures of physical function also showed significant improvement as indicated by increases in VO$_{2\text{ex}}$ of 5.29 ± 4.74 (95% CI, 4.38 to 6.19; p<0.001) ml/kg/min signifying improved aerobic capacity (figure 3). LEFS scores also showed improved functional performance by gains of 9 ± 11 (95% CI, 7 to 12; p<0.001) scale points, which is in line with the minimal detectable change (MDC) and minimum clinically important difference (MCID) of 9 scale points.(Binkley et al., 1999) CV profiles also demonstrated favorable changes as indicated by reductions in systolic (pre SBP: 125.7±15 vs. post SBP: 118.4±12 mmHg; p<0.001) and diastolic (pre DBP: 78.5 ± 10 vs. post DBP: 74 ± 8.5 mmHg; p<0.001) blood pressures (figure 4) and fasting blood glucose (pre FBG: 112.8±37 vs. post FBG: 99±18 mg/dL; p<0.001) as shown in figure 5. Dependent t-test analysis of all 11 sets of pre and post biomarkers revealed statistically significant results compared to baseline testing. Table 2 summarizes data and findings.

**Discussion**

The results of the present study demonstrate that weight loss achieved during a comprehensive 8-10-week physical therapy weight loss program is associated with reduced cardiometabolic risk factors and improved functional exercise performance in patients with obesity (see program model Figure 1). Such improvements in
cardiometabolic markers is the basis behind recommending lifestyle modifications as a first line of defense for cardiovascular risk reduction (Eckel et al., 2014).

In addition to the cardiometabolic consequences, obesity can also contribute to musculoskeletal complications; specifically, to the lumbar spine and lower extremities (Anandacoomarasamy et al., 2008; Paans et al., 2013). This relationship between obesity and musculoskeletal complications sheds light on the importance of incorporating physical therapists in obesity treatment and management. When physical therapists are faced with the task of rehabilitation following orthopedic injuries this process becomes increasingly confounded by the co-morbid status of overweight and obesity. Furthermore, overweight and obesity propagate sedentary lifestyles and pain. In many cases, the full functional rehabilitation of these patients may not be achieved until a significant portion of the excess weight is lost. For example, Martin et al. found that exercise capacity gains following cardiac rehabilitation were lower in obese patients at 3 months and 1 year after completion of the rehabilitation program (Martin et al., 2012). It is equally plausible to suggest that exercise capacity may be limited in patients with obesity unless confounding musculoskeletal complications are corrected. Given the specific training and expertise of physical therapists, and given the relationship between overweight/obesity and musculoskeletal disorders the importance and significance of this model can be appreciated.

Exercise and proper nutrition have long been known to produce weight loss and improvements in CV risk profiles (Eckel et al., 2014; Villareal et al., 2011), yet our study shows that this can effectively and safely be achieved in a comprehensive physical therapy program for aerobic endurance, strength and weight loss. Although it may be argued that a group of professions effectively participated in this model – behavioral
counselors, exercise physiologists, and registered dietitians, it is important to consider the interdisciplinary nature of weight loss during the rehabilitation process.

Given the current rates of obesity in the U.S. and around the world, incorporating novel educational paradigms in the treatment of obesity and obesity-associated cardiometabolic disorders appear highly relevant. Sack et al. (Sack, Radler, Dianne, Mairella, Kathleen, Touger-Decker, & Khan, 2009) showed that in general physical therapists show neutral attitudes towards treating obese populations. However, younger practitioners scored higher in terms of knowledge compared to more senior and experienced professionals (Sack et al., 2009). This finding may demonstrate a shift in physical therapy educational curriculums and theory for providing training in this area and thus increased professional and clinical emphasis. In addition, incorporation of intensive weight loss management in physical therapy practice and educational models may result in better clinical outcomes and successful management of multiple co-morbidities during obesity-associated orthopedic disease.

Along with nutrition counseling, physical activity is a cornerstone of weight loss management (Klein et al., 2004; Paans et al., 2013; Villereal et al., 2011). Current recommendations for clinical health messages include focusing on targeting healthy lifestyle behaviors, improvement in nutritional quality, assessment of physical activity behaviors, exercise promotion, assessment of cardiorespiratory fitness, and focus on weight and waist reductions (Després, 2015). The current study demonstrates the relative effectiveness of such a recommendation in a physical therapy incorporated comprehensive approach to weight loss. Adding cardiorespiratory fitness and anthropometric outcomes to standard physical therapy practice may be critical in the broader health care approach to the obesity epidemic and may have long-term effect on the high CV risk and obesity relationship.
Preliminary data (not shown here) suggest that long-term benefits of this approach may have resulted in the incorporation of this method into a longer term lifestyle pattern change since weight loss continued at 12 months and two years of follow-up of a subset of patients from this cohort. Future studies should focus on whether or not a short-term comprehensive intervention results in long-lasting behavior change and reduction in CV risks. Indeed, this style of physical therapy intervention would have broad public health implications.

Body weight and obesity is an important lifestyle characteristic that is associated with CV disease and disability. The prevalence of obesity continues to rise (World Health Organization, 2015; Yang & Colditz, 2015). Globally, the percentage of the population, both children and adults, who are either overweight [i.e., body mass index (BMI) 25.0 – 29.9 kg/m²] or obese (i.e., BMI ≥30 kg/m²]) has substantially increased over the last three decades and there is no apparent solution to reversing this trend (GBD 2013 Mortality and Causes of Death Collaborators, 2015). However, understanding and implementing weight loss strategies incorporated across health care programs including physical therapy and rehabilitation is critically important to having an impact on this disease trajectory in public health.

**Limitations**

The retrospective nature of this cross-sectional study and lack of control group limits our ability to discern cause-and-effect relationships between our specific interventions and functional outcomes. Future studies should focus on long-term controlled longitudinal interventions in physical therapy practice to address this limitation. In addition, although BMI and waist circumference are important surrogate measures of adiposity that are clinically relevant, other measures of percent body fat may be more
accurate in terms of body fat distribution and can be incorporated into clinical practice. Although adherence to the independent exercise and nutritional recommendations of the program were monitored via data from heart rate monitors and food diaries respectively, we did not account for possible variability between patients in this regard. We do believe however that the majority of patients followed independent exercise prescriptions and dietary allowances. Furthermore, the biomarker set analyzed for this study did not include testing of physiological changes that may occur over time, so it is not clear when the changes that were observed reached significance as patients’ progressed through the program. Finally, given the retrospective and clinical nature of the study, complete biomarker testing was achieved in a subset of patient records analyzed. While this is an apparent limitation of this study, future analysis will focus on prospective analysis.

Conclusions

In conclusion, the results of this study support the implementation of comprehensive weight loss strategies in physical therapy and rehabilitation programs. Specifically, cardiorespiratory fitness and muscle strength gains are reported after 8-10 weeks of physical therapy programs directed at weight loss. The combination of improved physical fitness, anthropometrics, and cardiometabolic risk associated with the broader implementation of comprehensive physical therapy programs that focus on weight loss may have important long-term public health implications on obesity and CV disease risk.

Declaration of Interest

Revolution Physical Therapy and Weight Loss provided partial financial support for the completion of this study.
References


http://doi.org/10.1001/jamainternmed.2015.2405.Author
Figure 1. Schematic depicting the therapy weight loss and testing model

- Patients were scheduled for initial readiness consultation with the motivation manager.
- Baseline biomarkers collected
- Exercise program created based on biomarker testing
- Treatment initiation: 1x/week with the behavioral counselor, 1x/week with the dietitian, 3x/week with the PT or EP.
- Post program biomarkers collected after 26 treatment visits.
Figure 2. Graph depicting mean waist circumference measures (cm) at baseline and following physical therapy weight loss program. Data are presented as mean ± SEM (*p<0.001 vs. baseline).

Figure 3. Exercise capacity measured as VO2 (ml/kg/min) at baseline and following physical therapy weight loss program. Data are presented as mean ± SEM (*p<0.001 vs. baseline).
Figure 4. Mean blood pressure (mmHg) changes with physical therapy weight loss program. Data are presented as mean ± SEM (*p<0.001 vs. baseline).

Figure 5. Mean fasting blood glucose (mg/dL) at baseline and following physical therapy weight loss program. Data are presented as mean ± SEM (*p<0.001 vs. baseline).