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The Effects of a Progressive Resistance Exercise (PRE) Approach to Training an Adult Classified as Sarcopenic

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Abstract

Background: The term sarcopenia includes the involuntary loss of muscle mass that occurs during the aging process beginning in middle adulthood.

Case Presentation: We present a case study that was used to determine the effectiveness of a 12 week resistance training (RT) intervention to enhance overall function in an adult classified as experiencing sarcopenia. The purpose of this investigation was to determine what benefits as measured by increases in muscular fitness objectives and skeletal muscle mass index a progressive RT program might provide a very old adult.

Conclusions: The subject experienced gains in upper and lower extremity strength as measured by 1RM testing. The Skeletal Mass Index (SMI) the outcome measure to determine sarcopenia showed clinical findings indicating that the subject was no longer classified as sarcopenic. The present study results also suggest that a progressive RT program is safe and effective for yielding strength gains in a very old individual.

Keywords: sarcopenia, resistance training, healthy aging

1. Background

Aging is associated with multiple physiological changes that contribute to the loss of muscle mass, strength and power, known as sarcopenia. Sarcopenia increases the risk of functional loss and physical disability two-fold in men and three-fold in women, and the ability to live independently (Bauer & Sieber 2008; Janssen, Baumgartner, Ross, Rosenberg, Roubenoff, 2004; Janssen, Heymsfield, Ross, 2002; Straight, Brady, Evans, 2013). The condition is also linked with functional impairment, physical disability, frailty, falls, fall-related fractures, as well as increased morbidity and mortality in older adults (Sayer, 2010; Straight; Wannamethee & Atkins, 2015; Delmonico, Hearris, Lee, Ivsser, Nevitt, Kritchevsky, Tylavsky, Newman, 2007; Landi, Cruz-Jentoft, Liperoti, Russo, Giovanninin S, Tosato, Capoluongo, Bernabei, Onder 2013). Many of the changes in muscle with aging may be attributed to Type II muscle fiber atrophy (Hunt, Chapa, Hess, Swanick Hovanec, 2015, Watson, 2012). Some atrophy may be the result of inactivity but other issues such as reduced protein turnover, reduced endocrine function, and neuromuscular denervation have all been implicated in research findings (Watson). Numerous age-related sensory changes have been documented including negative changes in response to tactile stimuli, decreased acuity of joint position, reduced efficiency in motor planning, and decreased sensory nerve conduction velocity in both median and sural nerves (O'Sullivan & Schmitz, 2007). Further, impaired contraction velocity and lower leg power have been shown to be contributors of poorer functional performance (O'Sullivan & Schmitz).

Interventions to reverse some of these changes in muscle can improve the quality of life and independence of older adults as well as reduce health care costs associated with the treatment of sarcopenia and its associated adverse health outcomes. One approach often used to improve muscle is resistance training. However, the exact training approaches used and their effectiveness need dissemination.

2. Case Presentation

In the older adult population a progressive resistance training model is commonly utilized. The exercise programming follows a progressive overload model, gradually and progressively increasing the amount of resistance an individual performs an exercise with, while decreasing the number of repetitions performed (Baechle & Earle, 2000).

2.1 Purpose

The purpose of this investigation was to determine if a progressive resistance training program in a very old adult would improve muscular fitness and skeletal muscle mass.

2.2 Design

The duration of the exercise intervention program was 12 weeks including a one-week familiarization phase. The familiarization phase was designed to allow the study participant three intervention sessions in which the training volume and intensity was low (resistance equaled 40% of 1RM) to allow for accommodation to the resistance training equipment and to ensure quality and safety of exercise execution. The familiarization phase utilized in this study has also been referred to as an anatomical adaption phase in contemporary resistance training literature. The main objectives of this phase include preparing the muscles, ligaments, tendon, and joints to endure the subsequent more strenuous resistance training phases (Bompa, 2005). The individual participating in the progressive RT program followed RT guidelines related to the principle of progressive overload, to promote adaptations to occur that might improve muscular fitness (Baechle & Earle, 2000). The RT program consisted of progressively increasing the resistance used in each exercise over a period of time with no pre-determined variation in training parameters other than the gradual increase in resistance.

2.3 Outcomes

The outcomes for this study were body composition as determined by bioimpedance analysis (BIA), Five Time Sit to Stand, Handgrip Dynamometer score, and 1RM scores in the Chest & Leg Press on Keiser ® pneumatic resistance equipment.

2.4 Intervention

The intervention program consisted of 12 weeks. The subject had a one week familiarization phase and then participated in a three times a week, 11-week individualized intervention. The number of sets, intensity, and total amount of weight lifted per week (or volume) is illustrated in Table 1.

Table 1. Training loads for intervention

Week 1	2 x 15@ 40%1RM
Week 2	2 x 12@ 65 %1RM
Week 3	2 x 12 @ 65% 1RM
Week 4	2 x 12 @ 65% 1RM
Week 5	2 x 12 @ 70% 1RM
Week 6	2 x 12 @ 70% 1RM
Week 7	2 x 12 @ 70% 1RM
Week 8	2 x 12 @ 70% 1RM
Week 9	2 x 12 @ 70% 1RM
Week 10	2 x 12 @ 70% 1RM
Week 11	2 x 12 @ 75% 1RM
Week 12	2 x 12 @ 75% 1RM

The initial load utilized, 40% of 1RM is considered by most to be light intensity and emphasized the use of correct technique and safety of the participant (Hunter et al, 2004). The subject was instructed to complete each lift using a 2-3 second concentric phase and a 2-3 second eccentric phase as advocated by the American College of Sports Medicine (ACSM) guidelines for resistance training in older adults (2007). The total volume is the sum of the weekly training volume multiplied by three sessions per week. Table 2 demonstrates the weekly training volumes throughout the duration of the 12-week program.

Table 2. Comparison of volumes during study period

Week	Relative Weekly Volume
1	12660
2	19392
3	22572
4	15516
5	1344
6	19764
7	19764
8	19764
9	19764
10	19764
11	19764
12	19764
Total Volume	**211,452**

2.4.1 Explanation of Treatment Parameters

The ACSM position stance on Exercise and Physical Activity for the Older Adult recommends older adults participate in resistance training at least two days a week (Chodzko-Zajko et al, 2009). In addition, The ACSM published in 2007 a current comment on resistance training in the older adult population authored by Mazzio which included the recommendation that the older adult perform resistance training activities at least two days per week but no more than four days per week, or an average of three days per week, with at least 48 hours rest period in between training sessions. The present study's training program adhered to these recommendations. Mazzio also recommended a rest period of 2-3 minutes between sets and a total training session duration of about 30 to 45 minutes. Each of these parameters of rest time and total time of exercise were adhered to in the exercise prescription. The ACSM also recommends a resistance training intensity of 65%-75% 1RM for older adults, with the number of repetitions ranging from 10-15. Previously, the training intensity of up to 65% 1RM had been utilized with success as an initial training intensity for older adults (Hunter et al, 2004). Mazzio indicated that the literature showed that older adults can tolerate resistance training intensities up to 85% 1RM, but this intensity was not included in the recommendations. However, knowing that contemporary findings have shown that the older adult could safely participate in a resistance training program using intensities up to 85% of 1RM facilitated the current study's program design.

2.4.2 Order of Resistance Exercises

The resistance exercises followed a whole body sequence of training large muscle groups first in multi-joint movements and then single joint movements (Baechle & Earle, 2000). The subject was instructed to alternate between upper and lower body exercises to allow for enhanced rest and recovery (Baechle & Earle). With these considerations taken into account the order of resistance exercises for the present study were:

- Seated Leg Press
- Seated Bench Press
- Knee (Quadriceps) Extension
- Latissimus Pulldown
- Knee (Hamstrings) Curl
- Seated Row.

The motivation behind using these particular exercises was primarily safety, since previous research has indicated that the same type of exercises have been utilized without harm in the older adult population (Geithner & McKenney, 2010).

2.4.3 Exercise Session Description

Each intervention session began with a general warm-up on a recumbent bicycle, Nu-Step ® machine or on a treadmill at a walking speed no more than 3.5 mph for approximately 5 minutes and a dynamic warm-up that lasted approximately 5 minutes. The dynamic warm-up utilized consisted of dynamic range of motion activities designed to prepare for the movements of the resistance exercise training session. The specific dynamic warm-up activities included neck clock stretch, chest hugs, high knee march for 20 seconds (approximately 50 feet), and arm range of motion (ROM) circles (Baechle & Earle, 2000). At the end of each exercise session the subject was provided a whole body static stretching routine that took about ten minutes to complete. The routine included a seated hamstring stretch, seated or side quadriceps stretch, calf stretch utilizing a wall, neck Rotation/Flexion/Extension stretches, straight arms behind back stretch, and reach arms overhead stretch (Baechle & Earle). Utilizing both a general and dynamic warm-up routine prior to beginning each training session is thought to reduce the risk of injury during training (Baechle & Earle). A pre-exercise protocol with similar exercises was utilized for the same type of population in Katula, Rejeski, and Marsh's 2008 study that compared muscle strength and power training.

2.4.4 Data Collection

Over the course of the 12 week program there were 35 total training sessions, with 3 sessions occurring in the first familiarization week and 2 testing sessions (pre and post). Attendance was taken at each training session. Testing results were recorded for the subject using a standard exercise log during each training session.

2.4.5 Data Analysis

Outcome variables were evaluated, and descriptive statistics were also reviewed and included age, gender, and training age (amount of time a subject has participated in exercise prior to study participation). Pre and post strength measures were evaluated by percentage of change.

2.5 Results

Over the 12 week program, there were 33 training sessions. Testing results were recorded for the subject using a standard exercise log during each training session. The subject attended 30 out of 33 sessions (i.e. 91%).

Prior to the intervention program, the subject had a SMI of 6.8 kg/m^2 indicating sarcopenia. However, post intervention the subject's SMI increased to 7.43 kg/m^2, that is a 9.3% increase and greater than the cut-point of less than 7.0 kg/m^2 for women classifying females as sarcopenic. The subject's body fat at pre-testing was 24.3% and at post testing it was 22.7% indicating a decrease of 1.6%. However, the subject also had a one pound increase in total body weight (See Table 3).

Table 3. Changes in skeletal mass index and body fat

SMI Pre-test	**SMI Post-test**	**%Change**	**Body Fat% Pre-test**	**Body Fat% Post-test**	**%Change**
6.8 kg/m^2	7.43 kg/m^2	9.3%	24.3	22.7	-1.6%

Findings from the post test for the chest press and leg press exercises yielded positive changes for both upper and lower body strength indices. For the participant's upper body strength there was 27% change. For lower body strength, the participant had a 23% change (See Figure 1). Both changes demonstrated a positive result from the individual performing a progressive RT program for 12 weeks.

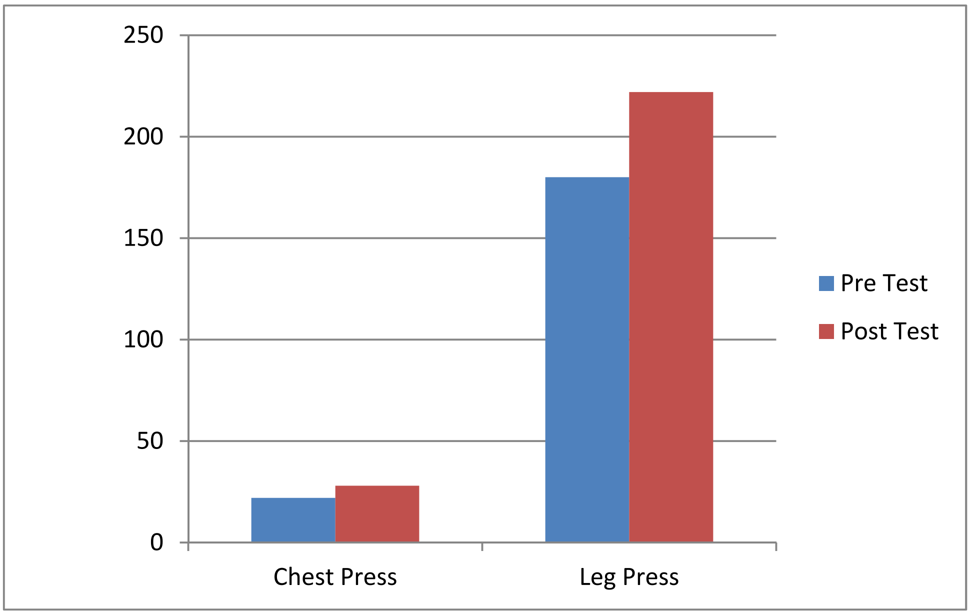

Figure 1

The results of the FTSTS test, a measure of functional power, indicated that the subject took longer to complete the test after the 12 week intervention study (Table 4).

Table 4. FTSTS results

FTSTS Results	FTSTS Average Pre Test	FTSTS Average Post Test
	11.97 seconds	13.5seconds

Although, the decrease in functional power is only for one subject, this finding may be of vital clinical importance. If the loss of functional power of the individual in this case study is at all indicative of functional power declines in the general population over 85 years of age, then it is potentially of primary importance to examine the inclusion of power training exercise with the very old adult population, particular at more advance ages.

3. Discussion

The current case study had three potentially clinically relevant findings. The first being that both upper extremity and lower extremity strength gains as measured by 1RM scores in the Chest press and Leg press increased. Second, the SMI indicated a possible attenuation of the loss of lean body mass. However, functional power, as measured by the FTSTS test, did not demonstrate any gains over the same 12-week intervention period and, in fact, experienced a slight decline as seen in the time it took to complete the FTSTS assessment.

The current study's results indicate that a structured progressive resistance training program can perhaps increase muscular fitness (i.e. muscular strength) in very old adults. Strength gains demonstrated in the current case study are similar to those demonstrated in previous studies examining the effect of resistance training in very old adults (Peterson, 2010; Deley et al, 2007). The corroboration of this study's results with previous research literature findings strengthens the evidence describing the benefits of resistance training on muscular fitness in very old adults (i.e. individuals greater than 80 years of age). Equally important, however, is this study also serves to demonstrate that structured, supervised progressive resistance training is safe for very old adults, even at training loads up to 85% 1RM. Previous recommended training intensities for the very old adult may prove too conservative in their design. The present case study demonstrates that a very old, previously untrained adult can safely tolerate and benefit from a progressive RT program that increases training volume and intensity in the same manner as younger populations (ACSM, 2007). This study also demonstrated that compliance related to training very old adults with higher training intensities and loads was satisfactory given that the subject attended 30 out of 33 sessions (i.e. 91%) and there was no incidence of intervention-related injury.

In addition to strength improvements, improvements were observed in the SMI / body composition. This finding may be clinically relevant, since it suggests that the intervention was effective in inhibiting the subject from showing a SMI score that had deteriorated further. Further studies are also needed to examine whether dietary modifications in conjunction with RT programs can attenuate and/or have a synergistic impact on sarcopenia. Especially since nutrition intervention alone has been shown to be beneficial. For example, the provision of a leucine-enriched whey protein powder and vitamin D for a 13 week period enabled significant gains in appendicular muscle mass and in lower extremity function in a group of 184 older adults diagnosed with low skeletal mass (Bauer et al 2015).

Improvements in functional power should also be potentially considered as a goal in very old adults and might need to be part of the design of future exercise intervention programs for older adults. However, the current study did not elicit a significant improvement in functional power as measured by the FTSTS assessment. This finding demonstrates that an intervention for very old adults might be considered that would allow them to perform high-velocity concentric contractions and quick multi-joint movements (i.e. chair squats) in order to potentially experience additional positive adaptations in muscular fitness, specifically, in the area of muscular power. The importance of improving muscular power in very old adults has been shown previously as having a significant role in the incidence of falls and ability to perform daily activities (Signorile, 2005). Given the current study's findings in an adult over 85 years of age combined with previous findings indicating the importance of power in functional ability and quality of life there appears to be mounting evidence supporting the necessity of including power movements in resistance exercise programming for very old adults.

However, the findings of the current case study do expose a potential weakness in the intervention design and underscores the importance for trained exercise professionals to identify and address specific strength and power impairments in an individualized manner to best serve clientele within a best practices evidence based paradigm.

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