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Abstract

The purpose of the study was to determine whether functional fitness is a good predictor of average and peak muscular power among adults over the age of 65. The 30-second chair stand and 8-foot-up-and-go test were used to define functional fitness and were administered to 57 older adults. Muscular power output was measured using the Tendo Weightlifting Analyzer during 5 chair stands. Relative average and peak power were used in the analyses. An independent t-test was run on all variables to distinguish differences between men and women, and multiple regression analyses were performed to detect the relationship between the two functional fitness variables and muscular power. There were no differences between genders, and 53.5% variance in both relative average and peak power was accounted for by the functional fitness measures ($p \leq .05$). Functional fitness, defined as 30-second chair stand and 8-foot-up-and-go test, is a good predictor of average and peak muscular power.

Keywords: functional fitness, muscular power, older adults

The Relationship Between Muscular Power and Functional Fitness Among Older Adults

Background and Significance

The older population is growing and with this comes issues that need to be addressed in order to improve their quality of life and contribute to the well-being of the nation. Older adults have low levels of functional fitness, meaning possessing the physiologic attributes required to carry out activities of daily living. Research has shown that functional fitness is directly proportional to muscular power. Foldvari et al. (2000) found that leg power had the strongest single variable correlation with self-reported functional status of all the physiologic factors tested in sedentary, community-dwelling women ages 69-79 years. Muscular power is dependent on force and speed of contraction and decreases with age (Fielding et al. 2002). This becomes increasingly important because of the graying of America and the suggested direct relationship between muscular power and functional fitness.

Muscular power is defined as the rate of performing work, or the product of force and velocity (Botarro et al. 2006). The decrease in muscular power with age could be due to the impairment of Type 2 fibers, or fast-twitch fibers, with increasing age (Izquierdo et al. 1999). This leads to a reduction in the muscles' ability to produce force quickly (De Vito et al. 1998; Izquierdo et al. 1999). Finding the relationship between power and other physiological variables and how close that relationship is could be the key to improving said variables.

The importance of functional fitness cannot be stated enough. It is tested multiple times every day in every individual. When one can no longer perform these activities of daily living (ADLs), that person should enter assisted living or a nursing home. This individual can no longer take care of himself or herself, has to leave home, and admit that the self-efficacy he or she once had is no more. Not only is this hard for the people who have to endure this, but their families and the community suffer too. The list of problems associated with diminished societal function is limitless. Discovering what can improve this issue, and applying it to the general population is of utmost importance. In order to know if there is improvement, there must be tests that accurately and reliably reflect functional fitness. Multiple tests have proven sufficient, one of which being the Senior Fitness Test (SFT). SFT is used to assess functional fitness among people 60 years of age and older and is useful in identifying an older adult who may be at risk for loss of functional capabilities (Jones & Rikli, 2002). The ability to do this is a key component in preventing or delaying the onset of diminished functionality.

There are, of course, other facets leading to the solution so desperately needed, such as what factors (power, gait velocity, etc.) are most closely related to functional fitness and how they are correlated. Once this is established, steps can be taken to resolve this ever-growing issue. Answering these fitness-related questions is the key to improving the physical aspect of the older population's lives. One suggested answer is increasing muscular power. Botarro et al. (2006) found that high-velocity resistance training was more effective for improving muscular power and functional performance in men between the ages of 60 and 76 than traditional resistance training or low-velocity resistance training, though both training regimens resulted in improved muscular strength. This implies that muscular power is linked to increased functional performance. "Peak power declines more precipitously than strength with advancing age and is a reliable measure of impairment and a strong predictor of functional performance (Fielding et al. 2002, p. 655)." Muscular power is important to maintain with age because studies have confirmed a link between increased muscle power and better performance in functional mobility tasks (Fielding et al. 2002).

The proposed study aims to contribute to modern research. It is known that muscular power output and functional fitness both decrease with age in the general population, but the strength of the relationship between the two is being tested. The purpose is to determine whether functional fitness, measured by 30-second chair stand and 8-foot-up-and-go, is a good predictor of average and peak muscular power among adults over the age of 65. The hypothesis is that power, both average and peak, can be predicted from functional fitness.

Methodology

Subject Requirements

Prior to study participation, each individual obtained medical clearance from a physician, completed a health history questionnaire (HHQ), and took the mini-mental state exam (MMSE). A score less than 23 (out of 30) disqualified the participant from additional participation (Reid et al. 2008). Signing of informed consent indicated participants were aware of the study purposes, procedures, and possible risks and benefits involved with participating. Once all inclusionary criteria were met, individuals were physiologically tested using three different measures.

Muscular power assessment

Muscular power output was determined using the Tendo Weightlifting Analyzer (Trencin, Slovak Republic). The Tendo measured average power (W), average velocity (m/s), peak power (W), and peak velocity (m/s) while the participants performed a power chair stand five times. All values for each repetition, as well as the average of each, were recorded. Power assessment is relative to each participant, with participant mass being the constant used for calculation.

Functional fitness assessment

Two aspects of functional fitness were measured by having the participant complete a 30-second chair stand test and an 8-foot-up-and-go test, both of which are part of the SFT. The 30-second chair stand determines the number of times an individual can rise from a chair in 30 seconds. A full stance had to be achieved in order for the repetition to be counted. The 8-foot-up-and-go test gives the amount of time it takes an individual to stand up from a seated position, walk 8 feet as quickly and safely as possible, and return to a seated position in the chair. A cone was placed 8 feet from directly between the front legs of the chair. The timer was started on the tester's cue to "go", and one practice trial was allowed before the two recorded trials were administered. If the participant ran, indicated by a period of time in which both feet are off the ground (Allen, 2013), in order to get a better time, that trial was repeated. Trial times were recorded to the nearest tenth of a second, and the better of the two was used for data purposes. These measures were chosen because they closely mimic the protocols used to assess muscular power output and incorporate leg extension power. Furthermore, some consider the ability to go from being seated to standing to be one of the most important measures of functional fitness (Kelly et al., 1976; Rodosky et al., 1989).

Statistical analysis

An independent t-test was run on all variables to distinguish differences between men and women. A multiple regression analysis was performed to detect the relationships between the two functional fitness variables, 30-second chair stand and 8-foot-up-and-go (independent variable), and muscular power (dependent variable). Statistical significance was set at $p < .05$ for all analyses. To account for making a type I error, Bonferroni correction was used when multiple t-tests were performed.

Results

The independent t-test for each variable displayed no difference between men and women ($p > .05$). Therefore, the findings of this study apply to both genders. The subject demographics are presented in Table 1, and the correlations between the muscular power and functional fitness measurements are shown in Table 2.

Table 1

Subject Demographics

Measure	Male (n = 16)	Female (n = 41)
Age (yrs)	78.19 ± 7.31	78.15 ± 6.40
Height (cm)	176.56 ± 8.18	160.57 ± 5.41
Weight (kg)	88.84 ± 11.71	65.68 ± 10.76
30-sec chair stand (reps)	13.13 ± 3.01	12.07 ± 3.96
8-ft-up&go (sec)	6.46 ± 1.39	6.91 ± 1.83
Ave power (W/kg)	5.09 ± 1.06	4.33 ± 1.41
Peak power (W/kg)	8.18 ± 1.76	6.64 ± 2.12

Table 2

Correlations Matrix

Measure	30-sec chair stand	8-ft-up&go	Peak power	Ave power
30-sec chair stand (reps)	1	-.66	.72	.73
8-ft-up&go (sec)		1	-.56	-.55
Peak power (W/kg)			1	.97
Ave power (W/kg)				1

Based on the multiple regression analyses, 53.5% of the variance was accounted for in the dependent variables (relative average and relative peak power) by knowing 30-second chair stand and 8-foot-up-and-go test scores ($\leq .05$). If a subject receives certain scores on 8-ft-up-and-go and 30-second chair stand, power can be computed using the regression equations on the following graphs. The hypothesis was supported and functional fitness, defined as 30-second chair stand and 8-foot-up-and-go test, is a good predictor of average and peak muscular power.

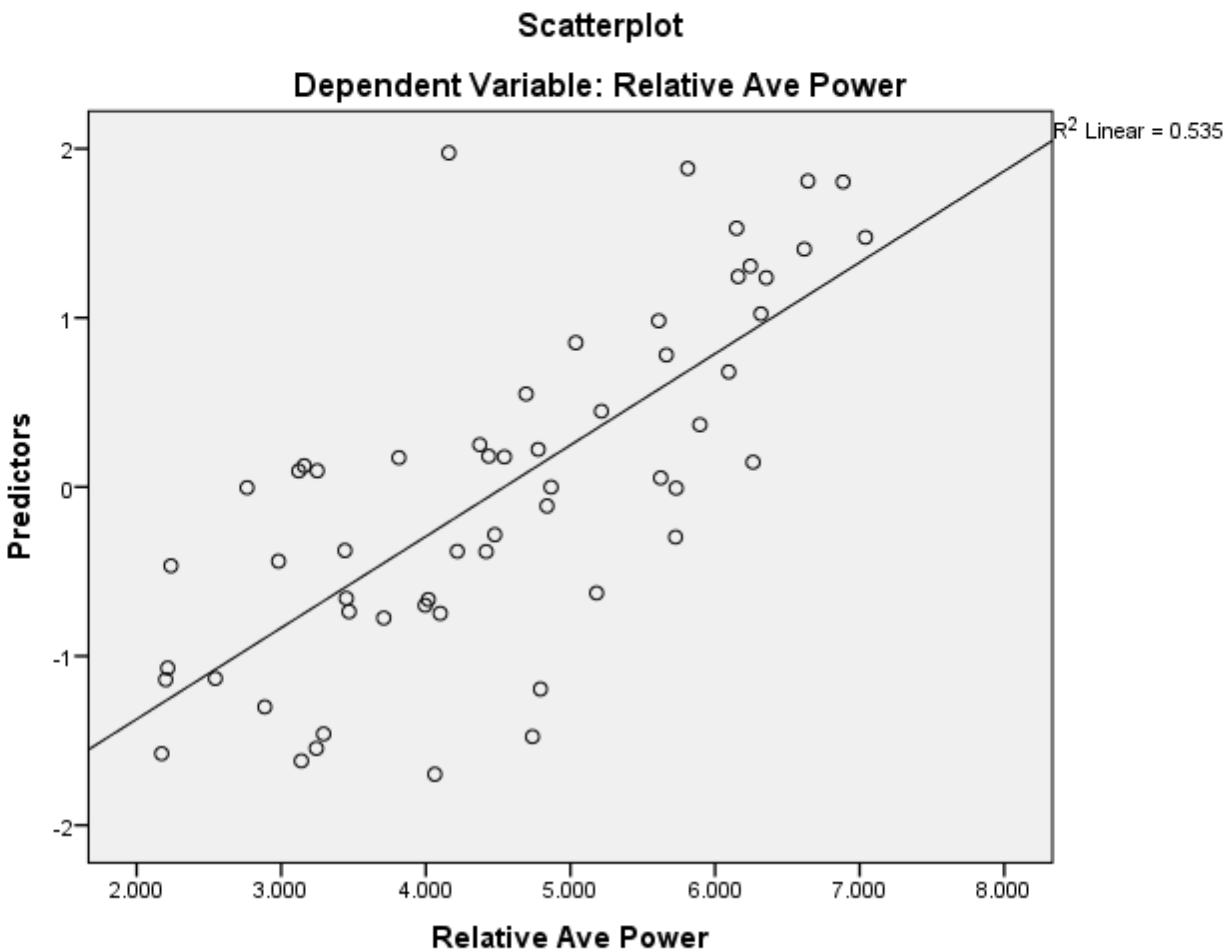

Figure 1. Relationship between relative average power and functional fitness predictors with the predictors being 8-foot-up-and-go and 30-second chair stand.

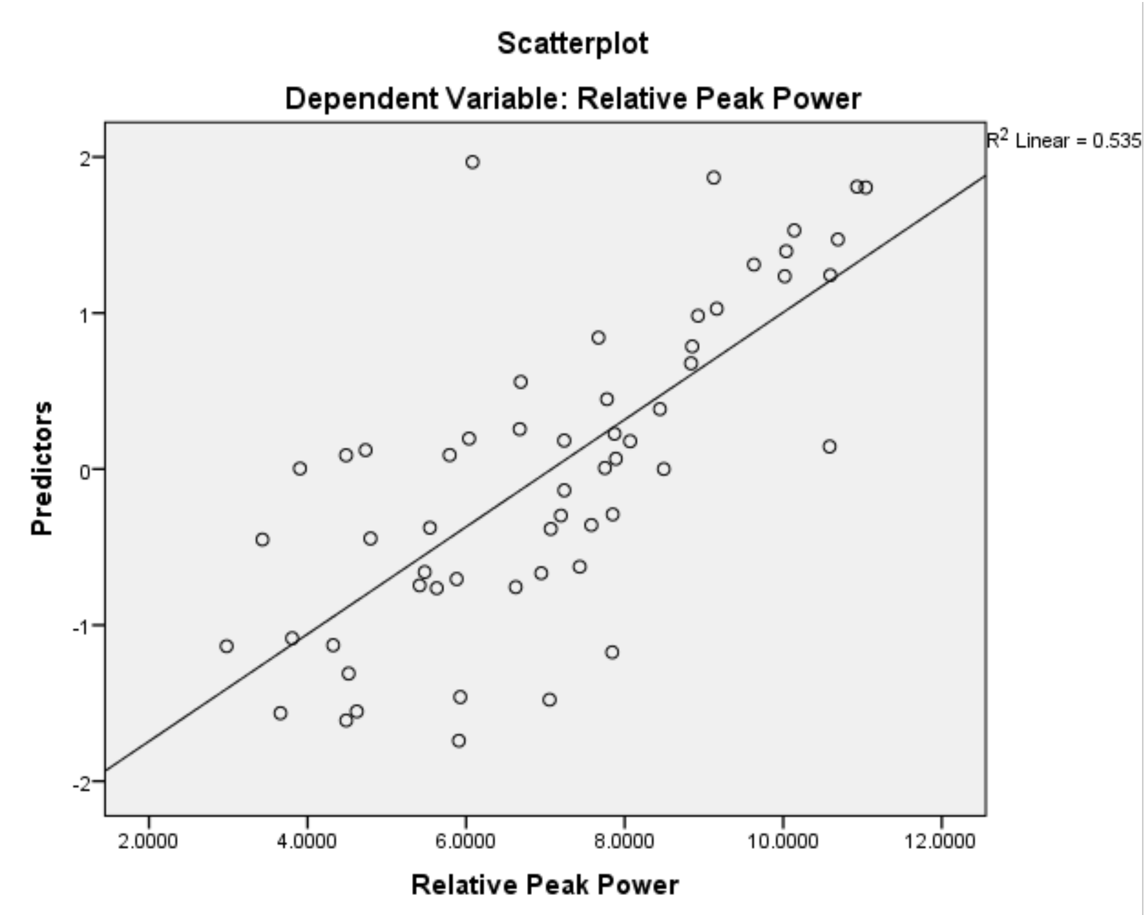

Figure 2. Relationship between relative average power and functional fitness predictors with the predictors being 8-foot-up-and-go and 30-second chair stand.

Discussion

The results indicate that muscular power, both average and peak, can be predicted from a 30-second chair stand and 8-foot-up-and-go test (functional fitness), supporting the hypothesis. These findings provide information that can greatly contribute to the quest of improving functional fitness and, therefore, quality of life in the elderly population.

It is known that muscular power and functional fitness are directly related, but knowing one can be predicted from the other is a profitable development. Measuring power can be expensive to say the least. Equipment to assess muscular power is specialized and highly priced. Not only is it costly, but individuals have to be trained on how to use it correctly and efficiently, which takes time. Since differences in muscular power among people can be accounted for by the measures of functional fitness used in this study, these assessments can be used in place of the upscale power analyzers used by university researchers and exercise physiologists to accurately reflect muscular power in individuals. This is advantageous and favorable when funds are lacking and other equipment is more hastily needed.

Additionally, the knowledge that these aspects of the Senior Fitness Test predict muscular power presents reason for further studies to be performed on the population. These potential future studies could test the percent to which other measures of functional fitness predict power. Furthermore, other aspects of physical fitness, such as strength, cardiovascular and muscular endurance, body composition, and flexibility, could be considered. The relationship between facets of functional fitness and these variables could be evaluated to detect if they are more or less related than muscular power and functional status. This can lead to centering focus on the most important forms of fitness involved in improving functional capacity in the elderly. More regression analyses could be completed to examine whether functional fitness indicators predict other physiological variables and vice versa. These positive results provide assurance that functional fitness and longevity of a productive lifestyle can be influenced by malleable physiological factors.

The findings reiterate the fact that power and functional fitness are directly proportional and add to the popular current views among exercise physiologists around the world. If level of functional fitness, as defined in this study, predicts average and peak muscular power, then functional fitness and power are, in fact, directly related. Increased muscular power will proceed to induce increased societal function because of functional fitness among the older population. This progression will better the community as a whole by increasing abundance of well-functioning adults and decreasing the amount of people reliant on others for relatively simple activities of daily living (ADLs).

It is important to improve functional fitness to ensure older adults are living independently for a longer period of time. Self-efficacy, less money spent on health care by the individual and country in its entirety, and family unity are a few reasons to strive toward achieving this goal. Maintenance of exercise habits is a struggle in any subpopulation, but McAuley, Lox, and Duncan (1993) obtained data from older adults suggesting that there were significant declines in performance 9 months after the conclusion of a 5-month training program. Long-term devotion to exercise constructively affects a whole mass of physiological processes including functional fitness, which according to this study and others initiates a continuous cycle leading to a promising future for individuals. In addition, functional fitness has been linked to long-term exercise adherence even more so than self-efficacy and other personal attributes (Barreto & Sanchez, 2011). So, if functional fitness is improved then amount of exercise could be increased. Since exercise increases level of function, higher initial functional fitness can facilitate its own improvements.

Based on discoveries in this line of research, it can be concluded that refining functional fitness can also precede amended muscular power, since amount of functional capacity predicts level of average and peak power. This is key because status of muscular power can be indicative of physical entities other than functional fitness. There is a linear relationship between muscular power and local fatigue (Monod & Scherrer, 2007). This implies there is also a direct association to anaerobic threshold (AT) or lactate threshold (LT). Devries, Moritani, Nagata, and Magnussen (1982) found power output at fatigue threshold was not significantly different than at AT in a study using electromyography (EMG) during cycling. Since functional fitness is a good predictor of muscular power, by association it could also potentially predict when AT and fatigue will occur. The higher the intensity of an activity, LT will happen sooner because at higher intensities, anaerobic energy systems are relied on more heavily. By delaying the onset of LT, the maximum muscular power that can be achieved and maintained is greater. Many exercise physiologists believe that exercising at or above LT can improve it and oxygen utilization, but much research still needs to be done. This is essential because lack of fatigue is central to everything, including the ability of the elderly to perform ADLs more efficiently. By improving one of these variables, functional fitness, muscular power, or AT, the other two will change for the better as well because of the interconnection of it all. This point is eluded to by the results of this study since amount of muscular power can be accounted for by level of functional fitness with additional current and future research done to discover ways to obtain a more advantageous value for these variables, functional fitness in the older population and all populations can be improved.

When it comes to the elderly, functional fitness is of main concern. As discussed, other physiological aspects affect it, but overall, diminished functional fitness is the issue that defines the older population as a whole in our society. Functional fitness, though, is not a specific process of the body that can be directly targeted. It has to be indirectly manipulated by improving biological processes that influence it. From results of this study and others, it is known that muscular power is one of these routes. Again, postponing the point at which lactate production trumps lactate removal in the blood plasma is a way to increase muscular power. The effect of vibrations on power of arm flexors, too, has been evaluated among athletes. Five vibrations were applied for one minute during isometric arm flexion with one minute in between. Subjects were tested before and immediately after the treatment, and average power was significantly greater in the arms that received the vibration therapy. Additionally, EMG signals showed massive increases in neuromuscular activity during the actual applied vibrations (Bosco, Cardinale, & Tsarpela, 1999). This is valuable information because with age comes decreased neural capacity and efficiency. Stimulation of the nervous system is beneficial in slowing this progression. Speed of muscle contraction while performing exercises with external weight has also been shown to influence increases in power. When a fast concentric phase was implemented as opposed to slow and controlled, the group using high-velocity contractions had larger percentage improvements in muscular power, though the low-velocity individuals had more increases in strength (Young & Bilby, 1993). This returns us to the previous question: which of these facets of fitness, muscular power or muscular strength, is most highly correlated with functional capabilities? The decision to use high-velocity or low-velocity in training to increase functional fitness in frail populations depends on the answer, according to this study. Functional fitness assessment can be used as an alternative to power output measurements, but whether it is a better, worse, or equal predictor of muscle strength could hold other implications for type of intervention used in rehabilitation or prevention of loss of functionality.

By studies comparing functional fitness to different components of fitness, over time and repeated findings, the best ways to improve functional fitness will come to light. With similar thoughts regarding the correlation between functional fitness and muscular power, another study has supported the hypothesis that increasing power does warrant positive changes in functional status. Konopack et al. (2008) tested this, as well as the effects of flexibility and the idea that self-efficacy constitutes better performance in functional tasks by increasing participation in different physical activities. Participants aged 58-84 years performed a functional fitness test, a maximal graded exercise test, and surveys concerning demographics and faith in one's own capabilities, and results displayed greater muscular power and flexibility underlying higher functional capacity. In addition, gender was the only significant factor of which flexibility was dependent on, signifying that age causes insignificant changes and men have more room for improvement in this area. The outcomes demonstrating more self-efficacy associated with larger amounts of muscular power give another path to improving power and, therefore, functional fitness. Another research investigation set out to distinguish certain elements of fitness that bring about variances in functional fitness agrees with Konopack and colleagues' study in the way that males surpass females in power output and women excel more than men in flexibility, but provided evidence that age does, in fact, negatively impact flexibility which might change views on striving to improve flexibility in the elderly to better functional status. Moreover, the Physical Activity Scale for Elderly (PASE) measured physical activity had a significant positive correlation with flexibility but not muscular power, inferring that in order to have an increase in physical power it must be specifically targeted (Ho, Wu, Matthews, Chiang, & Lin, 2013). It goes without saying that more research needs to ensue in order to settle these discrepancies. The confounding gathered information has differing implications for methods to fight declining functional fitness, so more subjects and statistics need to be recruited to further support or oppose these previous studies. The state of other physiological and psychological dimensions has been shown to influence the condition of functional fitness, as well. Collins et al. (2004) found that when adults 50 years of age or older completed the SFT after filling out a health history questionnaire, the best variables for predicting performance on the fitness test included education, self-rated health, obesity, diabetes, and ADLs. Many things potentially come into play when dealing with functional fitness.

Measures of functional fitness can accurately reflect muscular power in older individuals. This statement is supported by the findings of this study. Though more research can and should be done in this subject area of exercise science to expound upon proposed discoveries, this study and its results are a stepping-stone in the advancement of quality of life in old age.

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