ABSTRACT

Smolarek AC, McAnulty SR, Schoenfeld BJ, Cordeiro CW, Honorato IC, Ferreira LH, Mascarenhas LP, Souza WC, Oliveira CS, Laat EF, Utter AC, Souza-Junior TP. Strength Decline in Sedentary Males and Females of Different Ages. JEPonline 2018;21(2):40-50. The purpose of this study was to compare the muscle strength of sedentary adults within different age groups and investigate the effect of age on changes in strength and body composition. Six hundred and twenty-seven sedentary subjects were recruited (331 males and 296 females) and stratified into three age groups of 20 to 29 yrs (G1), 30 to 39 yrs (G2), and 40 to 49 yrs (G3). All subjects were not physically active. Subjects’ anthropometric measurements were taken prior to a 1-min sit-up test that was followed by an arm flexion and extension exercise. For females, their body mass decreased by 6.1% (P=0.01) when
comparing G1 with G3. For the 1-min sit-up test, there was a decrease of 27.7% and 53.3% (P=0.001 and P=0.001, respectively) when comparing G1 with G2 and G3, respectively. Also, G2 compared to G3 exhibited a decrease of 20% (P=0.001). Regarding males, there was a decrease in the 1-min sit-up test of 26.8% (P=0.001) when comparing G1 with G3 and a decrease of 23.1% (P=0.001) when comparing G2 with G3. But in the flexion and extension of the arms, a decrease in strength did not exist for either sex (P>0.05). The findings indicate that while an increase in sedentary adults stratified by age is associated with a significant increase in BM and BF in males and females, a significant increase in BMI in the males with no significant difference in females, a significant decrease in LM in females with no significant difference in males, a significant decrease in the 1-min sit-up test in males and females, there were no significant differences observed in the push-up test (EFE) in males and females.

**Key Words:** Aging, Fitness Conditioning, Power, Sedentarism

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**INTRODUCTION**

A decrease in muscle mass and functional capacity is a well-established process associated with aging (7). One way to reduce the decrease is to maintain a healthy lifestyle, which is characterized by an increase in physical fitness and appropriate food intake based on daily needs (31). The consequences of the decrease in muscle strength are manifested in an impairment in mobility and functional autonomy (4).

Severe cases of a decrease in strength are known as dynapenia or sarcopenia. Dynapenia is related to the reduction in muscle mass and the capacity to generate force, while sarcopenia is specific to reductions in muscle mass (7). In the last few decades, the scientific community has begun to have a better understanding of the impact of strength decreases associated with reductions in muscle mass.

Beyond the normal aging process, other factors such as genetic anomalies, gender, the use of medications, and alterations in body composition influence the maintenance of strength and muscle capacity. Another important factor that has a negative influence on strength is an injury, which decreases an individual’s range of motion as well as the adherence to and the intensity of physical activities. The effects of such an injury can be exacerbated by an attempt to protect the injured or weakened segment that frequently leads to a reduction in strength (22).

In addition to the hormonal and body composition factors, smoking and stress also contribute to the decrease in strength. For men, the factors are more related to physical characteristics, such as low levels of physical activity and chronic diseases. Therefore, research about muscle strength as well as certain intervention strategies must be analyzed specific to gender (27).

The decreases in growth hormone (GH) and insulin-like growth factor (IGF-1) in the circulation are associated with the aging process; a condition known as somatopause. This condition leads to a decrease in lean muscle mass, increase in body fat, increase in low-
density lipoprotein cholesterol, and a decrease in lipolysis (23,24) Aging also results in mitochondrial damage due to oxidative stress that results in the progressive decrease in age-related force (13).

Despite a wealth of research on this topic, it is still unclear how much muscle strength is lost throughout adulthood in sedentary individuals, as well as the effect on both males and females. Therefore, the purpose of this study was to compare muscular strength in sedentary men and women across different age ranges.

METHODS

Subjects
The sample consisted of 627 sedentary individuals (331 males and 296 females) who were stratified into three groups according to age: 21 to 29 yrs (G1), 30 to 39 yrs (G2), and 40 to 49 yrs (G3). This study included adults between the ages of 21 and 49 without physical problems that would compromise the physical test requirements. Prospective participants were deemed ineligible: (a) if they used dietary supplements or consumed medications shown to alter test results; (b) if the female subjects were pregnant; and (c) if the participants were engaged in competitive sports or were physically active on a regular basis (defined as physical exercise of 150 min·wk⁻¹. All subjects were instructed to maintain their habitual diet before testing.

This project was approved by the Research Ethics Committee of Centro-Oeste State University, Protocol No. 418544/2011, according to Resolution No. 196/96 of the CNS. All subjects were informed and given specific instructions about the research, and all subjects signed an informed consent.

Anthropometric Parameters

Body composition and body mass (BM) were taken using a Welmy™ brand scale. Stature was determined by a wall-mounted stadiometer (Sanny™). Body circumference was determined with a tape-measure (Cardiomed™) (5). Body mass index (BMI) was calculated via the body mass/height² ratio, expressed in kg·m⁻².

A Lange™ caliper was used to assess the five skinfold thickness measures: (a) suprailiac; (b) subscapular; (c) triceps; (d) biceps; and (e) medial calf. Values for each site were based on the mean of the three measures obtained. Body density (BD) was determined using the equation proposed by Petroski (20) and the percentage of body fat (% BF) was calculated using the equation proposed by Siri (25).

Motor Tests

For the motor tests, the 1-min sit-up test was performed first. This test required the subjects to perform as many correct bent-knee sit-ups as possible. The subjects laid on a mat in a supine position with the knees bent at an angle of approximately 90°, feet together, and the arms crossed at the chest with the hands on opposite shoulders. A technician held the subjects’ ankles for stabilization. The subjects performed a full sit-up to the upright position with their elbows touching their thighs and then returned to the supine position where their
shoulders (scapula) touched the mat surface. The number of repetitions in 1 min was counted as the final value (1).

Seven days later, the subjects performed a push up test. For the males, the test was started with their elbows fully extended and hands on the floor directly under their shoulders with their feet together on the floor while their trunk and legs remained fully extended. Movement was carried out by flexing the elbows until the chest just touched the floor and then immediately extending the elbows to return to the starting position. For the females, the position of the legs was modified to allow the knees to touch the floor (1). All measurements and tests were conducted by the same evaluator that had experience in physical evaluations.

**Statistical Analysis**

The data analysis consisted of mean ± standard deviation and percentage frequencies. The Kolmogorov Smirnov test was used to evaluate normality. One-way ANOVA was used to analyze the variance of physical fitness among the age groups, followed by Tukey's post hoc test with an alpha level of 0.05. All analyses were performed with SPSS™ 20.0 software (Chicago, IL).

**RESULTS**

For the females, advancing age was associated with changes in body composition and a decrease in the number of repetitions performed in the abdominal test (Table 1).

**Table 1. Mean Values and Standard Deviations (± SD) of Dependent Variables in the Female Subjects of Different Age Groups.**

<table>
<thead>
<tr>
<th></th>
<th>G1 (n=42)</th>
<th>G2 (n=196)</th>
<th>G3 (n=58)</th>
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<tbody>
<tr>
<td></td>
<td>20 to 29 yrs</td>
<td>30 to 39 yrs</td>
<td>40 to 49 yrs</td>
</tr>
<tr>
<td>BM (kg)</td>
<td>64.86 ± 15.1</td>
<td>64.87 ± 11.8</td>
<td>65.8 ± 10.1 b</td>
</tr>
<tr>
<td>%BF (mmHg)</td>
<td>27 ± 6.3</td>
<td>29.67 ± 5.3 a</td>
<td>32.24 ± 4.4 b,c</td>
</tr>
<tr>
<td>LM (kg)</td>
<td>47.35 ± 5.2</td>
<td>45.63 ± 6.1</td>
<td>44.59 ± 6.7 b</td>
</tr>
<tr>
<td>BMI (kg·m⁻²)</td>
<td>24.36 ± 4.7</td>
<td>25.02 ± 4.1</td>
<td>25.61 ± 3.7</td>
</tr>
<tr>
<td>EFE (rep)</td>
<td>15 ±10.4</td>
<td>14 ± 9.5</td>
<td>12 ± 6.7</td>
</tr>
<tr>
<td>ABD (rep·min⁻¹)</td>
<td>23 ± 9.7</td>
<td>18 ± 8.04 a</td>
<td>15 ± 5.5 b,c</td>
</tr>
</tbody>
</table>

aG1≠G2; bG1≠G3; cG2≠G3. BM = Body Mass; %BF = Relative Percentage of Body Fat; LM = Lean Mass; BMI = Body Mass Index; EFE = Push-Up Test; ABD = Sit-Ups in 1 Min; rep = Repetitions

Body mass increased 1.5% (P=0.04) when G1 was compared to G3 in the female subjects. Percent BF increased by 9.8% and 19.4% (P=0.01 and P=0.001, respectively) when G1 was
compared to G2 and G3, respectively. G2 to G3 comparisons resulted in an increase of 8.6% (P=0.01). However, in relation to LM, there was a decrease of 6.1% (P=0.01) when G1 was compared to G3. Finally, for the 1-minute sit-up test, a decrease of 27.7% and 53.3% (P=0.001 and P=0.001) were observed when G1 was compared to G2 and G3, respectively.

There was a similar pattern when G2 was compared to G3, showing a decrease of 20% (P=0.001). No significant differences were observed in BMI data and the push-up test (EFE) tests across groups for females. Table 2 shows the test results for the male samples, with the same groups stratified by age.

### Table 2. Mean Values and Standard Deviations (± SD) of the Dependent Variables in the Male Subjects of Different Age Groups.

<table>
<thead>
<tr>
<th></th>
<th>G1 (n=42) 20 to 29 yrs</th>
<th>G2 (n=196) 30 to 39 yrs</th>
<th>G3 (n=58) 40 to 49 yrs</th>
</tr>
</thead>
<tbody>
<tr>
<td>BM (kg)</td>
<td>76.9 ± 13.2</td>
<td>83.3 ± 16.1&lt;sup&gt;a&lt;/sup&gt;</td>
<td>86.05 ± 13.2&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>%BF (mmHg)</td>
<td>18.6 ± 6.7</td>
<td>23.3 ± 6.9&lt;sup&gt;a&lt;/sup&gt;</td>
<td>26.3 ± 5.5&lt;sup&gt;b,c&lt;/sup&gt;</td>
</tr>
<tr>
<td>LM (kg)</td>
<td>62.6 ± 6.4</td>
<td>63.9 ± 5.7</td>
<td>63.42 ± 7.3</td>
</tr>
<tr>
<td>BMI (kg·m&lt;sup&gt;-2&lt;/sup&gt;)</td>
<td>24.7 ± 3.8</td>
<td>27.2 ± 4.0&lt;sup&gt;a&lt;/sup&gt;</td>
<td>28.3 ± 3.9&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>EFE (rep)</td>
<td>21 ± 11.1</td>
<td>18 ± 11.1</td>
<td>17 ± 10.1</td>
</tr>
<tr>
<td>ABD (rep·min&lt;sup&gt;-1&lt;/sup&gt;)</td>
<td>33 ± 10.7</td>
<td>32 ± 11.6</td>
<td>26 ± 8.5&lt;sup&gt;b,c&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

<sup>a</sup>G1≠G2; <sup>b</sup>G1≠G3; <sup>c</sup>G2≠G3. BM = Body Mass; %BF = Relative Percentage of Body Fat; LM = Lean Mass; BMI = Body Mass Index; EFE = Push-Up Test; ABD = Sit-Ups in 1 Min; rep = Repetitions

For the male population, BM changed with time showing an increase of 8.7% and 11.8% (P=0.01 and P=0.002) when G1 was compared to G2 and G3, respectively. The percent BF was also increased by 25.6% and 41.3% (P=0.001 and P=0.001) when G1 was compared to G2 and G3, respectively. An increase of 12.8% (P=0.001) was observed when G2 was compared to G3. In regards to BMI, an increase of 10.1% and 14.5% (P=0.01 and P=0.01) was observed when G1 was compared to G2 and G3, respectively.

As to LM, no significant changes were observed in any of the comparisons. Finally, there was a decrease of 26.8% in the number of repetitions in the 1-minute sit-up test (P=0.001) when G1 was compared to G2. This difference was also observed when G2 was compared to G3. The decrease was 23.1% (P=0.001). There were no significant differences in EFE in males from either group.
DISCUSSION

The purpose of this study was to examine the decrease in muscle strength in sedentary adults of different age groups. For both genders, the decrease in the push-up test (EFE) was not significantly different between age groups. Aging is directly associated with the loss of lean mass and decrease in strength levels, commonly described by the terms sarcopenia and dynapenia. The ramifications of these conditions negatively impact the autonomy of the elderly population. Multiple factors can contribute to the rate of losses, including individual lifestyle (diet and physical activity level), hormonal dysfunctions, chronic inflammatory states, ectopic accumulation of adipose tissue, neural changes, vascular changes, and increased oxidative stress associated with advancing age (5,13).

Eating habits are considered fundamental for maintaining energy balance and consequently muscular functionality, since any alteration can affect the capacity to produce force (8). Energy replacement can contribute to good muscular health relating to an excess or lack of nutrients. This may lead to genotypic and phenotypic changes that decrease the contractile capacity due to deficiency of minerals such as calcium, proteins, and carbohydrates (3,17).

Diets with an adequate amount of protein in relation to body mass and when combined with strength training are favorable for maintaining muscle mass and muscle capacity in active women (3). However, in the present study, there were no attempts to control for nutritional intake and no systematized strength training protocol was instituted.

The decrease in physical activity and/or the complete absence of regular exercise are determinants of the age-related decrease in force production. A lack physical movement – mainly activities that prioritize fast contraction muscles – brings about detrimental bodily consequences including shortening of the telomeres, reductions of specific motor neurons for fast-twitch muscle fibers, difficulty in maintaining tensional force, and low recruitment of muscle fibers proportional to effort load (30). Beyond that, it is well known that inactive muscles with less LM increase the incidence of injuries by decreasing physical mobility and increasing functional limitations (8,30).

Chronic diseases can also lead to a decrease in LM that affect the capacity to produce muscular force, since the increase of insulin resistance, increase of intramuscular lipid content, and reduction of the mitochondrial oxidative rate are all responsible for metabolic alterations that inhibit the ability of skeletal muscles to generate strength (19). Guerrero et al. (12) showed that adults with type II diabetes present a significant decrease in strength and lean muscle mass when compared to non-diabetic adults, with females displaying the greatest decrease in strength. In the present study, there was also a decline in strength and lean mass in sedentary women of the G3 age group, even though the present study did not control for chronic diseases.

One possible explanation for the decrease in strength throughout adulthood may be the progressive decrease in activity of the functional axis of the somatotrophic mechanisms. These changes can be responsible for the decrease in activity of the GH / IGF-1 axis, also known as somatopause in adults. Somatopause may negatively impact body composition, metabolism, and aerobic capacity (10).
Moreover, somatopause becomes more common in the G3 age group as there appears to be an accelerated alteration in the hormonal axis with continued aging. This is thought to occur mainly because of damage to the DNA and macromolecules that progressively affect the vitality of body tissues. Therefore, the decline in LM and strength of women/men conceivably may be explained by the hormonal decreases in the G3 age group (16).

Another factor that contributes to this phenomenon is the interaction between estrogen and the regulation of GH secretion in women, which in turn has a direct effect on muscle tissue (10). A drastic decrease in the production of estrogen occurs during menopause, thereby altering GH regulatory function (10). It is also well established that estrogen has anabolic effects on muscle tissue (15). Therefore, advancing menopause may be related to reductions in strength with advancing age in women (21).

Strength training is known to acutely stimulate the release of testosterone, although its effect on chronic production of this anabolic hormone remains equivocal (2,11). In the present study, we investigated the strength of men who were not involved in any type of resistance exercise for at least one year, which made it possible to detect a progressive decline in age-related strength without potential confounding from hormonal alterations. The decline may occur due to a combination of lack of exercise and the reduction of testosterone production that accompanies aging. This may therefore be a factor that indirectly explains the decrease of strength in men (29).

Decreased mitochondrial function and content may be additional factors that are related to the decrease in muscle strength with advancing age (18). These changes may occasionally lead to a decline in the synthesis of muscle proteins, such as long-chain myosin, degradation of ATP-dependent proteins (6,15), and the low rate of muscle-specific mitochondrial oxidative phosphorylation (19).

Oxidative damage is also considered responsible for the decrease in muscle strength and mitochondrial activity with the aging process and sarcopenia (2). Chronically elevated levels of reactive oxygen species (ROS) during the aging process contributes to the permanent state of increased muscle cell damage (11), and it is well established that an alteration of the redox system that occurs in the muscles during aging leads to the irreversible degradation of skeletal muscle (13).

The aging process is associated with chronic oxidative stress, which is purported to be related to the loss of muscle proteins and muscular atrophy (26). Chronic oxidative stress is also attributed to a defective regeneration of muscle tissue innervation, ultimately causing a degeneration in skeletal muscle function (28). Furthermore, there is a reduced antioxidant response in intracellular resistance to ROS, inducing non-cell replacement and apoptosis (9).

**Limitations of this Study**

Limitations of the present study include an absence of caloric control, the use of indirect measures to estimate body composition, the absence of biochemical parameters related to the reduction in muscle strength, and the fact that motor tests until exhaustion did not
differentiate between peripheral and central fatigue. These research considerations should be incorporated and examined in future studies.

CONCLUSIONS

The findings indicate that while an increase in sedentary adults stratified by age is associated with a significant increase in BM and BF in males and females, a significant increase in BMI in the males with no significant difference in females, a significant decrease in LM in females with no significant difference in males, a significant decrease in the 1-minute sit-up test in males and females, there were no significant differences observed in the push-up test (EFE) in males and females.

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