PREDICTIVE FACTORS OF FUNCTIONAL MOBILITY IN OLDER WOMEN AFTER 12 WEEKS OF RESISTANCE TRAINING

OBJECTIVE: To analyze the association between functional mobility, anthropometric and functional characteristics of older women after 12 weeks of resistance training. METHODS: This is a quasi-experimental descriptive study with a multiple linear regression analysis. A significance level of 0.05 was adopted. Forty-seven community-dwelling older women underwent 12 weeks of supervised resistance training twice a week. The dependent variable (mobility measured by the Timed Up and Go test) and the independent variables (age, body mass index, fat-free mass of the lower limbs, waist circumference, peak knee torque at 60º/s, peak knee torque at 180º/s, functional reach test, and 30-second chair stand test) were measured before and after the intervention. RESULTS: A multivariate analysis showed that age, body mass index, waist circumference, and the 30-second stand test predicted 30% (R² = 0.30; p = 0.001; F = 5.53) of the total variance regarding an improvement in mobility after resistance training (p < 0.0001; [95% CI 0.72–1.20]; the effect size was considered large [0.90]) when comparing women before and after the intervention. CONCLUSIONS: Age, body mass index, waist circumference, and the 30-second stand test predicted 30% of the increase in functional mobility. KEYWORDS: resistance training; mobility limitation; muscle strength dynamometer.

RESUMO

OBJETIVO: Analisar a associação entre mobilidade funcional, variáveis antropométricas e funcionais de mulheres idosas após 12 semanas de treinamento resistido. METODOLOGIA: Este é um estudo descritivo quase experimental com múltipla análise de regressão linear. Foi adotado nível de significância de 0.05. Quarenta e sete idosas residentes na comunidade foram submetidas a 12 semanas de treinamento resistido supervisionado, duas vezes por semana. A variável dependente (mobilidade mensurada pelo teste Timed Up and Go) e as variáveis independentes (idade, índice de massa corporal, massa livre de gordura dos membros inferiores, circunferência da cintura, pico de torque do joelho a 60º/s, pico de torque do joelho a 180º/s, teste de alcance funcional e teste de sentar e levantar por 30 segundo na cadeira) foram medidas antes e depois da intervenção. RESULTADOS: A análise multivariada mostrou que a idade, o índice de massa corporal, a circunferência da cintura e o teste de sentar e levantar previram 30% (R² = 0.30; p = 0.001; F = 5.53) da variação total na melhora da mobilidade após o treinamento de resistência (p < 0.0001 [95% intervalo de confiança [CI], 0.72–1.20]; o tamanho do efeito foi considerado grande [0.90]) antes e depois da intervenção. CONCLUSÕES: Idade, índice de massa corporal, circunferência da cintura e teste de sentar e levantar predizem 30% de aumento da mobilidade funcional. PALAVRAS-CHAVE: treinamento de resistência, limitação de mobilidade, dinamômetro de força muscular.


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IN\introduction

The decline in muscular strength associated with age is an important predictor of functional limitation in older people. Mobility is essential for autonomy, independence, better quality of life, and is associated with time spent out of the house and general health perceptions. For older people, this represents the ability of living alone and performing pleasurable activities, that is, the capacity to adapt to day-to-day problems despite their physical, mental, or social limitations.

Therefore, maintaining functional status is relevant to active ageing, preventing morbidity associated with ageing, and reducing health care costs. Functional capacity thus emerges as a new concept of health for older people, since it allows independent self-care and the performance of daily activities despite their comorbidities.

Consequently, mobility assessment tools are important. The Timed Up and Go (TUG) test is a reliable, economic, safe, and efficient tool for assessing general functional mobility. An unfavorable TUG test performance has been associated with deficient functional mobility and balance, fear of falls, low gait speed, physical inactivity, and prejudice to basic activities of daily living (ADL). A study performed in Ireland, with a representative sample of older people, indicated that the TUG test was an instrument with a great predictive capacity for difficulties in basic ADL and instrumental activities of daily living (IADL), and it can be used to identify older individuals at higher risk of falls who require support services.

In fact, studies have demonstrated that functional capacity measured by the TUG test is clinically sensitive to multidisciplinary treatments such as physical exercise. Moreover, exercise programs adapted to this population have showed efficacy with strength, balance, resistance, coordination, and multi-component training (simultaneous strength, resistance, and balance training), resulting in beneficial effects in certain functional parameters among frail older people. Therefore, the musculoskeletal health of older people is critical for their mobility, dexterity, and capacity of working and actively participating in all aspects of life.

Based on this information, this study aimed to analyze the association between functional mobility and the anthropometric and functional characteristics of older women after a 12-week resistance training program.

Ethical aspects

The Ethics Committee for Research with Human Beings of Universidade de Brasília (UnB) approved this study on July 21, 2011, under protocol No. 081/11, according to Resolution No. 196/96 of the National Health Council. Participation in the study was voluntary. After the objectives and procedures of the study were explained, participants were invited to sign the Free and Informed Consent Form.

Sample

A convenience sample was recruited after the distribution of flyers at health care centers of Hospital de Ceilândia (Federal District, Brazil), churches, and senior centers. Subsequently, 5 lectures were given at UnB for clarifying the project.

Inclusion criteria were volunteers aged 60 years or older, living in the Federal District, who had a medical certificate for performing resistance training. Exclusion criteria were presence of joint injury, previous orthopedic surgery (in the last 6 months), heart disease, diabetes, cancer, neuropathy, prosthesis use, cardiac pacemaker use, or severe functional and/or cognitive limitations that could affect adherence to the resistance exercise program.

Instruments and procedures

We applied an initial assessment protocol, followed by a 12-week resistance training intervention. Once the exercise program was concluded, we performed a post-training assessment that was identical to the baseline protocol. This consisted of an anthropometric analysis (body mass, stature, body mass index [BMI], and waist circumference [WC]); a mobility test (TUG); a functional reach test (FRT); a lower limb strength test (30-second stand test), fat-free mass assessments (through dual-energy X-ray absorptiometry [DEXA]); and assessment of lower limb muscle strength (peak knee torque at 60°/s and 180°/s measured with an isokinetic dynamometer).

Individuals went through a 2-week familiarization period for neuromuscular adaptation; during the familiarization and training periods, the participants performed 9 exercises twice a week, with a recovery interval of 48 hours. The initial load was determined based on the number of repetition maximums (RM) reached in the adaptation period, and series were organized in 3 cycles: 15 RM between the third and fourth weeks, 12 RM between the fifth and eighth weeks, and 8 RM between the ninth and 12th weeks.

Resistance training comprehended 5 lower limb exercises (hip abduction, hip extension, side step, knee flexion, and knee extension) and 4 upper limb exercises (seated...
row, bench press, biceps curl, and triceps pushdown). The exercises were alternated between lower and upper limbs, with a rest interval of 1 minute. Resistance was provided by elastic tubes (Elastos®) and pneumatic equipment (EM-Dynamic).

For monitoring resistance, we used the OMNI Resistance Exercise Scale (OMNI-RES) with levels of subjective perceived exertion that varied from 1 to 4 points; resistance was gradually increased as training progressed, according to the training cycles. For increasing elastic resistance, we used a color scale (Elastos® elastic tubes) according to the mechanical evaluation of the equipment in the laboratory.

Intensity was adjusted by changing the currently used tube for the next color on the scale. When a participant reached the gold resistance level, another elastic tube was added respecting the progression scale, that is: gold + yellow. As variations in tube length (percent elongation) may affect exercise intensity, in order to control tube elongation a piece of adhesive tape attached to the ground was used as reference for indicating maximum elongation for all exercises. The exercise was then standardized and performed at 100% (knee extension, bench press, and seated row), at 150% (knee flexion and extension), or at 200% (hip extension and pushdown) tube elongation.

Dependent variable

TUG test

On a verbal command (“Go”), the individual stands up from a chair without armrests, walks towards a signaling cone 3 meters away, returns to the chair, and sits down as quickly and safely as possible. The time spent in a complete cycle is recorded using a chronometer. Participants were instructed to not use their arms for standing up, and no help was provided. A rehearsal cycle was performed for familiarizing participants with the test. After the test run, the time to complete the activity was measured 3 times and the fastest cycle was considered as each participant’s result.

Podsiadlo and Richardson considered that a normal performance took 10 seconds for healthy individuals and between 11 and 20 seconds for frail or disabled older people who were independent for almost all ADL. Test results between 21 and 29 seconds may indicate difficulties in day-to-day activities. Individuals with scores of 30 seconds or more may be considered completely dependent in many ADL and IADL.

For our analysis, we calculated the mean TUG value for all participants before and after the intervention; later, we measured the difference between results before and after the intervention (Δ), so that we obtained a Δ for the pre and postintervention moments.

Independent variables

Nine independent variables were used in this study: age (years), BMI (kg/m²), body mass (kg), stature (cm), WC (cm), fat-free mass of the lower limbs (kg), peak knee torque at 60°/s, peak knee torque at 180°/s, FRT (cm), and 30-second stand test (repetitions).

Age was measured in years, based on the year of birth indicated by the participant. Body mass was obtained using a digital scale (Techline®) with 100 g precision. Stature was measured using a portable stadiometer mounted on a wall with no skirting boards. In order to measure the participants’ height, they were instructed to stand barefoot with their backs against the stadiometer, feet together, arms next to the body, and straight spine and knees. Each participant was asked to inspire deeply so that the height measurement could be performed by an evaluator.

Based on the weight and height information, BMI was calculated by the following formula: body mass (kg)/height (m²). WC was obtained using an inelastic measuring tape at its largest site.

Fat-free mass of the lower limbs was measured in kg, using DEXA (Lunar Prodigy®, General Electric). Individuals were instructed to lay on the table in the dorsal decubitus position, with the lower limbs positioned in neutral rotation and placed in 2 braces and the upper limbs placed next to the body, palms facing down.

A Biodex Systems® (model III) isokinetic dynamometer was used for assessing peak torque of the lower limbs during concentric knee extension of the dominant limb. We used 2 protocols for assessing peak torque:

- Warming-up phase, with 10 knee extension repetitions at 300°/s, 2 series of 3 repetitions at 60°/s, and 2 series of 4 repetitions at 180°/s;
- Warming-up phase, with 10 knee extension repetitions at 300°/s, 2 series of 4 repetitions at 180°/s, and 2 series of 4 repetitions at 60°/s.

Rest intervals of 1 or 2 minutes were allowed between series, and verbal and visual encouragements were provided so that participants reached maximum exertion.

The FRT is a dynamic measure of the limits of stability during displacement of the center of gravity with a fixed base of support. The individual starts the test in an orthostatic position with the arm flexed at 90° and body next to the wall. The participant is then asked to reach forward as
far as he or she can without altering the position of the feet. Three attempts were allowed in this study, and only the largest distance was considered for analysis.

The 30-second stand test was developed for assessing muscle strength conditioning. It consists in the individual sitting on a chair, with a straight back and knees flexed at 90º, feet on the ground aligned with the shoulders, and arms crossed and held against the chest. The individual is then asked to stand up and return to the seated position as many times as possible during a 30-second period. The test was performed 3 times and the best result was considered for our analysis.

**Statistical analysis**

The sample was characterized using descriptive statistics. The Shapiro-Wilk test was performed for assessing data normality, and a multiple linear regression analysis was performed for verifying hypotheses. We presented descriptive data as absolute and relative frequencies and mean ± standard deviation (SD) or median (interquartile range), according to data distribution. The Student’s dependent sample t-test assessed differences that were statistically related to functional mobility before and after the intervention.

The mean difference (Δ) in functional mobility measured by the TUG test before and after the intervention was used as a dependent variable in the multiple linear regression analysis. The final predictive model considered the mean difference (Δ) in TUG results as the dependent variable and the mean difference (Δ) of the remaining independent variables — BMI (kg/m²), body mass (kg), lower limb strength (repetitions), WC (cm), peak knee torque at 60º (N.m), peak knee torque at 180º (N.m), FRT (cm), and 30-second stand test (repetitions). Only the age (in years) was not regarded as mean difference.

Variable selection was performed through the stepwise method. We considered multicollinearity in the occurrence of tolerance < 0.1 and variance inflation factor (VIF) > 10. Statistical significance was fixed at 5%, and all analyses were performed using the SPSS software, version 21.0.

**RESULTS**

This study aimed to assess whether functional mobility was associated with anthropometric and functional characteristics of older women after a 12-week resistance training program. We initially selected 74 individuals, but 10 were excluded for not meeting inclusion criteria and other 10 opted out of the training phase due to scheduling issues, distance, or lack of interest in participating. Therefore, 54 individuals started the training phase, of which 7 left the study due to scheduling issues (n = 3), domestic accidents (n = 2), pneumonia (n = 1), or orthopedic surgery (n = 1), totaling a final sample of 47 women since not all men concluded the resistance training program. Therefore, data from male participants were not included in the study.

Table 1 contains descriptive data of the study identified as mean (SD), or as median (interquartile range), when data distribution was not normal.

Figure 1 shows the behavior of functional mobility values before and after resistance training. We observed a statistically significant reduction in the time spent in the TUG test (p < 0.0001). The mean difference (Δ) between pre-test (6.42 seconds [0.86]) and post-test (5.44 seconds [0.56]) values was 0.98 seconds (95% confidence interval [CI], 0.72-1.20), and the size of the post-training effect was 0.90. Moreover, we observed a statistically significant difference in the FRT (pre-test = 37 cm ± 4.2; post-test = 39 cm ± 3.7 [95% CI 4.44–5.63; p < 0.0001]) and the 30-second stand test (pre-test = 12 repetitions ± 2.3 and post-test = 17 repetitions ± 3 [95% CI 0.51–2.23; p = 0.0025]). Data are not shown on the tables.

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<th>Table 1. Characteristics of the sample that underwent an elastic resistance training program for 12 weeks.</th>
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† standard deviation of the mean; rep.: repetitions; †values presented as means (25–75 interquartile range).
Table 2 shows the initial and final multivariate linear regression models, where 9 predictive models were tested considering the TUG test as the dependent variable. Only age ($\beta = -0.28$, $p = 0.02$), WC ($\beta = 0.62$, $p = 0.01$), and lower limb strength ($\beta = 0.44$, $p = 0.001$) presented statistically significant associations in the final model. Although the BMI did not demonstrate statistically significant results, it was included in the final regression model since its $p$-value was close to the significance threshold considered in the study, which suggested that this variable could be associated with an improved performance in the TUG test. Moreover, all these variables presented $R^2 = 0.30$, indicating that age, WC, and lower limb muscle strength predicted 30% of the improvement in functional mobility measured by the TUG test.

According to values observed on Table 2, age demonstrated a significant positive correlation with the decrease in the time for performing the TUG test. That is, the younger the individual, the better his or her performance. Regarding anthropometric data, WC and BMI presented significant negative correlations. That is, the smaller the values, the better the individual’s performance. However, the lower limb strength variable, measured by the 30-second stand test (positive correlation), was shown to be the most significant in the final model. Therefore, the higher the number of repetitions, the better the performance in the TUG test.

This final model, containing the BMI, WC, age, and 30-second stand test variables, predicted 30% of the functional capacity measured by the TUG test in Brazilian women aged between 63 and 73 years.

**DISCUSSION**

This study aimed to analyze the association between functional mobility and anthropometric and functional characteristics of older women after 12 weeks of resistance training. Results showed that, after a period of resistance training, older women performed better at the TUG test when compared to the pretraining period, and 30% of this improvement was predicted by age, BMI, WC, and the 30-second stand test.

It is known that mobility impairment in the older population is generally associated with a combination of factors related to age, such as the decline in muscle mass and reduction in sensorimotor acuity, which are risk factors for a loss of autonomy in ADL.20-23 It is also known that the time for performing the TUG test correlates with limitations in IADL and the risk of falls4, and that knee strength, number of medical conditions, age, cognitive function, and health state are independent predictors of TUG test performance.24,25

Therefore, although increasing age negatively affects muscle strength and mobility, the maintenance of adequate strength levels in older women predicts good functional mobility for facing struggles imposed by age.

These findings corroborate the results of this study, showing that a decrease in the time for performing the TUG test after the resistance training program may be effective in reducing and preventing functional decline associated with age. In addition, they indicate that age and lower limb strength...
are predictors of TUG test performance and, consequently, of functional mobility.

Considering that the BMI is correlated with global obesity, WC is correlated with central fat mass, and the 30-second stand test is correlated with strength in older people, these variables were relevant in the prediction of TUG test performance. Therefore, our results corroborate the current literature, indicating that obesity is associated with disability, abdominal circumference is related to physical inactivity and is a predictor of disability in older people, and that strength is linked to a decrease in ADL and mobility.\textsuperscript{26-29} TUG test measurements are objective and quantitative (seconds).

That being said, an explanation for the inverse association between the BMI and the TUG test is that, as a measurement of weight and height, it is possible that an increase in BMI causes a decrease in gait speed and, consequently, a worse TUG test performance.\textsuperscript{6} In contrast, the association between WC and the TUG test requires further investigation through longitudinal studies. It is known that an increase in WC results in a change in the center of gravity, which may interfere with balance and functional capacity in older persons, resulting in people with higher WC values presenting a different gait pattern from those with smaller WC.\textsuperscript{30} This pattern may vary from difficulties in maintaining balance, which is more accurately measured by qualitative tests, to an acceleration of gait during quantitative tests such as TUG, which does not assess gait quality and motor pattern. In this sense, an increase in WC may indicate a change in gait pattern in older women, which leads to an accelerated walk and a better performance in the TUG test.

Regarding the positive association between lower limb strength measured by the 30-second stand test and the TUG test, our explanation is that although the time for completing the TUG test is correlated with a limitation in IADL and fear of falls\textsuperscript{24} and lower limb weakness is a risk factor for falls and inability to perform lower limb functional tasks, studies show a positive association between lower limb muscle strength and TUG test performance.\textsuperscript{24,25}

This study presents strong aspects, including the demonstration that simple and low-cost variables predict functional capacity in older people. In addition, it was performed in a Brazilian population and may be used by health professionals who provide care to women in public health services.

At the same time, an exclusively female sample may be considered a limitation of this study, just as a limited number of variables that were analyzed as predictive, since although we found a 30% prediction of the TUG test result, 70% of this performance still has not been explained. New studies, with more variables that approach physical, psychological, and social aspects, should thus be performed.

In conclusion, anthropometric and functional variables are associated with mobility in older women who participated in a training program with elastic resistance. Specifically, age, BMI, lower limb strength (measured by the 30-second stand test), and WC can predict up to 30% of the increase in functional mobility in older women after a 12-week resistance training program.

**CONCLUSION**

Age, BMI, lower limb strength (measured by the 30-second stand test), and WC are associated with the mobility of older women who performed a training program with elastic resistance and predicted up to 30% of the increase in functional mobility in this population.

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**CONFLICTS OF INTEREST**

The authors declare no conflicts of interest.

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**AUTHOR CONTRIBUTIONS**

MTG: conceptualization, data curation, investigation, methodology, writing – original draft. JSML: formal analysis, writing – review & editing. MSNL: formal analysis, writing – review & editing. ALAR: formal analysis, writing – review & editing. MPS: formal analysis, writing – review & editing. SBP: formal analysis, writing – review & editing. WRM: conceptualization, data curation, formal analysis, funding acquisition, project administration, resources, software, supervision.
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