



ISB 2013 BRAZIL

XXIV CONGRESS OF THE INTERNATIONAL
SOCIETY OF BIOMECHANICS

XV BRAZILIAN CONGRESS
OF BIOMECHANICS

THE RELATIONSHIP BETWEEN BALANCE, WALKING SPEED AND KNEE EXTENSION MUSCLE STRENGTH IN WELL-FUNCTIONING OLDER ADULTS

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SUMMARY

Aging is associated with increased balance instability, decreased mobility, gait speed, and muscle strength. In fact muscle strength, within sarcopenia context, is considered a major determinant of mobility decline. Therefore we investigated the independent and joint contributions of balance (static, dynamic and postural sway using force platform technique) and walking speed, on KE strength in older adults. Potential confounding variables were also included, namely DXA-derived body fat mass, objectively measured physical activity, age, and gender.

Data highlight that in well-functioning older adults, walking speed is more important for knee extension strength prediction than balance control/instability.

INTRODUCTION

Current evidence suggests that loss of muscle strength is an important predictor of mobility limitation, physical disability, and mortality [1]. Previous research has focused on determining the sex-specific knee extensor strength levels associated with subsequent risk of lower extremity limitation [2], as identifying different strength levels should help to provide treatment targets for prevention of functional limitation. As increasing evidence suggests that muscle strength is a better predictor of mobility decline and disability than muscle mass, understanding how muscle strength is related to mobility [3] is currently wanted. Therefore, we assessed the influences of walking speed and balance control on KE strength in well-functioning older adults.

METHODS

Participants

One hundred community-dwelling subjects with 60 years and up were recruited through advertisements in the Porto area newspapers for participation in this university-based study. This study was conducted according to the guidelines laid down in the Declaration of Helsinki, and all procedures involving human participants were approved by the Institutional Review Board.

Knee Extension Strength

Knee extension (KE) strength of the right leg was measured concentrically at 60° per second on an isokinetic dynamometer (Biodex System 4 Pro; Biodex, Shirley, NY), carried out in accordance with the manufacturer's instructions for KE/flexion. The highest value peak torque adjusted to body weight was used for the statistical analyses. Relative KE strength was categorized according to established sex-specific cutpoints associated with future mobility limitation [2].

Walking test

Walking speed was measured using the 6-min walk test (6MWT) performed over a 45-m course within an enclosed level corridor [4]. Participants were asked to 'Walk as fast as you can without feeling unsafe and without running'. Gait speed was determined as m/min by dividing the recorded distance walked for each participant during the 6MWT by 6 min.

Balance control

Each subject performed two balance tests: 8-foot Up and Go Test (UG) [4] and one-leg stance (OLS) [5]. The OLS test involved standing upright as still as possible (the maximum time was set at 45 s) in a unipedal stance unassisted (on the nondominant leg) on a 40–60 cm force platform (Force Plate AM 4060-15; Bertec, Columbus, OH) with eyes open, head erect, and arms relaxed by the side of the trunk.

The signals from the force platform were sampled at 500 Hz. We used a personal computer to collect the data with the customized AcqKnowledge-based software (AcqKnowledge 3.9.1; Biopac, Goleta, CA). Data analysis was performed using MATLAB software (MATLAB 7.0; MathWorks, Natick, MA). Data from horizontal forces (F_y and F_x) and center of pressure (COP) time series were low pass-filtered with a zero-lag, fourth-order Butterworth filter with a cut-off frequency of 10 Hz.

The outcome variables were anterior–posterior (AP) and medial–lateral (ML) mean velocity (cm/s) of the COP, and

the elliptical area (EA) was calculated using the equation $H2ry\ 9\ H2rx$. Mean velocity was determined by dividing the total distance along the signal trajectory by the total recording time.

Other Assessments

Whole-body percent body fat (%BF) was determined by DXA (Hologic QDR 4500A, Hologic Inc., Waltham, MA, USA). Height and body mass were recorded using a portable stadiometer and balance weighing scales, respectively. Body mass index (BMI) was calculated as body mass (kilograms) divided by height (meters) squared. The Actigraph GT1 M accelerometer (Manufacturing Technology, Fort Walton Beach, FL) was used as an objective measure of daily. Average daily number of steps was chosen as the main outcome.

Statistical analyses

All data analyses were performed using the SPSS Statistics (version 19; SPSS Inc., Chicago, IL) with a significance level of 0.05. One-way ANOVA was performed to compare variables of interest within the mobility limitation risk categories. The independent variables that showed significance in univariate analysis were entered into the multivariate linear regression procedures to identify the significant predictors of the KE strength.

RESULTS AND DISCUSSION

Altogether there were 16 participants in the high-risk, 36 participants in the moderate-risk, and 48 participants in the low-risk category. One-way ANOVA showed that %BF, BMI, and UG performance increased across risk categories, while number of daily step (as a proxy of physical activity level) and walking speed decreased across functional mobility risk groups. No group differences were found in the OLS time and variables of postural sway (Table 1). Participants in the moderate-risk group were significantly older than low-risk group ($p=0.017$). Although poor postural balance is one of the major risk factors for falling due to direct relation with age [6], OLS time and variables of postural sway were not associated with KE strength. Adjusting for the covariates age, gender, %BF, and number of steps, walking speed was the only statistically significant predictor, and the final model explaining 48.8% ($p < .001$)

of the variance in KE strength. Multiple backward regression analysis indicated that walking speed (stronger association, $b=-1.967$, $p<0.001$), %BF ($b=1.010$, $p<0.001$) and number of steps ($b=0.002$, $p=0.031$) had independent associations with KE strength (adjusted $R^2 = 0.49$, $p<0.001$). The reduced musculoskeletal function resulting from physiological and neuromuscular age-related changes may explain the reduced gait function associated with aging [7]. Previous studies have demonstrated the obesity increases the risk for functional decline in later years [8], which is corroborated by the present results.

CONCLUSIONS

Postural sway may have a limited independent influence on KE strength in well-functioning older adults, nevertheless mobility/dynamic balance showed a significant correlation with KE strength. Walking speed, %BF and daily physical activity largely explained variance in KE strength. Special attention needs to be paid to gait adaptations of older adults, and specifically to declines in gait speed, due to its apparent association with KE strength and subsequent risk of future mobility limitation. Daily physical activity and body fat mass may offers additional insight into the mechanisms by which KE strength decline becomes hazardous in older age.

ACKNOWLEDGEMENTS

This work was supported by the Portuguese Foundation of Science and Technology (FTC) Research Council (grant number Pest-OE/SAU/UI0617/2011).

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Table 1: Mean and standard deviation values for walking, dynamic and static balance tests, and covariates (BMI, %BF, number of steps) stratified by risk category associated with future mobility limitation.

Variables	Low-risk	Moderate-risk	High-risk	p-value
Age (years)	67.56 ± 5.49	70.94 ± 5.23*	68.44 ± 4.80	0.017
OLS (s)	28.47 ± 14.81	30.82 ± 14.14	30.77 ± 14.57	0.727
EA (cm ²)	7.34 ± 5.73	6.66 ± 5.21	10.66 ± 10.16	0.114
AP velocity (cm/s)	3.84 ± 1.06	3.73 ± 0.84	3.58 ± 1.29	0.664
ML velocity (cm/s)	4.17 ± 1.78	3.96 ± 1.63	4.30 ± 2.59	0.803
UG (s)	5.52 ± 0.82	5.96 ± 1.04	6.68 ± 1.47*	0.001
Walking speed (m/min)	95.63 ± 13.24	89.26 ± 10.01*	81.20 ± 13.02*	<0.001
BMI (kg/m ²)	26.65 ± 3.49	29.09 ± 3.54*	31.81 ± 5.85*	<0.001
Body Fat (%)	35.03 ± 6.15	35.52 ± 7.45	39.97 ± 5.11* [#]	0.031
Number of steps	9096.51 ± 3062.88	7757.83 ± 2017.23*	7102.61 ± 1539.40*	0.008

* Significant different from low-risk group; [#] Significant different from moderate-risk group; Games-Howell procedure was used as post-hoc test.