11-20-2019

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Open Access Journal of Sports Medicine

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ORIGINAL RESEARCH

Relation Between Relative Handgrip Strength, Chronological Age and Physiological Age with Lower Functional Capacity in Older Women

This article was published in the following Dove Press journal:
Open Access Journal of Sports Medicine

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Purpose: Relative handgrip strength (RHGS), Aged Based on Exercise Stress Testing (A-BEST), and chronological age were evaluated as predictors of impaired mobility in older women.

Methods: Participants included 88 older women (mean age 68.13±6.02 years) referred for exercise stress testing. Estimated physiological age was computed based on exercise capacity, chronotropic reserve index, heart rate recovery, and medication that could affect heart rate. RHGS was measured using a validated handgrip hydraulic dynamometer and mobility was evaluated by timed up and go test (TUG-test). A hierarchical multiple regression predicted TUG-test performance from A-BEST, chronological age and RHGS.

Results: After adjustment for diabetes, RHGS was the only variable to add significantly to the prediction model (p=0.001). An increase in RHGS of 1 kg/body mass index was associated with a decrease in TUG-test of 0.7 seconds.

Conclusion: Relative handgrip strength test was a better predictor of impaired mobility when compared with chronological and physiological age in older women. Moreover, RHGS represents an inexpensive, simple, portable, noninvasive measurement for a clinician when compared with an exercise stress testing.

Keywords: muscle strength, biological age, chronological age, older, functional capacity

Introduction

The aging process is associated with progressive decline in muscle strength, power, impaired balance, altered cardiac function and vascular function.[1] These alterations negatively affect exercise capacity, increase cardiovascular disease risk, and have implications for physical function and risk of falling.[1] Furthermore, an increase in the population aged 60 years and over is projected to increase from 13.8% in 2020 to 29.4% in 2050 according to data from the Brazilian Institute of Geography and Statistics.[2]

Chronological age is considered to be a good predictor of health status, while considerable inter-individual variability has been reported, with some older people displaying very good health, and others showing the accelerated onset of weakness, disability and frailty.[3] Compounding this burden, given that aging is the progressive decline of the organism, the rate is not universal, and as a result, age when measured chronologically might not be a reliable indicator of the progressive decline of body's function.[4] For example, age is not different between subjects with higher and lower grip strength at baseline, and a weak grip strength has

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submit your manuscript | www.dovepress.com
DovePress
http://doi.org/10.2147/OAJSM.S227720

a significant negative relationship with future physical status, as lower 3 m time up and go test (TUG-test).[5]

Thus, different methods were developed to provide a better predictive of health status than chronological age.[4] Clearly, there is a need to objectively and quantitatively evaluate the importance of each biomarker of aging that is directly correlated with the body's rate of decline breakdown.[6] Considering that, every biological process might change with age as, muscle strength, mobility (slower walking), and muscle mass.[3] Thus, every biological parameter can be considered a "biomarker of aging".[6]

Physiological age, also known as, the combination of a number of varying biomarkers as, C-reactive protein, serum creatinine and systolic blood pressure, can be a more reliable predictor of mortality and later life depression than chronological age and might facilitate preventative interventions for health.[4,7] However, handgrip strength and gait speed (a measure of mobility and risk of falls) should also be measured in older adults, as they provide additional prognostic information regarding cardiovascular mortality and inflammation in addition to traditional risk factors included in a number of varying mathematical algorithms used to estimate the physiological age.[4,8,9] Furthermore, older subjects with poor mobility and increased risk of falls, generally have a poorer state of health (e.g. low muscle strength and mobility) and are more heavily medicated.

The timed up and go test (TUG-test) is an objective, inexpensive, quick and easy method to perform and assess mobility, and also to predict the risk of falls in community-dwelling older adults.[10,11] Intrinsic factors that cause falls in older subjects include; age, vertigo, lower extremity weakness, diabetes, antidepressants, syncope and stroke, but most of the intrinsic factors previously cited were not used for the estimate of physiological age and a significantly greater number of fractures are the result from falls caused by an intrinsic cause.[12] Thus, it is important to bear in mind that the role of health professionals is to identify inexpensive and simple biomarkers of age associated with reduced mobility and falls in older subjects.

Moreover, the measure of handgrip strength does not require highly trained personal, is an inexpensive tool that is a simple, portable, noninvasive measurement, and seems relevant in the screening of older subjects with poor health outcomes (e.g. hospitalization, disability, fracture, stroke and all-cause mortality).[8,13–15]

Nonetheless, studies use different risk factors to estimate the physiological age (i.e. cardiovascular and immune). Recently, peak estimated metabolic equivalent of a task, abnormal heart rate recovery (AHRR), chronotropic reserve index (CRI), and medications that affect heart rate (beta-blocker and calcium channel antagonists) were used to estimate patients' physiological age based on exercise stress testing performance and the Aged Based on Exercise Stress Testing (A-BEST), or physiological age, was the best predictor of mortality when compared with chronological age.[16] However, most older individuals are unable to satisfactorily complete a treadmill exercise test.[17]

While stress tests are not applicable for the vast majority of older persons who are interested in enhancing their physical function through a program of physical activity,[17] evaluation of handgrip strength might provide additional prognostic information regarding poor health outcomes (i.e. mobility), all-cause mortality and cardiovascular mortality in older adults of multiple nationalities and ethnicities in addition to traditional risk factors included in a number of varying mathematical algorithms used to estimate the physiological age.[8]

As a weak handgrip strength is associated with lower physical performance (i.e. 10-m gait time and TUG-test), impaired heart rate recovery and low chronotropic index.[5,18] Also, is a stronger predictor of death than systolic blood pressure, even after adjustments for age, sex, country income level, education level, employment status, tobacco, alcohol use, diabetes, heart failure, coronary artery disease, chronic obstructive, pulmonary disease, self-reported prior stroke, self-reported prior cancer, body mass index, and waist-to-hip ratio.[14]

In this evaluation, additional clinical inexpensive tools that are simple, portable and noninvasive measurements as handgrip strength test are needed to create clinically applicable information for the evaluation of reduced mobility in older subjects. Thus, we sought to compare the efficiency of handgrip strength with chronological age and A-BEST in estimating declines in mobility assessed by the TUG-test in older women. The initial hypothesis is that higher handgrip strength better predicts impaired mobility when compared with chronological and physiological age in older women.

Methods

Subjects

A total of 157 obese older women from a community located in the Federal District, Brazil were assessed for eligibility. To be eligible for participation in this study, women needed to be aged 60–100 years with body fat percentages ≥30% as assessed by dual-energy x-ray absorptiometry (DEXA). Of those, 69 were excluded (did not meet inclusion criteria for body fat percentage) leaving 88 participants who met the inclusion criteria. These women were not specifically representative of the Brazilian population, and were recruited on a voluntary basis through posters and lectures about the study. Subjects were interviewed and responded to a medical history questionnaire (past medical history, cardiac risk factors, prior cardiac events and procedures, and osteoarticular disorders), underwent anthropometric measures, answered a questionnaire about lifestyle information, and use of medications. Subjects were classified as hypertensive by diagnostic criteria used in previous studies and diabetes was defined as documented prescription of insulin or other hypoglycemic medications.[19–21] Characteristics of the study subjects are presented in Table 1.

The present study was approved by the Institutional Research Ethics Committee of the Catholic University of Brasília (UCB) (protocol 45648115.8.0000.5650/2016). The study design and procedures were in accordance with ethical standards and the Declaration of Helsinki. Each subject was fully informed about the risks associated with study participation and gave their written informed consent.

Table 1 Subjects' Characteristics

Subject Variables	Overall (n = 88)
Clinical	
Age, mean ± SD, years	68.13 ± 6.02
Height, mean ± SD, m	1.54 ± 6.11
Body weight, mean ± SD, kg	68.55 ± 11.32
Body mass index, mean ± SD, kg/m^2	28.83 ± 4.39
Body fat, %	39.82 ± 6.16
RHGS, mean ± SD, m^2	1.70 ± 0.48
Absolute HGS, mean ± SD, kg	24.61 ± 4.49
Timed up and go, mean ± SD, seconds	6.85 ± 0.85
Medications*	
Angiotensin receptor blockers	36 (40.91)
Diuretics	38 (43.18)
β-blockers	15 (17.05)
Calcium channel antagonists	9 (10.23)
Angiotensin-converting enzyme inhibitors	16 (18.18)
Statins	24 (27.27)
Hypoglycemic Medications	16 (18.18)
Disease*	
Hypertension	64 (72.73)
Diabetes mellitus type 2	16 (18.18)
Exercise data	
A-BEST, mean ± SD	57.23 ± 2.09
Resting SBP, mean ± SD, mmHg	126.31 ± 15.17
Resting DBP, mean ± SD, mmHg	72.71 ± 8.79
Peak HR, mean ± SD, mmHg	142.72 ± 16.87
Peak METs, mean ± SD	5.84 ± 0.78
AHRR, n	2
CRI, mean ± SD	0.80 ± 0.18

Note: *Data presented as frequency and percentage values.
Abbreviations: BMI, body mass index; RHGS, relative handgrip strength; MET, metabolic equivalent; SBP, systolic blood pressure; DBP, diastolic blood pressure; n, number.

Evaluation of Mobility

The timed-up and go test consisted of rising from a chair and walking as fast as possible to a cone 3 m away, circling around the cone, and returning to sit on the chair.[10,11] Subjects were allowed three trials to perform each test with 1 min of interval between trials, and received instructions to perform each test as fast as possible without running. Participants initiated the test with their back against the chair and their hands on their hips.

Handgrip Strength

Handgrip strength was determined by the use of a handgrip Hydraulic dynamometer (Saehan Corp®, SH5001, S. Korea). Three measures on the right and left hand were obtained and the highest value was recorded. The second position was used for all the subjects; with the forearm in a neutral position, elbow fully extended; standing position; and verbal encouragement was used for all subjects with one-minute rest intervals between measurements. To calculate the relative handgrip strength (RHGS), the highest reading from each hand was divided by the subject's body mass index (BMI). Previous research supports strength corrected for BMI over the absolute strength measures.[22,23]

A-BEST

To estimate A-BEST we included the same parameters reported in a previous study.[16] Thus, peak estimated metabolic equivalent of task (METs), abnormal heart rate recovery (AHRR), chronotropic reserve index (CRI), and medications (beta-blocker and calcium channel antagonist) from our subjects were used.

Treadmill Stress Testing

Exercise testing procedures in the laboratory have been described in detail elsewhere from our research group.[24,25]

Subjects underwent a symptom-limited treadmill test using a ramp-treadmill protocol. The protocol used velocity increments (between 0.004 and 0.005 km/h each second) and grade (between 0.015% and 0.021% each second), adjusted for subjects to reach maximal exercise capacity within the recommended range of 8–12 mins. The initial and final velocity was 3.0 km/h and 6.0 km/h, respectively, while the initial and final grade was 1.0% and 14.0%. Subjects were encouraged to exercise until voluntary-exhaustion, and the achievement of 85% of maximum predicted HR and/or respiratory exchange ratio >1.02 was used for the termination of testing.[24,25] During each exercise stage and recovery stage, symptoms (chest discomfort, rate of perceived exertion, and dizziness), blood pressure, and heart rate were recorded. Following peak exercise (maximum time spent in the test), subjects walked for a 2-min cool-down period at 2.0 km/h and 2.5% grade.[26] Heart rate recovery was measured during the first and second minutes of the cool-down period and was defined as the difference between heart rate at peak exercise and first minute and second minutes following exercise. Subjects were permitted to lean on the handrails during exercise.

Statistical Analyses

All statistical analyses were conducted using SPSS software version 18.0 (SPSS Inc., Chicago). A hierarchical multiple regression was utilized to predict TUG-test performance from A-BEST, chronological age and RHGS. The covariate diabetes was also included, as is an independent risk factor for reduced mobility and falls.[12] There was linearity as assessed by partial regression plots and a plot of studentized residuals against the predicted values. There was independence of residuals, as assessed by a Durbin–Watson statistic of 2.01. There was homoscedasticity, as assessed by visual inspection of a plot of studentized residuals versus unstandardized predicted values. There was no evidence of multicollinearity, as assessed by tolerance values greater than 0.1. The assumption of normality was met, as assessed by a Q–Q Plot. An alpha level of $p \leq 0.05$ was considered significant.

Results

Regression coefficients and standard errors can be found in Table 2 (below).

The multiple regression model statistically significantly predicted TUG-test, $F(4, 85) = 8.05$, $p < 0.0001$, adj. $R^2 = 0.24$. Only RHGS added significantly to the prediction equation (p = 0.001). An increase in RHGS of 1 kg/BMI is associated with a decrease in TUG-test of 0.70 s.

Table 2 Summary of Multiple Regression

Model				
Variable	***B***	***SE_B***	***β***	***P***
Intercept	3.136	2.493		0.212
Age	0.040	0.020	0.286	0.051
RHGR	−0.702	0.162	−0.405	0.001*
A-BEST	0.038	0.059	0.093	0.524

Notes: *p <0.05; *B* = unstandardized regression coefficient; SE_B = standard error of the coefficient; *β* = standardized coefficient; Model 2 was adjusted for diabetes.
Abbreviation: RHGS, relative handgrip strength.

Discussion

The present study demonstrates that RHGS performs better in predicting impaired mobility evaluated by TUG-test in older women when compared with chronological age and physiological age (i.e. A-BEST).[16] In addition, RHGS remained significantly associated with TUG-test, even after adjustment for diabetes.

According to Cruz-Jentoft et al[27] muscle strength is an important predictor of poor patient outcome as increased functional limitation and when choosing tools for measurement of physical performance in clinical practice, handgrip strength might represent an important and simple tool to identify subjects with increased risk of impaired mobility. Recently, Silva et al[18] demonstrated that older women with high RHGS presented a higher peak O_2 consumption, a higher chronotropic index, and a better heart rate recovery in the first and second minutes. Furthermore, subjects with higher levels of handgrip strength are significantly more likely to have lower levels of systemic inflammatory markers, C-reactive protein and fibrinogen at follow-up.[9] In addition, grip strength is inversely associated with risk mortality in females only.[9]

Independent of A-BEST or RHGS values, those with abnormal HRR after a stress test (one of the parameters included for the calculation of physiological age) are older, are more likely to have hypertension, diabetes and to smoke.[26] In addition, those with low RHGS are more likely to be obese, to have reduced physical function and less independence in daily living.[28]

As a weak handgrip strength is associated with lower physical performance, impaired heart rate recovery, low chronotropic index, and death even after adjustments for age, sex, country income level, education level, employment status, tobacco, alcohol use, diabetes, heart failure, coronary artery disease, chronic obstructive, pulmonary disease, self-reported prior stroke, self-reported prior cancer, body mass index, and waist-to-hip ratio.[5,14,18] It is reasonable to suggest that our findings provide evidence that RGHS is highly associated with the TUG-test, which has been utilized in predicting the risk of falls in community-dwelling older adults.[10,11]

The scale is more easily understood by both patients and clinicians, and is more easily administered than the A-BEST. For example, it might be more relevant to tell a 67-year-old patient who achieves a RHGS of 1.48 m^2 (low RHGS) that an increase in one unit (kg/BMI) diminishes the TUG-test in 0.70 s and increases mobility, but such approach must be explored in subjects perception in future studies.[13]

Furthermore, handgrip strength is a powerful predictor of poor patient outcomes such as longer hospital stays, increased functional limitation, poor health-related quality of life and death.[9,13,14,29] In addition, handgrip strength does not require highly trained personal, and is an inexpensive tool that is simple and portable. Lastly, handgrip strength represents a noninvasive measurement for a clinician when compared with the stress testing which most older persons are unable to satisfactorily complete.[8,13–17]

Our study has some limitations. First, it was conducted in a small sample size of older women. Second, this correlational analysis on a cross section of older women cannot be utilized to uncover any direct causes of low handgrip strength and decreased mobility in this population. Third, we only included diabetes as the covariate variable; cause is an independent risk factor for reduced mobility and falls.[12] However, other important risk factors as; dementia, previous falls, cardiotonic glycoside, neuroleptics and antidepressants were not controlled in our study.[12] Thus, the hypothesis that RHGS is the main predictor of mobility in older women assessed by TUG-test needs to be confirmed in prospective studies.

A lot of independent risk factors are involved in reduced mobility and falls, and estimating chronological and physiological age is necessary for diagnoses and to determine whether an older subject tends to have increased risk for reduced mobility. However, the current use of 13 allostatic load markers or more to estimate the physiological age might not be always effective and the use of handgrip strength that outperforms traditional risk factors can help gauge as a new and important test to improve the health span of the older subjects.[14] Because of this, we recommend that RGHS be utilized by clinicians as a convenient tool to predict impaired mobility and fall risk in older women and to include the low handgrip strength as a new allostatic load or a new index of physiological dysregulation that decreases up through 60s.[30]

Conclusion

In summary, RHGS better predicts impaired mobility evaluated by TUG-test in older women when compared with chronological age and physiological age.

Acknowledgments

The last author (DCN) would like to thank his family and in particular his mother Rita Cunha and his son Nicolas Cunha. Furthermore, we appreciate the assistance of Jeeser Alves de Almeida, PhD., during A-BEST interpretation.

Author Contributions

All authors contributed to article preparation, took part in drafting the article and reviewing critically for important intellectual content, gave final approval of the version to be published, and agree to be accountable for all aspects of the work.

Disclosure

The authors report no conflicts of interest in this work.

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