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ORIGINAL RESEARCH

Grip strength predicts physical function in nursing home residents

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PURPOSE: To analyze the relationship of grip strength and physical function in institutionalized older people.
METHODS: One hundred and fifty-seven nursing home residents of seven different long-stay institutions underwent evaluation of body composition, cognitive function, grip strength, mobility, balance (balance scale test BERG and single-leg stance test) and gait speed.
RESULTS: Volunteers had no impairment of cognitive function, functional mobility, balance or gait speed. Men had higher grip strength and achieved higher scores in BERG. Fittest volunteers (i.e., P_{75} to P_{100}) had better functional mobility, BERG and gait speed; less fit volunteers (i.e., P_0 to P_{25}) were taller and had better gait speed. The grip strength was independently associated with functional mobility and balance in the single-leg stance test only in females. The cognitive function (female, P_{25} to P_{75}, male, total sample) and age (male, total sample) showed a tendency to be mediators of functional mobility. Age and body weight seem to confound the gait speed, especially for females (P_{25} to P_{75}), while cognitive function confound it in males (P_{75} to P_{100}). However, age and body weight are significantly associated with gait speed (female, total sample).
CONCLUSION: We can conclude that grip strength was independently associated with functional mobility and balance of institutionalized older women.

KEYWORDS: Balance, elderly, institutionalization, muscle strength, physical function.

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INTRODUCTION

Multidimensional geriatric assessment considers important parameters for the clinical diagnosis of elderly individuals. Such parameters must not only have the sensitivity to establish current clinical status, but also the power to predict future events.[1]

Grip strength has been widely suggested as a relevant parameter to be included in the clinical assessment of individuals with different specific clinical status.[2,3] It has been demonstrated that grip strength appears to offer the best simple field procedure for evaluating the muscularity of older individuals, and is even better than the one repetition maximum test (1RM); scores obtained through principal component analysis (PCA) showed the closest correlation with both overall muscularity and lean body mass.[4] It is a simple, fast and low cost measurement[4] that can be employed for children and adolescents,[5,6] and primarily for elderly individuals,[7-10] because it is intrinsically related to physical function and to different health outcomes.[7]

Physical function plays a key role in the contemporary perspective of health. Elderly individuals should have the ability to adapt to different daily stressors, as well as to the self-manage of their own lives.[11,12] This process has direct implications upon the capacity of elderly individuals to perform the basic and instrumental activities of daily living, which in turn

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depend on the balance,[13] muscle strength[14] and functional mobility.[15] Certainly, these factors determine the threshold of disability (e.g., inability to shop for groceries) and the zone of physical dependence (e.g., inability to get in and out of bed) with special significance for institutionalized elderly people.[16] Therefore, the purpose of this study was to evaluate the relationship between grip strength and physical function in nursing home residents.

METHODS

Subjects

We recruited volunteers from long-term care facilities for older individuals. We screened interested individuals to determine their prior and current health status, as well as their use of medications, smoking history, nutritional status, and level of physical activity. We selected 157 volunteers from seven different long-term care facilities. They underwent a detailed physical examination along with an interview regarding depressive symptoms and self-reported capacity to perform the instrumental activities of daily living. We excluded potential candidates according to the following criteria: (i) diagnosed with a psychiatric disorder; (ii) chemical dependency; (iii) cardiovascular disease, metabolic disorder, or uncontrolled lung disease; (iv) any musculoskeletal condition that could preclude or be exacerbated by the tests to be conducted; (v) past surgeries or confinement to bed rest within the previous three months; (vi) under treatment for cancer.

All volunteers were informed that the participation in this study was voluntary, and they could withdraw at any time from the study. The potential health risks and benefits were explained to the volunteers as well as the study criteria and procedures; following this explanation participants were invited to and agreed to give written informed consent. The study was approved by the institutional research ethics committee.

Body Composition

Height and weight were determined with a stadiometer and a digital scale, respectively, with the subjects wearing light clothing and no shoes. Body mass index (BMI) was calculated as weight in kilograms divided by height in meters squared.[17]

Cognitive Function

Cognitive function was evaluated with the Mini-Mental State Examination (MMSE), which comprises five domains (orientation in time and space; short-term memory; attention and calculation; recall; and language). Individual domain scores are added to obtain the total score. The total score of the MMSE for was adopted as the measurement of global cognitive function.[18]

Grip strength

Maximal isometric grip strength was measured by an adjustable handheld dynamometer (Takei TK005, Tokyo, Japan), repeated two times for each hand, alternating between right and left hands to avoid muscular fatigue. Participants were instructed to squeeze the handgrip as hard as possible, with the sum of the two best values for each hand used in the analysis. We stratified grip strength values (in Newtons) by percentiles: P_0 to P_{25} (≤ 255.06 N); P_{25} to P_{75} (255.07-476.77 N); and P_{75} to P_{100} (≥ 476.78 N).

Mobility

To evaluate mobility, we employed the timed up and go (TUG) test:[19] subjects start from a sitting position on a chair with back support and armrests: they stand up, walk (at a comfortable, self-selected pace) for 3 m, turn around, walk back and sit on the chair again; total time elapsed is recorded.

Balance

We evaluated subject balance with the Berg Balance Scale and the single-leg stance test. The Berg Balance Scale comprises 14 items, scored from 1 to 4 with the total possible score being 56 points. Higher scores indicate better balance.[20] A second measure of balance was the single-leg stand test in which we asked subjects to stand on one leg, with the opposite leg flexed 90° at the knee, their arms crossed over their chest, and looking straight ahead. Standing on the dominant leg, each subject made three attempts to maintain balance for 30 seconds, with a 60-sec interval between attempts. We registered the longest of the three recorded results.[21]

Gait speed

We asked subjects to walk 3.33 m at a usual comfortable and self-selected pace to determine gait speed. The time was recorded and speed calculated in meters per second.[22] The best time of three trials was considered for analysis.

Statistical analysis

We used the Kolmogorov-Smirnov test to determine the normality of the data. Descriptive statistics are presented as mean ± standard error of the mean. Student's *t*-test for independent samples was used to compare grip strength and the parameters of physical function by gender within grip strength category (P_0 to P_{25}, P_{25} to P_{75}, and P_{75} to P_{100}). We used hierarchical multiple regression analysis to investigate whether grip strength was associated with the parameters of physical functioning. We used Predictive Analytics Software (version 18.0, SPSS Inc., Chicago, IL, USA) for all analysis. Significance was set at $p < 0.05$

RESULTS

General characteristics

Most of the volunteers evaluated were in the 70-79-year range. Table 1 shows that body weight and height values were higher for the men than women, but that body mass index was comparable between the genders. All of the volunteers were classified as eutrophic and exhibited little to no impairment in cognitive function, functional mobility, balance, or gait speed (absolute and relative speed). However, we found that the men had greater grip strength and higher Berg scores than the women.

When we stratified the volunteers into percentiles by grip strength (as shown in Table 2), we found that males in the highest percentile (P_{75} to P_{100}) had the best functional mobility (TUG test) and balance (Berg scale). Gait speed (absolute and relative speed) was highest for males in the P_{25} to P_{75} and lowest for males in the P_{75} to P_{100}. However, there was no statistical difference between genders in terms of physical function in the P_{25} to P_{75}. In general, the male volunteers were younger, taller, and stronger, as well as having lower BMI.

Association between grip strength and physical function

In addition to grip strength and the parameters of physical function, we introduced the following variables into the multiple regression models (Tables 3 and 4): age, weight, and cognitive function (MMSE score). Among the women in the P_{25} to P_{75} grip strength, as well as the men

Table 1. General characteristics.

	Male (n: 59)	Female (n: 98)	Total (n: 157)
Age (years)	71.5 ± 1.3	76.1 ± 1.5*	74.3 ± 1.0
Body mass (kg)	66.8 ± 1.9	58.9 ± 1.8*	62.0 ± 1.4
Body height (m)	1.63 ± 0.1	1.48 ± 0.1*	1.54 ± 0.1
BMI (kg•m^2)	24.9 ± 0.6	26.5 ± 0.7	25.9 ± 0.5
Cognitive function	16.1 ± 1.0	14.6 ± 0.8	15.3 ± 0.6
Grip strength (N)	498.7 ± 22.0	299.5 ± 11.6*	377.0 ± 13.7
TUGT (s)	18.4 ± 1.4	20.8 ± 1.2	19.9 ± 0.9
BERG	44.3 ± 1.6	36.7 ± 2.9*	40.5 ± 1.7
Single leg stance (sec)	9.1 ± 1.6	7.1 ± 1.6	7.9 ± 1.2
Gait	-	-	-
ABSspeed (s)	6.9 ± 0.5	9.0 ± 0.8	8.2 ± 0.6
RELspeed (m•s^{-1})	2.1 ± 0.1	2.7 ± 0.2	2.5 ± 0.2

* $P < 0.05$ (shaded areas indicate significant differences); BMI: body mass index; BERG: Berg balance scale; TUGT: *timed up and go test*; ABSspeed: absolute speed; RELspeed: relative speed.

Table 2. General characteristics, according to the grip strength and gender.

	Grip strength					
	P_0 to P_{25}		P_{25} to P_{75}		P_{75} to P_{100}	
	Male (n: 10)	Female (n: 18)	Male (n: 40)	Female (n: 65)	Male (n: 9)	Female (n: 15)
Age (years)	74.8 ± 4.3	74.6 ± 2.5	74.2 ± 2.0	80.1 ± 1.6*	69.7 ± 1.7	52.0 ± 9.7
Body mass (kg)	60.2 ± 7.7	50.5 ± 3.2	63.5 ± 3.6	61.2 ± 2.0	69.9 ± 2.2	76.2 ± 9.0
Body height (m)	1.60 ± 0.2	1.45 ± 0.2*	1.59 ± 0.1	1.49 ± 0.7*	1.66 ± 0.1	1.57 ± 0.4
BMI (kg•m^2)	23.3 ± 2.8	24.0 ± 1.5	24.4 ± 1.6	27.6 ± 0.9*	25.5 ± 0.7	31.2 ± 4.3
Cognitive function	7.8 ± 2.4	13.3 ± 1.4	13.5 ± 1.8	15.0 ± 1.1	18.9 ± 1.1	21.7 ± 1.7
Grip strength (N)	219.9 ± 17.8	186.2 ± 9.4*	386.2 ± 11.7	346.5 ± 8.2*	614.2 ± 19.3	559.2 ± 42.6
TUGT (s)	19.6 ± 2.3	25.4 ± 2.0	20.8 ± 2.1	19.5 ± 1.5	16.9 ± 2.2	10.4 ± 1.7*
BERG	43.5 ± 1.5	27.6 ± 7.6	40.8 ± 2.0	36.6 ± 3.4	46.5 ± 2.3	53.0 ± 1.0*
Balance (s)	4.4 ± 1.2	2.6 ± 0.8	4.6 ± 1.9	7.7 ± 2.3	13.0 ± 2.5	22.8 ± 6.3
Gait	-		-		-	
ABSspeed (s)	7.1 ± 0.9	10.3 ± 1.1*	8.2 ± 0.6	9.1 ± 1.2	6.1 ± 0.8	3.9 ± 0.3*
RELspeed (m•s^{-1})	2.1 ± 0.3	3.1 ± 0.3*	2.5 ± 0.2	2.8 ± 0.4	1.8 ± 0.2	1.2 ± 0.1*

* $P < 0.05$ (shaded areas indicate significant differences); BMI: body mass index; BERG: Berg balance scale; TUGT: *timed up and go test*; ABSspeed: absolute speed; RELspeed: relative speed.

in the sample as a whole, cognitive function showed a tendency toward being a major mediator of functional mobility (TUG test). We also found that grip strength was independently associated with the female gender when balance was evaluated with the single-leg stance test. However, age appeared to be the most important mediator of functional mobility and balance among men (Table 3).

Grip strength was not significantly associated with gait speed in either gender or in any grip strength percentile group. However, we found that age and weight were both weakly associated with gait speed (absolute and relative speed) among the women in the P_{25} to P_{75}, as well as with cognitive function among the men in the P_{75} to P_{100}. Nevertheless, we found that age and weight were both significantly associated with gait speed (relative speed) for females in the sample as a whole (Table 4).

DISCUSSION

This study provides evidence that grip strength is independently associated with mobility and balance in institutionalized older women, but not in their male counterparts. The association was significant only in the sample as a whole and not for any of the grip strength percentiles. Our data also supports the idea that grip strength should be considered a marker not only of muscle strength but of physical function as well (especially for mobility and balance). We believe that grip strength should be included in the multidimensional geriatric assessment of institutionalized individuals because it can indicate the general health status[3,8] since it is a major predictor of the ability of older individuals to perform activities of daily living.[23] We have already shown that grip strength is a powerful predictor of muscularity and lean body mass in older individuals.[4] Conversely we have also shown that muscular power is strongly correlated and can therefore be predicted by various body parameters, such as whole body mass and lean body mass.[24]

The frail phenotype stratifies grip strength values by gender and BMI quartile. The trigger for the development of the frailty syndrome appears to be strongly associated with grip strength[10] regardless of the remaining markers (physical activity, exhaustion, unintentional weight loss, and gait speed). Grip strength has been considered a simple marker of frailty and a powerful predictor of future adverse events.[8,9] For example, low grip strength is associated with an increased risk of premature death, development of deficiencies, risk of postoperative complications and longer postoperative recovery time.[3] An association was also identified between the rate of decline in the grip strength and all-cause mortality risk. The current muscle strength, and its rate of decline, are both associated with an increased risk of death in individuals over than 85 years of age.[7]

A number of factors should be considered in subsequent studies. One limitation is that not all of the subjects completed all of the procedures. This probably

Table 3. Model summary represented by *R* (adjusted R^2), and beta (significance level) of values from multiple regression analyzes of physical function as a function of age, body mass, cognitive function and grip strength. The dark shading indicates significant beta coefficients.

	Model summary		Age		Body mass		Cognitive function		Grip strength	
	M	F	M	F	M	F	M	F	M	F
TUGT										
P_0 to P_{25}	---	.49 (.07)	---	.292 (.367)	---	.064 (.841)	---	-.022 (.942)	---	-.358 (.246)
P_{25} to P_{75}	.50 (.05)	.52 (.14)	-.059 (.844)	.172 (.347)	.337 (.283)	.220 (.207)	-.274 (.376)	-.341 (.051)	-.252 (.429)	-.257 (.177)
P_{75} to P_{100}	.50 (.16)	---	.111 (.577)	---	-.059 (.787)	---	-.284 (.179)	---	-.283 (.185)	---
Total	.43 (.11)	.53 (.23)	.070 (.636)	.198 (.116)	.036 (.818)	.153 (.254)	-.320 (.062)	-.211 (.100)	-.157 (.376)	-.387 (.006)
BERG										
P_0 to P_{25}	---	---	---	---	---	---	---	---	---	---
P_{25} to P_{75}	.65 (.04)	.48 (.03)	.206 (.597)	-.473 (.129)	.232 (.559)	-.173 (.540)	.144 (.712)	.184 (.507)	.427 (.312)	-.040 (.896)
P_{75} to P_{100}	.54 (.09)	---	-.002 (.994)	---	.307 (.265)	---	.191 (.461)	---	.210 (.425)	---
Total	.53 (.17)	.60 (.23)	.036 (.834)	-.315 (.114)	.304 (.110)	-.109 (.600)	.164 (.410)	.262 (.190)	.223 (.290)	.325 (.130)
Balance										
P_0 to P_{25}	---	.21 (.38)	---	-.041 (.914)	---	-.108 (.775)	---	.089 (.802)	---	.156 (.659)
P_{25} to P_{75}	.29 (.25)	.18 (.10)	-.216 (.500)	.100 (.631)	.011 (.973)	-.043 (.826)	.058 (.855)	-.006 (.976)	-.178 (.592)	.213 (.321)
P_{75} to P_{100}	.47 (.05)	---	-.438 (.059)	---	-.170 (.483)	---	-.116 (.614)	---	.016 (.944)	---
Total	.48 (.15)	.34 (.05)	-.383 (.012)	-.055 (.698)	-.148 (.348)	-.091 (.545)	-.058 (.730)	.021 (.883)	.279 (.120)	.347 (.026)

* $P < 0.05$ (shaded areas indicate significant differences); TUGT: *timed up and go test*; BERG: Berg balance scale.

Table 4. Model summary represented by R (adjusted R^2), and beta (significance level) of values from multiple regression analyzes of gait speed as a function of age, body mass, cognitive function and grip strength. The dark shading indicates significant beta coefficients.

	Summary model		Age		Body mass		Cognitive function		Grip strength	
	M	F	M	F	M	F	M	F	M	F
Absolute speed										
P_0 to P_{25}	---	.36 (.14)	---	.207 (.488)	---	.260 (.390)	---	-.283 (.320)	---	.057 (.838)
P_{25} to P_{75}	.43 (.11)	.51 (.16)	.084 (.779)	.327 (.078)	.170 (.577)	.334 (.058)	.021 (.945)	-.169 (.318)	-.466 (.152)	-.213 (.258)
P_{75} to P_{100}	.52 (.13)	---	-.105 (.599)	---	-.045 (.834)	---	-.371 (.083)	---	-.284 (.185)	---
Total	.43 (.10)	.46 (.16)	.015 (.919)	.317 (.016)	-.119 (.443)	.307 (.028)	-.202 (.228)	-.159 (.224)	-.210 (.235)	-.234 (.094)
Relative speed										
P_0 to P_{25}	---	.36 (.14)	---	.207 (.488)	---	.260 (.390)	---	-.283 (.320)	---	.057 (.838)
P_{25} to P_{75}	.43 (.11)	.51 (.16)	.084 (.779)	.327 (.078)	.170 (.577)	.334 (.058)	.021 (.945)	-.169 (.318)	-.466 (.152)	-.213 (.258)
P_{75} to P_{100}	.52 (.13)	---	-.105 (.599)	---	-.045 (.834)	---	-.371 (.083)	---	-.284 (.185)	---
Total	.43 (.10)	.46 (.16)	.015 (.919)	.317 (.016)	-.119 (.443)	.307 (.028)	-.202 (.228)	-.159 (.224)	-.210 (.235)	-.234 (.094)

* P <0.05 (shaded areas indicate significant differences).

explains the fact that some of the regression analyses were performed with low predictive power, especially for the strata within the extremities (P_0 to P_{25} and P_{25} to P_{75}), as well as with a low power to identify collinearities (e.g., weight and gait speed). A larger sample size would allow other influential variables to be included in the regression models. Such variables would likely be unique to institutionalized individuals (e.g., number, duration, and severity of diseases; use and dosage of medications; and length of institutionalization). Studies involving larger samples would also have the power to evaluate the role played by those variables (e.g., age, weight, and cognitive function). Likewise, the stratified analysis might represent a valid strategy because grip strength is an important criterion for the clinical diagnosis of frailty syndrome.[10] The fact that we identified no significant associations for the P_0 to P_{25} and P_{25} to P_{75} might be attributable to the small sample size in those percentiles. In addition, grip strength appears to be associated with a greater number of frailty markers than the chronological age *per se*.[9] It seems to be a better predictor of adverse events than the weight-for-height ratio, weight loss, body circumferences and serum albumin.[25]

Our results allow us to conclude that grip strength is independently associated with functional mobility and balance in elderly women who are residents of long-term care facilities. However, the stability of the associations of the grip strength with functional mobility and balance should be tested in samples of individuals whose characteristics are substantially different from our sample (e.g., clinical status, socioeconomic level).

CONFLICTS OF INTEREST

The authors declare that they have no conflict of interest.

AUTHOR CONTRIBUTIONS

Study concept and design: Raso V. Acquisition of data: Mancini RB and Matsudo SMM. Analysis and interpretation of data: Raso V and Tolea M. Drafting of the manuscript: Raso V and Tolea M. Critical revision of the manuscript for important intellectual content: Raso V and Tolea M. Statistical analysis: Raso V. Administrative, technical, or material support: Mancini RB, Matsudo SMM. Study supervision: Matsudo SMM.

A FORÇA DE PREENSÃO MANUAL PREDIZ A FUNÇÃO FÍSICA DE RESIDENTES DE INSTITUIÇÕES DE LONGA PERMANÊNCIA PARA IDOSOS

OBJETIVO: O objetivo deste estudo foi analisar a relação da força de preensão manual com a função física em indivíduos idosos institucionalizados.

MÉTODOS: Cento e cinquenta e sete idosos institucionalizados de ambos os sexos em sete diferentes instituições de longa permanência foram submetidos a avaliação da composição corporal, função cognitiva, forca de preensão manual (PREENSAO), mobilidade funcional, equilíbrio corporal (escala de equilíbrio de BERG e teste unipodal) e velocidade de caminhada (VELCAM).

RESULTADOS: Em geral, os participantes deste estudo não apresentaram comprometimento da função cognitiva, mobilidade funcional, equilíbrio corporal ou da VELCAM. Os homens desenvolveram maior PREENSÃO e alcançaram maior escore em BERG. Os voluntários mais aptos (i.e., P_{75} a P_{100}) apresentaram melhor função física, BERG e VELCAM; os menos aptos (i.e., P_0 a P_{25}) apresentaram maior estatura e melhor VELCAM. A PREENSAO foi independentemente associada à função física e ao equilíbrio unipodal somente no sexo feminino (amostra total). A função cognitiva (feminino, P_{25} a P_{75};

masculino, amostra total) e a idade (masculino, amostra total) demonstraram tendência de interferência em relação à avaliação da função física. A idade e o peso corporal parecem ser candidatos a preditores da VELCAM, sobretudo no P_{25} a P_{75} do sexo feminino, enquanto a função cognitiva é preditor de VELCAM no sexo masculino (P_{75} a P_{100}). Por outro lado, a idade e o peso corporal são significativamente associados a VELCAM (feminino, amostra total).

CONCLUSÃO: Os dados deste estudo piloto permitem concluir que a forca de preensão manual foi independentemente associada a função física de mulheres idosas institucionalizadas.

PALAVRAS CHAVES: Equilíbrio corporal, função física, forca muscular, idoso, institucionalização.

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