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ARTICLE

Influence of physical performance on elderly mortality, functionality and life satisfaction: FIBRA's study data

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Abstract *Objective: To verify the influence of physical performance on elderly mortality, functionality and life satisfaction. Materials and methods: A follow-up was performed on 900 Brazilian non-hospitalized elderly in the period 2008-2016, in which 154 deaths from natural causes were included in the survival analysis. Results: the worst grip strength (RR = 1.60; CI 95% = 1.15-2.23, p = 0.005) and gait speed (RR = 1.82; CI 95% = 1.30-2.55, p < 0.001) performances were associated with increased mortality risk. Age was a confounding factor for strength (RR = 1.06; CI 95% = 1.03-1.09, p < 0.001) and rheumatoid arthritis was a confounding factor for speed (RR = 2.02; CI 95% = 1.36-3.01, p < 0.001). The elderly with good physical performance realized more instrumental and advanced activities of daily living, and good gait performance had a significant effect on life satisfaction (F = 6.87, p = 0.009). Conclusions: good physical performance seems to be fundamental for longevity and for accomplishing daily tasks. Furthermore, good mobility can affect life satisfaction-related mechanisms.*

Key words *Mortality, Functionality, Life satisfaction*

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Introduction

In elderly patients, estimates of physical performance are essential parameters for health assessment. The most commonly used physical performance variables are handgrip strength and gait speed. The first consists of an indicator of isometric muscular strength, which is related to mobility, daily physical activity level and sarcopenia[1,2]. Gait speed, in turn, is associated with the strength of lower limbs[3] and physical disability[4]. That is, they are measures that allow to infer other physical capacities and require low economic expenditure, and become valuable tools in clinical and scientific practices.

These physical performance variables can also be used to predict future events. Studies have shown that poor handgrip strength[5,6] and mobility[7-11] are associated with an increased risk of mortality. Despite this, few studies have investigated the influence of these two variables simultaneously and in non-hospitalized elderly[12].

Considering that low handgrip strength levels are associated with an increased risk of motor limitation[13] and that the frailty process affects the organic systems simultaneously[14], then perhaps the use of these variables in association ensures greater predictive reliability.

Also, guidelines on healthy aging surpassed the longevity paradigm, emphasizing the importance of maintaining functionality and autonomy in old age[15]. Thus, we should not only reflect on the quantity of life but also consider how those additional years are being lived. Therefore, this study aimed to verify the influence of physical performance on mortality, functionality and life satisfaction of the elderly.

Materials and methods

Cohort study

This is a cohort study in which a sample of 900 elderly individuals was monitored to investigate the influence of physical performance on the risk of mortality. The sample was established from the database of the Study on Brazilian Elderly Frailty (FIBRA), from which we selected the information of the participants of the city of Campinas-SP.

FIBRA was developed for the screening of frailty conditions of elderly residents in urban areas. Initiated in 2008, participants were 65 years of age or older and had no memory, attention, spatial orientation, speech, hearing, vision or mobility disorders, sequelae of stroke or advanced neurodegenerative disease. For more information, please read FIBRA[16] study's full methodology.

Mortality data

The date of death was identified through the Mortality Information System of the Municipality of Campinas-SP. The cause of death was obtained through the International Code of Diseases (ICD-10). December 31, 2016 was adopted as the deadline for the follow-up of the sample. Total follow-up time was 8.4 years, and the elderly who died from unnatural causes or who did not die during the follow-up period were censored. Among the unnatural causes of death were traffic accidents and accidents with firearms. Survival time was calculated by the difference between the date of entry in the study and date of death (or the cut-off date). The Research Ethics Committee of the State University of Campinas approved the study.

Physical performance

It consisted of handgrip strength and usual gait speed. The former was evaluated three consecutive times through a hydraulic dynamometer set in the dominant hand of the elderly. Performances were categorized dichotomically according to the median, with cutoff points adjusted for gender (weak: $\leq$ 34 kg men, $\leq$ 20.6 kg women). Gait speed corresponded to the travel time, at a usual pace, of 4.6 meters, three consecutive times. The simple mean travel time was used to calculate the mean speed ($Vm = \Delta s / \Delta t$). According to the median, we used the gender-adjusted dichotomous classification (slow: $\leq$ 1.00 m/s men; $\leq$0.91 m/s women).

Confounding variables

Confounding variables were defined by theoretical criteria and were grouped in: age, psychological aspects, body composition and chronic diseases.

Psychological aspects

The Mini-Mental State Examination (MMSE)[17] was applied to screen cognitive function. The definition of cutoff points followed the recommendations of the Brazilian Academy of Neurology, which is based on Brucki et al.[18] and

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on a standard deviation. The definition of cut-off points is important because, according to Neri et al.[16], cognitive impairment could compromise the validity of self-reported responses. Therefore, cut-off points adjusted for schooling time were adopted: illiterate=17; 1-4 years=22; 5-8 years=24; ≥ 9 years=26.

Participants scoring above the cut-off point in the MMSE responded to the Abridged Geriatric Depression Scale (GDS-15). GDS-15 was categorized as follows: <6 = no depressive symptoms; ≥ 6 = with depressive symptoms[19].

Body composition

It consisted of the classification of overweight by the Body Mass Index (BMI)[20] and risk by the Waist to Hip Ratio (WHR)[21]. BMI: < 23 low weight; ≥ 23 and < 28 normal weight; ≥ 28 and < 30 overweight; ≥ 30 obesity. The risk score for the WHR was adjusted for gender: Men: < 0.91 low; 0.91-0.98 moderate; > 0.98 high. Women: < 0.76 low; 0.76-0.83 moderate; > 0.83: high.

Chronic diseases

A questionnaire was applied that asked the elderly or family member (if the score was below the MMSE cutoff point) whether the doctor had diagnosed heart disease, hypertension, diabetes, cancer, lung disease, arthritis and osteoporosis[22].

Activities of daily living and life satisfaction

The elderly who scored above the cut-off point in the MMSE were asked about the activities of daily living (ADLs) and their life satisfaction level.

The Basic Activities of Daily Living (BADLs) consisted of items related to self-care, in which the elderly were classified as "independent" or "dependent"[23]. One point was assigned for each "independent" task and zero for each task that the elderly could not perform alone. The maximum score was 6 points.

The Instrumental Activities of Daily Living (IADLs) consisted of 7 items about household tasks, in which the elderly was classified as "independent", "partially independent" or "dependent"[24]. Three points were assigned to each "independent" item, two points for "partially dependent" tasks and one point for "dependent" items. The maximum score was 21 points.

The Advanced Activities of Daily Living (AADLs) corresponded to 16 items on activities more complicated than BADLs and IADLs, in which the elderly were classified as "do", "do not do" or "never did"[25]. For the score of this tool, we considered the activities that the elderly do and stopped doing, and we disregarded the activities never performed. Then, we calculated the percentage value representing the proportion of activities that the elderly still performed at the baseline, using the following formula:

$$\left(\frac{\text{Do}}{\text{Do + Stopped doing}} \right) *100$$

The score ranged from 0 to 100, with functionality directly proportional to the score.

Life satisfaction consisted of 8 items evaluating aspects, such as overall satisfaction, comparison with others same age, ability to handle everyday chores, social relationships, environment, access to health services and transportation, which were classified as "very satisfied", "more or less satisfied" or "not very satisfied"[26]. Three points were awarded for each item "very satisfied", two for "more or less satisfied" and one for items that the elderly person was "not very satisfied". The maximum achievable score was 24 points.

Statistical analysis

Descriptive statistics were used to characterize the database. Proportions were compared through the chi-square test. The Mann-Whitney test was run for the variables with abnormal distribution. Kaplan-Meier curves were performed to verify the rate of mortality according to the strength and speed categories. The Log-Rank test compared survival functions. The association of handgrip strength and usual gait speed with mortality was verified using the Cox regression. Relative Risk (RR) indexes for mortality were initially calculated without any adjustment (Model 1). The following models were adjusted for age (Model 2), psychological aspects (Model 3), body composition (Model 4) and chronic diseases (Model 5).

A Multivariate General Linear Model was performed to verify the influence of physical performance on ADLs and life satisfaction. Variables with abnormal or heterogeneous distribution were transformed into Z-scores. The size of the effect was estimated by Eta Squared (η^2). All statistical analyses were done in the Statistical Package for the Social Sciences, version 24, and statistical significance was set at $p < 0.05$.

Results

Physical performance and mortality

One hundred sixty deaths (17.8%) were recorded during follow-up, of which 154 (17.1%) were due to natural causes. Considering only deaths from natural causes, mean survival was 4.4 years (± 1.9), with 4.6 years (± 1.8) for men and 4.3 years (± 1.9) for women. On average, the elderly died aged 79.7 years (± 7.2), with 78.7 years (± 7.2) for men and 80.4 years (± 7.2) for women. Figure 1 shows the comparison of handgrip strength (A) and usual gait speed (B) between survivors and deceased from natural causes, by gender. The Mann-Whitney test showed that survivors were stronger (men: $p = 0.013$, women: $p < 0.001$) and faster (men: $p = 0.003$; women: $p < 0.001$) at baseline against individuals who died during the follow-up period.

About the deceased, at baseline, 90 (58.4%) participants had low levels of handgrip, while mobility disability was found in 92 (59.7%) elderly.

Table 1 shows the characteristics of elderly survivors and those who died from natural causes. About the deceased, 2 (1.3%) preferred not to respond on the marital status. Thirty-eight (24.7%) had low weight, 65 (42.2%) normal weight and 23 (14.9%) were overweight. Regarding WHR, 59 (38.3%) elderly were classified as low risk, and 42 (27.3%) had a moderate risk. Overall, 689 (76.5%) elderly individuals were not diagnosed with cognitive impairment. Among them, 673 (97.7%) answered the GDS-15, of which 541 (80.4%) did not evidence depressive symptoms.

Figure 2 shows the Kaplan-Meier survival curves and the number of elderly at risk of mortality according to the follow-up time. When comparing survival functions, there was a statistically significant difference between the functions of handgrip strength (Log Rank: $X^2 = 12.18$, $p < 0.001$) and gait speed (Log Rank: $X^2 = 16.64$, $p < 0.001$), showing that the mortality speed was enhanced for individuals with both strength and mobility impairments.

As shown in Table 2, the risk of mortality was 1.6 times higher for elderly with handgrip strength deficit. The effect was maintained in the adjustments of Models 3, 4 and 5, but age (Model 2) was a statistically significant confounding factor (RR = 1.06; 95% CI = 1.03-1.09, $p < 0.001$). Elderly patients with slow gait had 1.82 times higher mortality risk in relation to the elderly without mobility impairment. The effect was maintained in the adjustments of Models 2, 3 and 4, but the presence of rheumatoid arthritis (Model 5) was a statistically significant confounding factor (RR = 2.02; 95% CI = 1.36-3.01; $p < 0.001$).

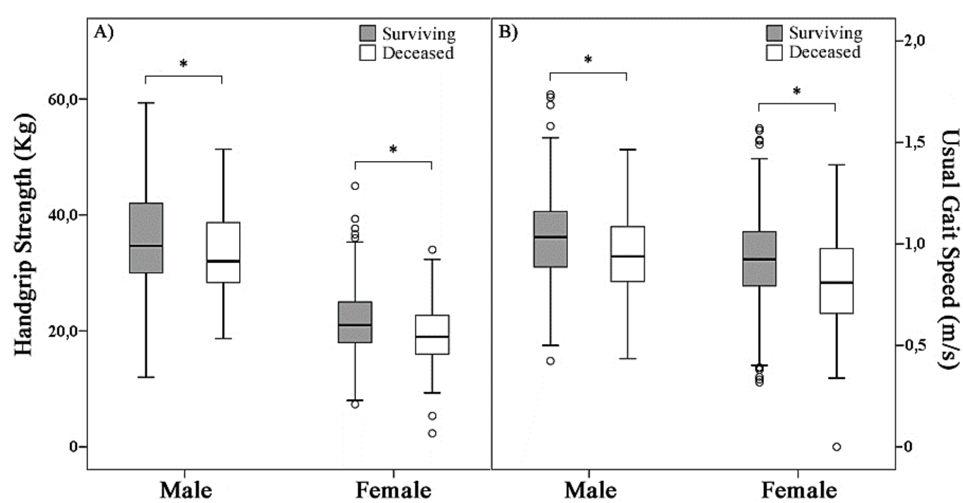

Figure 1. Comparison of handgrip strength (A) and usual gait speed (B) levels among surviving and deceased elderly according to sex.

* Statistically significant difference ($p < 0.05$) obtained with Mann-Whitney's Test.

Table 1. Characteristics in the baseline of the elderly of Campinas-SP according to the mortality status.

	Surviving		Deceased		
	N = 740		N = 154		P value
Women (n, %)	530	(71.6)	88	(57.1)	<0.001
Age (mean, SD)	72.2	(5.3)	75.2	(7.0)	<0.001
Marital status (n, %)					0.450
Married	386	(52.2)	76	(49.4)	
Single	44	(5.9)	9	(5.8)	
Divorced	55	(7.4)	10	(6.5)	
Widowed	252	(34.0)	57	(37.1)	
Psychological aspects (n, %)					
Cognitive impairment (MMSE)	163	(22.0)	44	(28.6)	0.081
GDS ≥ 6 (NS=566; ND=107)	117	(20.7)	15	(14.0)	0.107
Body composition (n, %)					
Overweight (BMI)	211	(28.5)	27	(17.5)	<0.001
High Risk (WHR)	268	(36.2)	52	(33.8)	0.848
Chronic Diseases (n, %)					
Cardiovascular	138	(18.6)	43	(27.9)	0.006
Hypertension	371	(50.1)	71	(46.1)	0.934
Diabetes	120	(16.2)	29	(18.8)	0.401
Cancer	54	(7.3)	10	(6.5)	0.921
Lung disease	53	(7.2)	13	(8.4)	0.641
Arthritis	259	(35.0)	33	(21.4)	0.015
Osteoporosis	151	(20.4)	26	(16.9)	0.792
Handgrip strength (mean, SD)	25.5	(9.2)	25.2	(9.4)	0.777
Gait speed (mean, SD)	0.96	(0.2)	0.87	(0.2)	<0.001

SD = Standard Deviation; BMI = Body Mass Index; WHR = Waist to Hip Ratio; MMSE = Mini Mental State Examination; GDS = Geriatric Depression Scale; NS = Number of surviving participants; ND = Number of deceased participants; P-value = statistical significance ($P < 0.05$) obtained with Chi-Square or Mann Whitney test.

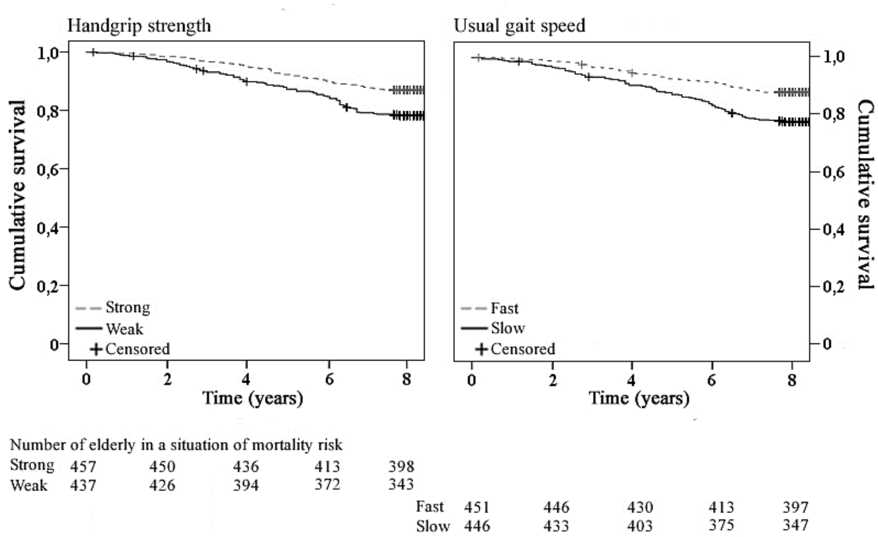

Figure 2. Kaplan-Meier survival curves according to the levels of handgrip strength and usual gait speed of the elderly in Campinas-SP.

Table 2. Mortality risk estimated by Cox proportional hazards regression according to levels of handgrip strength and usual gait speed of elderly in Campinas-SP.

	Handgrip strength (Kg)			Usual gait speed (m/s)		
	Weak	Strong		Slow	Fast	
	R.R. (CI 95%)	R.R. (CI 95%)	P value	R.R. (CI 95%)	R.R. (CI 95%)	P value
Model 1	1.60 (1.15–2.23)	1 (ref)	0.005	1.82 (1.30–2.55)	1 (ref)	<0.001
Model 2	1.30 (0.92–1.84)	1 (ref)	0.133	1.62 (1.15–2.28)	1 (ref)	0.006
Model 3	1.63 (1.10–2.40)	1 (ref)	0.014	1.55 (1.05–2.27)	1 (ref)	0.026
Model 4	1.48 (1.06–2.07)	1 (ref)	0.020	1.97 (1.40–2.77)	1 (ref)	<0.001
Model 5	1.50 (1.02–2.22)	1 (ref)	0.039	1.39 (0.95–2.05)	1 (ref)	0.093

CI = Confidence interval; R.R. = Relative Risk obtained through Cox proportional hazards regression; P-value = statistical significance ($P < 0.05$). Cutoff points of handgrip strength: Weak = ≤ 34 kg men; ≤ 20,6 kg women; Cutoff points of usual gait speed: Slow = ≤ 1,00 m/s men; ≤ 0,91 m/s women. Model 1 = no adjustment; Model 2 = adjusted for age; Model 3 = adjusted for cognitive impairment and depressive symptoms; Model 4 = adjusted for risk classification based on the Body Mass Index and the Waist to Hip Ratio; Model 5 = adjusted for cardiovascular disease, hypertension, diabetes, cancer, lung disease, arthritis and osteoporosis.

Physical performance, ADLs and life satisfaction

The population without cognitive impairment and that performed the physical tests totaled 655 elderly. Among them, 306 (46.7%) were classified as weak, while gait disability was observed in 283 (43.2%) elderly. The results for the multivariate model are shown in Table 3. There was a statistically significant effect of handgrip strength on IADLs ($F = 4.72$, $\eta^2 = 0.01$) and AADLs ($F = 7.03$; $\eta^2 = 0.01$). The gait speed showed a statistically significant effect on life satisfaction ($F = 6.87$; $\eta^2 = 0.01$), IADLs ($F = 19.85$; $\eta^2 = 0.04$) and AADLs ($F = 6.02$; $\eta^2 = 0.01$). According to the means, the stronger elderly did more IADLs and AADLs, while faster elders were more satisfied with life, and made more IADLs and AADLs.

Discussion

We verified the influence of two important components of physical fitness on the risk of mortality, functionality and life satisfaction of the elderly. The results suggest that elderly with good levels of handgrip strength and usual gait speed are more likely to live longer. Also, good physical performance seems to be fundamental for functionality in the face of daily demands and a good perception of life.

The findings about the influence of physical performance on mortality corroborate other studies[7,8,27,28]. We found that low levels of handgrip strength were associated with increased risk of mortality in models adjusted for psychological aspects, body composition and chronic diseases. However, age was a statistically significant confounding factor, because a natural physical decline[29] occurs with age, affecting mainly strength[30] and muscle mass[31].

Slow gait was associated with an increased risk of mortality in the models adjusted for age, psychological aspects and body composition. In contrast, self-reported rheumatoid arthritis was a statistically significant confounding factor. Rheumatoid arthritis is an inflammatory, limiting disease that may progress to irreversible conditions of deformity[32]. Weiss et al.[33] showed that patients with rheumatoid arthritis had a substantial gait speed reduction. As justification, the disease impairs the mobility of several joints such as hip, knee and ankle, compromising gait's biomechanics.

Two hypotheses are considered as possible physical performance actions mechanisms in the mortality risk: one situational and one inflammatory. The situational hypothesis begins with the assumption that low physical performance would signal a frailty process. Thus, it has already been shown that low levels of strength and gait are part of the frailty phenotype[1]. Frail individuals may evidence sarcopenia, neuroendocrine and immunological dysregulation, which deplete energy reserves and organic resistance in response to stressors[34]. All these factors would make individuals more susceptible to diseases and infections, culminating in increased mortality risk.

The inflammatory hypothesis is based on the assumption that poor physical performance

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Table 3. Influence of handgrip strength and the usual gait speed on life satisfaction and activities of daily living of the elderly in Campinas-SP.

		Mean	(SD)	CI 95% difference	P-value
Handgrip strength (n=655)	Life satisfaction				
	Weak	20.60	(2.8)	-0.16–0.71	0.222
	Strong	20.94	(2.7)		
	BADL				
	Weak	5.87	(0.3)	-0.29–0.74	0.387
	Strong	5.90	(0.3)		
	IADL				
	Weak	20.3	(1.4)	0.02–0.40	0.030
	Strong	20.6	(1.0)		
	AADL				
	Weak	63.7	(20.3)	1.17–7.82	0.008
	Strong	68.6	(22.0)		
Usual gait speed (n=655)	Life satisfaction				
	Slow	20.4	(2.9)	0.15–1.03	0.009
	Fast	21.1	(2.6)		
	BADL				
	Slow	5.86	(0.4)	-0.01–0.09	0.090
	Fast	5.91	(0.3)		
	IADL				
	Slow	20.1	(2.9)	0.24–0.61	<0.001
	Fast	20.7	(2.6)		
	AADL				
	Slow	63.2	(22.1)	0.82–7.48	0.015
	Fast	68.3	(20.5)		

SD = Standard Deviation; CI = Confidence interval; BADL = Basic Activities of Daily Living; IADL = Instrumental Activities of Daily Living; AADL = Advanced Activities of Daily Living; P-value = statistical significance (P < 0.05) referring to the Multivariate General Linear Model.

may make the elderly feel more fatigued when performing daily tasks, increasing the odds of immobility and sarcopenia[35]. Physical inactivity may lead to a chronic inflammatory state, signaled by pro-inflammatory cytokines such as Interleukin 6 (IL-6), Tumor Necrosis Factor Alpha (TNF-α) and C-reactive protein (CRP)[36]. These cytokines decrease protein synthesis, feedback the sarcopenia process, and increase the risk of chronic diseases[36], which together would increase the mortality risk.

Another observed result is that good physical performance seems to benefit daily activities, especially more complex tasks. This is a predictable result, since day-to-day activities demand physical abilities such as strength, speed, flexibility, etc. The complexity of tasks, such as in the IADLs and AADLs increases with greater physical demand. Thus, maintenance of physical capacities is fundamental for the elderly to continue performing their usual tasks. This statement is in line with the World Health Organization (WHO) report on Aging and Health[15], which emphasizes healthy aging as one in which the elderly retain their functionality and maintain their independence and autonomy vis-à-vis daily demands.

There was no statistically significant effect of physical performance on the BADLs, which may be sample bias, since participants recruited for this study had a robust profile[16], without physical and cognitive impairments. Thus, the detection of possible shortcomings was achieved only by increasing the complexity of daily tasks, such as in the IADLs and AADLs.

We also identified that the elderly without gait impairment were more satisfied with life. Although this result was statistically significant, we should use some caution in its analysis. After all, from the practical point of view, a negligible difference in the comparison of the groups and a low size of effect was observed. However, from the theoretical point of view, gait speed may influence regulation mechanisms, which can contribute to a better perception of life.

Life self-assessment is influenced by individual regulation in the face of the noxious effects of aging[37]. Factors such as social roles, purpose in life[38], interrelationships[39] and even the comparison with worse-off elderly[40] are some of the regulatory mechanisms. Also, it has been shown that individuals with restricted mobility tend to have low social involvement[41]. That is, good mobility allows the elderly to remain active agents in their homes and communities, stimulating important aspects, such as a sense of purpose, self-esteem and self-confidence. Thus, we believe that people without mobility impairments tend to live more actively, and are more exposed to social, emotional and environmental interactions, which may reflect a better perception of life.

Taking into account that mortality and functionality were influenced by physical performance, then, we inevitably stress the importance of having an active life in old age, mainly through the practice of physical exercises, because, in addition to improving functionality[42], physical exercise acts on biological[29] and psychosocial aspects[43], reducing mortality risks and enhancing the regulatory mechanisms mentioned above.

This study differs from other investigations by adopting measures of physical performance in association, applied in a sample of non-ambulatory elderly. The results shown here reinforce the importance of adopting physical performance variables in clinical and scientific practices, since they are reliable in the prediction of future events, such as death, in addition to being associated with subjective variables. This study enables reflections based solely on the time of existence, admitting physical performance as the key to an extensive and intense life.

As limitations of this study, the results should not be generalized for outpatient elderly, since, as previously mentioned, the profile of the population investigated was of robust and proactive elderly[16]. Also, the cutoff points adopted for the classification of physical performance were different from other studies, which is due to a particular characteristic of the sample. An example is gait speed's cutoff point. Descriptive results showed that males were generally faster than females. Had we used the same cutoff point adopted in other studies (0.8 m/s)[44,45], we would have had an imbalanced proportion of individuals with and without mobility impairment (the same goes for strength). On the other hand, knowing that the general population includes men and women with varying levels of mobility, we chose to equalize the variables according to gender, minimizing sample-related biases. Finally, information on chronic diseases was obtained by self-report, which may have overestimated the prevalence of diseases.

Future studies may adopt repeated measures to investigate the magnitude of physical declines over the follow-up period, which may later be associated with mortality risk. Another suggestion relates to the evaluation of functionality. Here we infer it from the self-report of daily activities. An alternative would be the adoption of specific physical tests for the assessment of abilities such as balance, coordination and double task.

Conclusions

We showed that older adults with good physical performance live longer and better. Thus, good physical performance was associated with reduced risk of mortality and better functionality in daily tasks. The associated use of handgrip strength and the usual gait speed proved to be an effective strategy because of its good predictive capacity for death. Finally, we showed that mobility could act in protection mechanisms associated with life satisfaction.

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Collaborations

VN Soares wrote the manuscript and also performed the statistical analysis; Fattori undertook a critical review of the manuscript and statistical analysis; AL Neri developed the methodology of the study Fragility in Brazilian Elderly; and PT Fernandes worked on the logic of discourse and the final revision of the manuscript.

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