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Ability to sit and rise from the floor as a predictor of all-cause mortality

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Abstract

Background: While cardiorespiratory fitness is strongly related to survival, there are limited data regarding musculoskeletal fitness indicators. Our aim was to evaluate the association between the ability to sit and rise from the floor and all-cause mortality.

Design: Retrospective cohort.

Methods: 2002 adults aged 51–80 years (68% men) performed a sitting-rising test (SRT) to and from the floor, which was scored from 0 to 5, with one point being subtracted from 5 for each support used (hand/knee). Final SRT score, varying from 0 to 10, was obtained by adding sitting and rising scores and stratified in four categories for analysis: 0–3; 3.5–5.5, 6–7.5, and 8–10.

Results: Median follow up was 6.3 years and there were 159 deaths (7.9%). Lower SRT scores were associated with higher mortality ($p < 0.001$). A continuous trend for longer survival was reflected by multivariate-adjusted (age, sex, body mass index) hazard ratios of 5.44 (95% CI 3.1–9.5), 3.44 (95% CI 2.0–5.9), and 1.84 (95% CI 1.1–3.0) ($p < 0.001$) from lower to higher SRT scores. Each unit increase in SRT score conferred a 21% improvement in survival.

Conclusions: Musculoskeletal fitness, as assessed by SRT, was a significant predictor of mortality in 51–80-year-old subjects. Application of a simple and safe assessment tool such as SRT, which is influenced by muscular strength and flexibility, in general health examinations could add relevant information regarding functional capabilities and outcomes in non-hospitalized adults.

Keywords

Functional assessment, health-related quality of life, musculoskeletal fitness, survival

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Introduction

Following a trend for a longer life expectancy in populations around the world, there has been growing interest in strategies to preserve health-related quality of life and individual autonomy. Middle-aged subjects and those entering seniority represent a growing proportion of the world population,[1] and these individuals are known to develop progressively diminished levels of physical fitness and have an increased risk of unfavourable health outcomes.[2] Thus, it is of utmost clinical relevance to develop simple, reliable, and valid prognostic indicators.[3]

While studies have clearly demonstrated that a lower cardiorespiratory fitness, as evaluated by exercise testing, significantly predicts a higher risk for all-cause mortality in middle-aged and elderly adults,[4–6] there is broad recognition that other measurements are needed to provide a more comprehensive depiction

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of functional capacity. Specifically, body composition, muscle strength and power, flexibility, and postural stability are also relevant for proper health and functioning.[7,8] Although there are scarce data regarding the relationship between different indicators of musculoskeletal fitness and all-cause mortality, the available evidence has suggested positive associations between higher levels of these indicators and survival.[9–12]

Sitting and rising from the floor is a basic functional task required for autonomy. The inability to perform these and similar actions are closely related to the risk of falling, and if a fall has occurred, the capacity to return to an upright position is critical.[13] Proper levels of muscle strength/power, coordination, body composition, balance,[14] and flexibility[15] are required for various daily activities and, more specifically, for a successful transition from standing to a sitting position as well as rising from the floor.[16] In the late 1990s, Araújo[17] proposed a simple method to assess the ability to sit and rise from the floor, termed the sitting-rising test (SRT), which objectively quantifies the number of supports (i.e. hand or knee) needed and the presence or absence of balance stability for these actions. Given the ability of the SRT to reflect an essential aspect of an individual's functional capabilities, we evaluated whether SRT performance predicts all-cause mortality in subjects aged 51–80 years.

Methods

Participants

This retrospective single-centre cohort study comprised all evaluations carried out from 1997 to 2011 in a total of 2076 subjects aged between 51 and 80 years at the time of evaluation. Subjects that met any of the following criteria were excluded: (a) those regularly competing in sports events; (b) presenting with any relevant musculoskeletal limitations that could affect SRT; and (c) refusal in performing the SRT. A final sample comprising 2002 individuals (1356 men; 67.7%) who were followed from the date of the baseline examination until the date of death or 31 October 2011. Mortality surveillance data were obtained from the official registries of Rio de Janeiro State. All subjects volunteered for the evaluation and signed an informed consent. The evaluation protocol and data analysis were formally approved by an institutional Ethics Committee and the study was conducted according to the Declaration of Helsinki principles.

Sitting-rising test

The SRT assesses components of musculoskeletal fitness through evaluation of the subject's ability to sit and rise from the floor, assigning a partial score for each of the two required actions.[17] SRT was administered on a non-slippery flat surface, in minimal space of 2×2 m, with the subject standing barefoot and wearing clothing that did not restrict body movements. Before the SRT, the evaluator instructed: 'Without worrying about the speed of movement, try to sit and then to rise from the floor, using the minimum support that you believe is needed.'

SRT partial scores began with a maximum of 5 points, separately for sitting and rising. One point was subtracted for each support utilized, that is, hand, forearm, knee, or side of leg, and an additional 0.5 point was subtracted if the evaluator perceived an unsteady execution (partial loss of balance) occurring during the action. In addition, one point was subtracted if the subject placed one hand on the knee in order to sit or rise. Crossing the legs for either sitting or rising from the floor was allowed, while the sides of the subject's feet were not used for support. If a 5 score was not obtained, the evaluator provided some advice that might assist the subject to improve their SRT score in other attempts. In this context, a total of 11 possible separate scores in the range 0–5 were generated (0, 0.5, 1, . . . 4.5, 5) for each of sitting and rising from the floor. A video illustrating SRT performance and scoring is available at www.youtube.com/watch?v = MCQ2WA2T2oA.

Independently of the number of attempts performed, the resulting SRT partial scores were considered as the best score for each one of the actions, e.g. 4 and 2 for the actions of sitting and rising from the floor, respectively. In addition, a composite score, hereafter termed the SRT score, was obtained by adding sitting and rising partial scores, to give a total of 21 possible separate scores in the range 0–10 (0, 0.5, 1, . . . 9.5, 10). Previous studies have shown that SRT scoring is highly reliable[18] and has been applied in a variety of research contexts.[19–22] Age (5–95 years) and sex-specific norms for SRT scoring – both partial and total scores – are available from the senior author.

Statistical analysis

Results were separated and ranked by four categories according to SRT score as follows: C1, 0–3; C2, 3.5–5.5; C3, 6–7.5; and C4, 8–10. In order to establish the cutoffs to be used in SRT, log rank test and ROC curves were applied; however, we felt that minor adjustments in these cutoff values would be more logical and practical in clinical terms. Initially, Kaplan–Meier curves were constructed for the four categories and log-rank tests were used to analyse survival time. The relationship between SRT score and all-cause mortality was modelled by Cox univariate and multivariate analyses using adjustments for age, sex, and body mass index (BMI). Cox regression and proportional hazards analyses were performed using the highest category (8–10) as the reference. One-way analysis of variance was used for comparing continuous variables, such as age, height, weight, and BMI for the four categories. Statistical significance level at 5 and 95% confidence intervals was used for all results. Calculations were carried out and figures prepared by using either Prism (version 5.01; Graphpad, USA) or SPSS (version 17; SPSS, USA).

Results

Descriptive analyses for entire cohort and the four categories ranked according to SRT score ranges are provided in Table 1. Median follow-up time was 6.3 years (range 0.1–13.9 years). The median age of 62 years was identical for male and female participants. During follow up there was an overall death rate of 7.9%.

The distribution of SRT scores in the four categories according to 5-year age intervals is displayed in Figure 1. While the vast majority of the deaths were found in those participants with a low SRT scores, just one male, aged 64 years, and one female, aged 54 years, died having an SRT score of 10 during follow up. On the other hand, no subject older than 70 years scored 10 on the SRT.

Log-rank tests (Figure 2) indicate that survival in the four SRT categories differed significantly (chi-square 107.43; $p < 0.001$). Based on an age-, gender-, and BMI-adjusted Cox analysis, there was a 3-year shorter life expectancy among subjects placed in the lowest score category as compared to subjects with the best score category (Figure 3). Proportional hazards analysis identified that SRT score was a significant predictor of all-cause mortality, with subjects in the lower score range exhibiting a 5–6-times higher risk as compared to those in the reference (C4). Multivariate analysis adjusting for age, sex, and BMI confirmed these findings, with similar hazard ratios as those in the unadjusted model (Table 1). By proportional hazards analysis, each increment in the SRT score was associated with a 21% reduction in all-cause mortality.

Discussion

Health-related physical fitness testing has been extensively investigated for much of the last century.[23] For example, approximately 70 years ago, Cureton[24] asserted that flexibility was one of the integral components of physical fitness and stated that 'old age is marked by stiffness in the joints and accompanying physical awkwardness'. In contrast to other health-

Table 1. Major characteristics of the subjects according to SRT scoring (N = 2002) and Cox proportional HR analyses for SRT scoring and all-cause mortality

		SRT score			
	All ($n = 2002$)	0–3 ($n = 311$)	3.5–5.5 ($n = 244$)	6–7.5 ($n = 473$)	8–10 ($n = 974$)
Variables (mean ± SD, 95% CI)[a]					
Age (years)	63 ± 8.1 (52–77)	71 ± 7.0 (56–80)	67 ± 7.8 (53–79)	63 ± 7.4 (52–76)	59 ± 6.3 (51–71)
Weight (kg)	78.4 ± 15.8 (55.0–106.0)	81.5 ± 19.9 (53.8–121.0)	83.1 ± 17.7 (57.5–119.0)	80.2 ± 15.6 (57.3–106.0)	75.2 ± 13.1 (54.0–97.1)
Height (cm)	168 ± 9.2 (152–182)	164 ± 9.9 (149–181)	168 ± 9.4 (152–182)	168 ± 9.4 (152–183)	170 ± 8.5 (155–183)
BMI (kg/m^2)	27.5 ± 4.5 (21.3–35.7)	30.0 ± 5.9 (22.2–41.5)	29.3 ± 4.9 (22.4–37.9)	28.2 ± 4.1 (22.0–35.4)	25.9 ± 3.3 (20.9–31.5)
Hazard ratios (95% CI)[b]					
Model a	–	6.56 (4.32–9.97)	3.84 (2.37–6.20)	1.88 (1.16–3.04)	Ref.
Model b	–	5.44 (3.11–9.53)	3.44 (2.00–5.93)	1.84 (1.11–3.04)	Ref.
Follow up (median, range)	6.3 (0.1–13.9)	4.7 (0.04–13.1)	5.4 (0.04–13.2)	6.4 (0.09–13.2)	6.1 (0.09–13.5)
Events (n, %)	159 (7.9)	60 (19.2)	32 (13.1)	32 (6.7)	35 (3.6)

[a]$p < 0.001$ for comparisons among the four ranges of SRT score; [b]$p < 0.05$ for comparisons among the four ranges of SRT score.Model a, unadjusted; Model b, adjusted by age, sex, and BMI. Events: number of deaths.

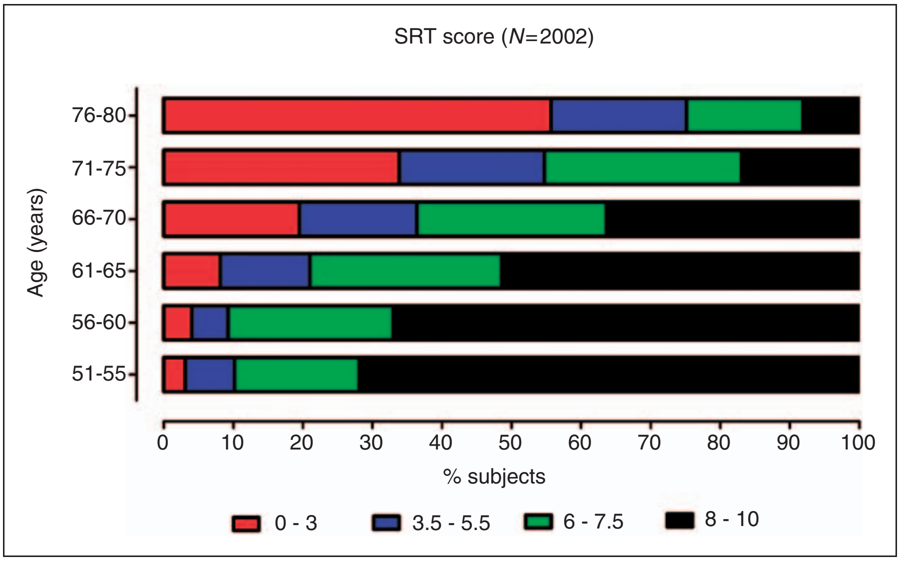

Figure 1. Distribution of SRT scores according to age ranges.

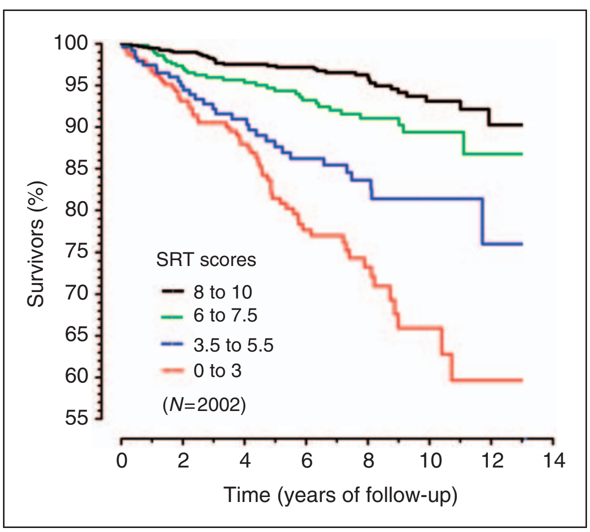

Figure 2. Kaplan-Maier survival analysis for four ranges of SRT scoring in subjects aged 51–80 years.

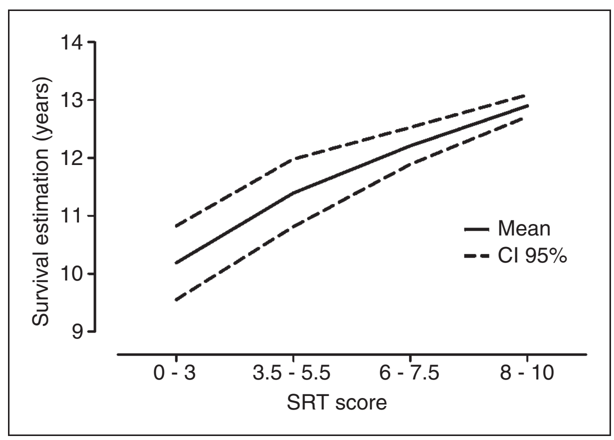

Figure 3. Survival estimation (years) for subjects aged 51 to 80 years based on SRT scores, Curves are based in Cox model and were adjusted for age, gender, and BMI.

related physical fitness or function tests that assess the ability to rise, such as the 'Get-up and Go'[25] and its variations,[26] the SRT can be applied with no equipment and minimal space. Moreover, the commonly used chair-to-stand methods tend to be influenced by the height of the chair or by the degree to which armrest support is available,[27] which interfere with the standardization of the tests and the interpretation of the results.

In a recent study, the gait speed test was shown to discriminate mortality in elderly community-dwelling subjects (minimal age 65 years; mean age 73.5 years; 5% of the sample aged >85 years);[11] however, for subjects aged between 51 and 65 years, this test has very poor discriminatory power. In contrast, our results indicate that SRT scoring is quite useful for discriminating musculoskeletal fitness in a different age range (51–80 years). Moreover, in contrast to the gait speed test, SRT requires neither timing nor a corridor to walk, thus minimizing some constraints that could limit its clinical use. By offering 21 possible scores covering a wide spectrum of musculoskeletal fitness profiles, SRT scoring allows sufficient discrimination of performance capabilities, as shown in Figure 1. Thus, as compared to other approaches to functional testing, the SRT does not require specific equipment and is safe, easy to apply in a short time period (<2 minutes), and reliably scored. In our clinical practice, the SRT has been shown to be useful and practical for application to a large spectrum of populations, ranging from pediatric to geriatric.[19,20,22]

We considered participants who achieved minimum partial scores of 4 in sitting and rising from the floor (SRT scores 8–10) to have preserved functional independence regardless of age. The ability to achieve a high SRT score could reflect the capacity to successfully perform a wide range of activities of daily living, such as bending over to pick up a newspaper or a pair of glasses lying under the bed or table. Moreover, a high SRT score likely indicates a reduced risk of falls.[28] It is also noteworthy that during the application of SRT in our centre over a 14-year period, there have been no adverse events, reflecting a high level of safety associated with this simple assessment tool.

Since our study groups somewhat differed both in age and BMI, we have used an adjusted analysis in order to minimize interference of these variables on the interpretation of the SRT score with mortality. Thus in our cohort, we found that the inability to sit and rise from the floor was related to lower survival, irrespective of age, sex, and BMI. To our knowledge, this is the first study to demonstrate the prognostic value of the SRT. SRT scores <8 (that is, requiring more than one hand or knee support to sit and rise from the floor in a stable way) were associated with 2–5-fold higher death rates over 6 years in men and women aged 51–80. SRT scores in the range 8–10 indicated a particularly low risk of death during the tracking period (Figure 2). Even more relevant is the fact that a 1-point increment in the SRT score was related to a 21% reduction in mortality. The SRT can be considered a simple screening procedure in which a low score largely reflects the degree of impairment in the components of musculoskeletal fitness – mainly those indicating a reduction in muscle strength and/or joint flexibility.

Despite being regularly recommended as part of an exercise programme, there are very few investigations linking flexibility to overall health.[15] One study[29] evaluating overall flexibility (sum of scores obtained from 20 body movements) of 4711 participants from 5 to 91 years of age confirmed Cureton's classic principle related to the reduction in overall mobility levels with aging.[24] Interestingly, using a more limited flexibility assessment tool, the sit-and-reach test, poor trunk flexibility has been suggested to be a predictor of arterial stiffness.[30] It is reasonable to believe that loss of mobility would adversely influence the ability to sit and to rise from the floor, and therefore results in a lower SRT score; while this is intuitive, this hypothesis requires confirmation.

Regarding muscular fitness, it is clear that muscle wasting and sarcopenia are physiologic attributes closely related to the aging process[31,32] and likely contribute to the muscle strength decrement in older adults.[33] The primary musculoskeletal changes that occur with aging include decreases in muscle mass, reductions in the number, and size of type II fibres, as well as a reduced number of motor units.[31] These changes may lead to impairment in muscle strength determined by maximum voluntary contraction,[34] which has been associated with an increased fall risk in the elderly.[8] The loss of strength with aging appears to begin at about 35 years of age.[35] As previously stated, lack of strength and/or muscle power has also been associated with poor survival.[10,36] Thus, while not directly assessing muscle power, the SRT may reflect this metric without the need for a cumbersome test that would not be suitable for some older subjects. Evidence demonstrates that the indices of functional status in the elderly are strongly related to lower limb muscle power and strength,[37] suggesting the potential use of the SRT as a functional assessment tool in elderly subjects.

There are some limitations to our study. It is possible that some results were negatively influenced by subclinical degenerative changes or recent injuries that were either not reported or identified in the medical history or physical exam prior to the SRT. We were unable to control for physical activity patterns, but it no doubt varied considerably. While it is highly likely that activity level influenced SRT scores, it is unclear whether this influenced the external validity of our data. Our sample was primarily derived from Caucasian subjects, typically from a high socioeconomic status. Thus, it is possible that the results could be different in other populations with more diverse cultural, morphological, or physical activity patterns or other characteristics. We were unable to quantify other health outcomes, such as estimates of quality of life or ability to carry out daily activities. In addition, we could not determine specific causes of mortality. Since it is well established that properly designed exercise programmes improve musculoskeletal[38] and cardiorespiratory[39] fitness, future studies are needed in order to identify the effect of exercise interventions on SRT scores. Studies are also needed to characterize the association between changes in SRT performance and health-related quality of life and other relevant health outcomes.

In conclusion, a low score on a simple functional assessment tool, the SRT, was associated with >6-fold higher all-cause mortality in men and women. The SRT therefore may be a useful tool for screening, functionally classifying, and risk stratifying large samples of subjects.

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References

1. Cohen JE. Human population: the next half century. *Science* 2003; 302: 1172–1175.
2. Hunt DR, Rowlands BJ and Johnston D. Hand grip strength – a simple prognostic indicator in surgical patients. *J Parenter Enteral Nutr* 1985; 9: 701–704.
3. Nauman J, Janszky I, Vatten LJ, et al. Temporal changes in resting heart rate and deaths from ischemic heart disease. *JAMA* 2011; 306: 2579–2587.
4. Kokkinos P, Myers J, Doumas M, et al. Heart rate recovery, exercise capacity, and mortality risk in male veterans. *Eur J Prev Cardiol* 2012; 19: 177–184.
5. Kokkinos P, Myers J, Faselis C, et al. Exercise capacity and mortality in older men: a 20-year follow-up study. *Circulation* 2010; 122: 790–797.
6. Myers J, Prakash M, Froelicher V, et al. Exercise capacity and mortality among men referred for exercise testing. *N Engl J Med* 2002; 346: 793–801.
7. Di Iorio A, Abate M, Di Renzo D, et al. Sarcopenia: age-related skeletal muscle changes from determinants to physical disability. *Int J Immunopathol Pharmacol* 2006; 19: 703–719.
8. Moreland JD, Richardson JA, Goldsmith CH, et al. Muscle weakness and falls in older adults: a systematic review and meta-analysis. *J Am Geriatr Soc* 2004; 52: 1121–1129.
9. Rantanen T, Harris T, Leveille SG, et al. Muscle strength and body mass index as long-term predictors of mortality in initially healthy men. *J Gerontol A Biol Sci Med Sci* 2000; 55: M168–M173.
10. Ruiz JR, Sui X, Lobelo F, et al. Association between muscular strength and mortality in men: prospective cohort study. *BMJ* 2008; 337: 92–95.
11. Studenski S, Perera S, Patel K, et al. Gait speed and survival in older adults. *JAMA* 2011; 305: 50–58.
12. Elbaz A, Sabia S, Brunner E, et al. Association of walking speed in late midlife with mortality: results from the Whitehall II cohort study. *Age (Dordr)* 2012 (Epub ahead of print). DOI: 10.1007/s11357-012-9387-9.
13. Alexander NB, Ulbrich J, Raheja A, et al. Rising from the floor in older adults. *J Am Geriatr Soc* 1997; 45: 564–569.
14. Riley PO, Krebs DE and Popat RA. Biomechanical analysis of failed sit-to-stand. *IEEE Trans Rehabil Eng* 1997; 5: 353–359.
15. Garber CE, Blissmer B, Deschenes MR, et al. American College of Sports Medicine position stand. Quantity and quality of exercise for developing and maintaining cardiorespiratory, musculoskeletal, and neuromotor fitness in apparently healthy adults: guidance for prescribing exercise. *Med Sci Sports Exerc* 2011; 43: 1334–1359.
16. Roorda LD, Roebroeck ME, Lankhorst GJ, et al. Measuring functional limitations in rising and sitting down: development of a questionnaire. *Arch Phys Med Rehabil* 1996; 77: 663–669.
17. Araújo CGS. Teste de sentar-levantar: apresentação de um procedimento para avaliação em Medicina do Exercício e do Esporte. *Rev Bras Med Esporte* 1999; 5: 179–182.
18. Lira VA and Araújo CGS. Teste de sentar-levantar: estudos de fidedignidade. *Rev Bras Ciên e Mov* 2000; 8: 11–20.
19. Araújo CGS and Chaves CPG. Prolapso da valva mitral em mulheres adultas: características clínicas, fisiológicas e cineantropométricas. *Rev SBC/RJ* 2007; 20: 112–120.
20. Araújo DSMS and Araújo CGS. Autopercepção das variáveis da aptidão física. *Rev Bras Med Esporte* 2002; 8: 37–49.
21. Brito LBB, Araújo DSMS and Araújo CGS. Does flexibility influence the ability to sit and rise from the floor? *Am J Phys Med Rehabil* 2012 (Epub ahead of print). DOI: 10.1097/PHM.0b013e3182744203.
22. Ricardo DR and Araújo CGS. Teste de sentar-levantar: influência do excesso de peso corporal em adultos. *Rev Bras Med Esporte* 2001; 7: 45–52.
23. Kaminsky LA and American College of Sports Medicine. *ACSM's health-related physical fitness assessment manual*, 3rd edn. Philadelphia: Wolters Kluwer/Lippincott Williams & Wilkins Health, 2010.
24. Cureton TK. Flexibility as an aspect of physical fitness. *Res Quart* 1941; 12: 381–390.
25. Mathias S, Nayak US and Isaacs B. Balance in elderly patients: the 'get-up and go' test. *Arch Phys Med Rehabil* 1986; 67: 387–389.
26. Wall JC, Bell C, Campbell S, et al. The Timed Get-up-and-Go test revisited: measurement of the component tasks. *J Rehabil Res Dev* 2000; 37: 109–113.
27. Janssen WG, Bussmann HB and Stam HJ. Determinants of the sit-to-stand movement: a review. *Phys Ther* 2002; 82: 866–879.
28. Bergland A and Wyller TB. Risk factors for serious fall related injury in elderly women living at home. *Inj Prev* 2004; 10: 308–313.
29. Araújo CGS. Flexibility assessment: normative values for flexitest from 5 to 91 years of age. *Arq Bras Cardiol* 2008; 90: 280–287.
30. Yamamoto K, Kawano H, Gando Y, et al. Poor trunk flexibility is associated with arterial stiffening. *Am J Physiol Heart Circ Physiol* 2009; 297: H1314–H1318.
31. Frontera WR, Suh D, Krivickas LS, et al. Skeletal muscle fiber quality in older men and women. *Am J Physiol Cell Physiol* 2000; 279: C611–C618.
32. Rantanen T, Guralnik JM, Sakari-Rantala R, et al. Disability, physical activity, and muscle strength in older women: the Women's Health and Aging Study. *Arch Phys Med Rehabil* 1999; 80: 130–135.
33. Fiatarone MA, Marks EC, Ryan ND, et al. High-intensity strength training in nonagenarians. Effects on skeletal muscle. *JAMA* 1990; 263: 3029–3034.
34. McDonagh MJ, White MJ and Davies CT. Different effects of ageing on the mechanical properties of human arm and leg muscles. *Gerontology* 1984; 30: 49–54.

35. Vianna LC, Oliveira RB and Araújo CGS. Age-related decline in handgrip strength differs according to gender. *J Strength Cond Res* 2007; 21: 1310–1314.
36. Artero EG, Lee DC, Ruiz JR, et al. A prospective study of muscular strength and all-cause mortality in men with hypertension. *J Am Coll Cardiol* 2011; 57: 1831–1837.
37. Hernandez ME, Goldberg A and Alexander NB. Decreased muscle strength relates to self-reported stooping, crouching, or kneeling difficulty in older adults. *Phys Ther* 2010; 90: 67–74.
38. Katula JA, Rejeski WJ and Marsh AP. Enhancing quality of life in older adults: a comparison of muscular strength and power training. *Health Qual Life Outcomes* 2008; 6: 45.
39. Blair SN, Kohl HW, Barlow CE, et al. Changes in physical fitness and all-cause mortality. A prospective study of healthy and unhealthy men. *JAMA* 1995; 273: 1093–1098.