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Criterion-referenced fitness standards for predicting physical independence into later life

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ABSTRACT

Objectives: The aim of the current study was to develop sex and age-adjusted criterion-referenced fitness standards to predict independent physical functioning into later life.
Design: Cross-sectional.
Setting: National Survey of Physical Fitness and Physical Activity, Portugal.
Participants: A national representative sample of 3074 non-institutionalized older adults (65–84 years).
Measurements: Projected capacity for physical independence was assessed by the Composite Physical Function (CPF) scale, and physical fitness was assessed using the *Senior Fitness Test* battery. ROC analyses were used to evaluate the classification accuracy of physical fitness components, and determine the best cutoff values of functional fitness to predict loss of independence. Stepwise multivariate logistic regression was used to identify sex and age category fitness components that were predictors of independence with follow-up ROC analysis to verify the model's discriminative capability.
Results: ROC curve analysis showed that the fitness tests were good in diagnosing physical independence (AUC > 0.7). Logistic regression models demonstrated that different fitness components should be targeted according to age and sex, but with an emphasis on aerobic endurance and agility/dynamic balance. Overall, models provided higher AUC (males: 0.79–0.86; females: 0.73–0.85) when comparing the best fitness tests for each sex and age category. The sensitivity of newly developed models ranged from 80.5 to 87.7 in males and from 68.2 to 86.3 in females, while the specificity ranged from 62.1 to 73.8 in males and between 58.2 and 82.9 in females.
Conclusion: The *Senior Fitness Test* provides a good field tool that allows the identification of fitness levels that older adults need to achieve to be physically independent later in life, and permits the accurate planning and implementation of exercise-based interventions for older adults.

1. Introduction

Age-related physiological changes affect a wide range of tissues, organ systems, and functions, which, cumulatively, can impact the preservation of physical independence (Chodzko-Zajko et al., 2009), resulting in a reduction in quality of life, life expectancy, and elevated long-term health-care costs (Paterson and Warburton, 2010). About 20% to 30% of community-dwelling older adults report disability in mobility, and impairments in instrumental and basic activities of daily living, such as, household tasks and basic self-care (Fried et al., 2004).

The 12-item Composite Physical Functional scale allows for the identification of older adults who are at risk for losing physical independence later in life (Rikli and Jones, 1998, 2013). The scale discriminates across a wide range of functional abilities and has age-adjusted norms that allow for the early prediction of independent functioning in later years (90 years old) (Rikli and Jones, 2013). This novel approach represents a new early diagnostic tool to identify older adults at risk for later functional impairment.

Maintaining physical fitness is a key factor in preserving mobility and physical independence later in life (Paterson et al., 2007). It is of extreme importance that older adults preserve a minimum level of physical fitness necessary to perform common everyday activities without additional assistance; this includes the ability to independently perform daily tasks such as, simple housework, lifting and carrying objects, negotiating steps, and walking far enough to do one's own shopping and errands (Rikli and Jones, 2013). Several physical fitness components including aerobic endurance, muscle strength, agility, gait speed, or dynamic balance have been shown to be significant determinants of physical independence (den Ouden et al., 2013a,b; Kuo et al., 2006; Paterson et al., 2004, 2007; Wennie Huang et al., 2010).

The *Senior Fitness Test* (Rikli and Jones, 1999, 2013) is commonly used to assess physical fitness in older adults as it represents an easy-

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to-use field test battery that allows for the assessment of physical fitness components that are important for maintaining independent functioning. Recently, Rikli and Jones (2013) have developed criterion standards for the *Senior Fitness Test* in North American older adults that estimate the minimum fitness level necessary to maintain physical independence in later years. However, it is unclear to what degree these standards can be generalized to other populations.

Structured physical activity programs reduce major mobility disability among older adults (Pahor et al., 2014) and identifying the physical fitness level that a person needs to achieve in order to be physically independent later in life is essential if we are to develop successful physical activity interventions that are effective in preserving physical independence. Therefore, the aim of the current study was to develop sex and age-adjusted criterion-referenced physical fitness standards to predict physically independent functioning in old age (90 years old).

2. Materials and methods

2.1. Design and subjects

A total of 3074 participants were considered for data analysis (1021 males and 2053 females). Data for the present study were derived from a cross-sectional representative sample of community-dwelling Portuguese older adults aged 65 and over, who were sampled from five regions of mainland Portugal (Marques et al., 2013). Study participants were volunteers who were recruited from community senior centers, public and private institutions, sport clubs, and at sports and social events. The study was carried out in full compliance with the Helsinki Declaration and approved by the local ethics committee. All subjects read and signed the consent form before the testing procedures, and completed a questionnaire assessing basic demographic information. Sample characteristics are presented in Table 1.

Table 1
Characteristics of the study population.

Variable	All participants (n = 3074)	Females (n = 2053)	Males (n = 1021)
Age (years)	73.13 ± 5.49	73.03 ± 5.45	73.33 ± 5.57
Age categories, n/%			
65–69 (years)	966/31.4	655/31.9	311/30.5
70–74 (years)	928/30.2	633/30.8	295/28.9
75–79 (years)	652/21.2	428/20.8	224/21.9
80–84 (years)	528/17.2	337/16.4	191/18.7
Education, n/%			
Illiterate	151/4.9	109/5.3	42/4.1
Under 5th grade	2197/71.5	1503/73.2	694/68.0[c]
5–9 grade	453 /14.7	284/13.8	169/16.6
High school	161/5.2	93/4.5	68/6.7[c]
Above high school	112/3.6	64/3.1	48/4.7[c]
Body mass index (kg/m^2)	28.15 ± 4.34	28.47 ± 4.55	27.51 ± 3.79[c]
Waist circumference (cm)	95.59 ± 11.53	94.10 ± 11.67	98.59 ± 10.62[c]
Functional fitness			
Chair stand (reps/30 s)	13.9 ± 5.5	13.7 ± 5.6	14.1 ± 5.4
Arm curl (reps/30 s)	16.6 ± 6.0	16.3 ± 5.9	17.3 ± 5.9[c]
6-minute walk test (m)	426.1 ± 157.4	411.4 ± 151.7	455.9 ± 164.5[c]
8-foot up-&-go (s)	8.84 ± 6.87	9.23 ± 7.36	8.06 ± 5.68[c]
Moderate functioning ability[a], n/%	2261/73.6	1437/70.0	824/80.7[c]
Chronic disease[b], n/% yes	966/31.4	619/30.2	347/34.0[c]
History of falls, n/%	1160/37.7	898/43.7	262/25.7[c]
High blood pressure, n/%	1490/48.5	1035/50.4	455/44.6[c]
Current Smoker, n/%	98/3.2	29/1.4	69/6.8[c]
Participation in PA, n/% yes	2181/70.9	1521/74.1	660/64.6[c]

Abbreviations: CPF, Composite Physical Function; PA, physical activity.
[a] As determined by Age-Adjusted Scores on the Composite Physical Function scale.
[b] Heart conditions, diabetes, cancer, or asthma.
[c] Significant differences between sexes ($p < 0.05$).

2.2. Outcome measures

2.2.1. Physical independence

Physical independence was assessed through self-report using the 12-item Composite Physical Function (CPF) scale (Rikli and Jones, 1998). The age-adjusted scoring option was used to define the level of functioning that predicts physical independence at age 90, rather than current ability to function independently was used in this study The age adjusted scoring reflects an anticipated decline in functional ability of 10–15% (Rikli and Jones, 2013), which is close to the decline observed for a range of functional fitness tests in the Portuguese older adult population (Marques et al., 2013). Accordingly, physical independence was dichotomized as: low (at risk) functioning and moderate functioning.

2.2.2. Physical fitness

Physical fitness was assessed using the *Senior Fitness Test*, a measurement battery for assessing fitness parameters in older adults developed by Rikli and Jones (1999). Physical fitness parameters selected included lower and upper body strength, agility/dynamic balance and aerobic endurance. The items were evaluated by the following tests: chair stand (repetitions/30 s), arm curl: women 5 lb; men 8 lb (repetitions/30 s), 8-foot up-and-go (s), and the 6-minute walk test (m).

2.2.3. General information

Socio-demographic variables were included for the purpose of describing population characteristics. A questionnaire was administered by a trained interviewer to reduce the likelihood of misinterpretation of items and/or skipping of questions. Variables included were: age, sex, educational attainment (used as a marker of socioeconomic status), fall history, chronic diseases history (heart conditions, diabetes, cancer, or asthma), acknowledged hypertension, medication use, current physical activity participation, and current smoking habits. Smoking was dichotomized into two categories: smokers and nonsmokers. We categorized education into categories of illiterate, under 5th grade education, 5th to 9th grade education, high school education, and beyond high school education. We also included objectively measured body mass index and waist circumference as indicators of body size, as previously described (Marques et al., 2013).

2.3. Data analysis

Statistical analyses were performed using IBM SPSS® Statistics version 20 for Windows (SPSS Inc., an IBM Company, Chicago, IL, USA) and MedCalc Statistical Software version 11.1.1.0 (Mariakerke, Belgium), with a significance level of 0.05. Descriptive statistics were calculated for all outcome measurements.

Chi-squared tests were used to test for differences between-groups for categorical variables or for differences in proportions. The Kolmogorov–Smirnov statistic was used to test the normality and comparisons between sexes were performed using independent sample t-tests or the Mann–Whitney test (nonparametric alternative).

Subjects were divided into four age categories: 65–69 years, 70–74 years, 75–79 years, and 80–84 years. Receiver operating characteristic (ROC) curves were used to determine optimal cutoff values, determined by the point of convergence of sensitivity and specificity (i.e., by simultaneously maximizing the two) for each sex and age category. The areas under the ROC curve (AUC) were calculated to determine the overall accuracy of physical fitness components in identifying true positive participants (projected moderate functioning).

Multivariate logistic regression analysis was conducted to develop a global classification model (by sex and age categories) that allows for the identification of the fitness determinants for each age and sex that predict independent functioning (moderate functioning in later years). A stepwise backward (likelihood ratio) method was used to retain the variables (fitness tests) that were significant in the final model. The model's discriminative capability was determined with ROC analysis.