Validation of the flexibility component of the AAHPERD Functional Fitness Assessment in Brazilian older adults

Validação do teste de flexibilidade da aahperd para idosos brasileiros

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Abstract – Flexibility is an indispensable component of the ability to carry out activities of daily living. The flexibility test proposed by the American Alliance for Health, Physical Education, Recreation and Dance (AAHPERD) is easy to administer and requires little equipment. Thus, the present study sought to ascertain the validity of the flexibility component of the AAHPERD Functional Fitness Assessment in Brazilian older adults. The study sample comprised 330 subjects (278 women and 52 men), with a mean age of 69.45 ± 6.19 years, who took part in a physical activity program for older adults. The Leighton Flexometer was chosen as a comparator instrument. The Pearson correlation coefficient (r), simple linear regression, and Bland-Altman plots were used for statistical analysis. The correlation between AAHPERD Functional Fitness Assessment and Leighton flexometer findings was r = 0.93 and r = 0.86 (p <0.01) for males and females respectively. The AAHPERD Functional Fitness Assessment explained 74.3% of variance in Leighton flexometer findings in female participants and 86.6% in male participants. We conclude that the flexibility component of the AAHPERD Functional Fitness Assessment provides adequate estimation of lumbar and hip flexibility in Brazilian older adults.

Key words: Flexibility; Pliability; Range of Motion; Validation Studies.

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Resumo – *A flexibilidade é um componente indispensável para realizar as atividades da vida diária. O teste de flexibilidade proposto pela American Alliance for Health, Physical Education, Recreation and Dance (AAHPERD) é de fácil aplicação e necessita de poucos equipamentos. Assim, o presente estudo pretende verificar indicadores de validade do teste de flexibilidade da bateria de testes da AAHPERD para os idosos brasileiros. A amostra foi composta de 330 idosos (278 mulheres e 52 homens), com média de idade de 69,45 (± 6,19) anos, participantes do programa de atividade física para a Terceira Idade. O instrumento considerado como padrão de referência foi o Flexômetro de Leighton. Empregaram-se o Coeficiente de Correlação de Pearson (r), a regressão linear simples e a plotagem de gráficos Bland-Altman. Os resultados de correlação obtidos entre o teste da bateria AAHPERD e o flexômetro de Leighton, foram de r = 0,93 e r = 0,86 (p<0,01), para homens e mulheres, respectivamente. O teste da bateria AAHPERD foi capaz de explicar a variação do flexômetro de Leighton FLEXO em 74,3% no sexo feminino e 86,6% no masculino. Pode-se concluir que o teste de flexibilidade da AAHPERD reflete adequada avaliação dos níveis de flexibilidade da região lombar e do quadril em idosos brasileiros.*

Palavras-chave: Amplitude de Movimento Articular; Estudos de Validação; Flexibilidade; Idoso.

INTRODUCTION

The process of aging is observed in all living beings. With aging comes physical decline, expressed as a reduction in physical qualities throughout the life course due to the influence of a number of variables, such as genetic factors, physical damage accrued over time, lifestyle habits, and psychoemotional changes[1].

Of the various physical qualities, strength, aerobic endurance, balance, and flexibility are directly associated with the health of older adults[2]. Approximately 8 to 10 centimeters of lower back and hip flexibility are lost per decade from the age of 60[3]. This reduction in flexibility may be caused by aging, and is essentially due to decreased muscle elasticity and deterioration of cartilage, ligament, tendon, synovial fluid, and muscle tissue. Specific tests are available for measurement of flexibility. The trunk flexion test is commonly used to assess the flexibility of the lower back and hamstrings, as potential dysfunctions and injuries may affect flexibility. In addition to muscle injuries, biomechanical changes may also lead to patellofemoral dysfunction, osteitis pubis, lower back pain, tendinitis, and postural issues[4].

Several instruments and procedures have been developed for direct and indirect measurement of flexibility. Those most widely used include goniometers, the Wells-Dillon flexometer, the Leighton flexometer, and the Flexitest. The Leighton flexometer is a highly accurate device and is regarded as a good reference standard for flexibility measurement. It is watch-shaped and has a strap that attaches to the segment being evaluated. The Leighton flexometer is a gravity-type device and can be used to measure the range of motion of several joints, during a variety of joint actions, whether in a healthcare setting, in rehabilitation, or in athletes[5]. Its main limitations are the high cost of the device and the time required for measurement.

Of the various field tests available for flexibility assessment, the sit-and-reach test[6] is one of the most widely known and used[7-9]. The objective is to measure lower back and hamstring flexibility[9]. The American Alliance for Health, Physical Education, Recreation and Dance (AAHPERD) developed a flexibility assessment based on the sit-and-reach test. Flexibility is the first component measured in the AAHPERD Functional Fitness Assessment, by means of a user-friendly, dynamic procedure that can be performed with affordable and easily accessible equipment. However, a search of the Brazilian literature yielded no assessments of the validity of this test in older adults.

Within this context, the objective of the present study was to ascertain the concurrent validity of the flexibility component of the AAHPERD Functional Fitness Assessment in a sample of Brazilian older adults.

METHODS

The present study was approved by the Universidade Federal de Santa Catarina (UFSC) Human Subject Research Ethics Committee (judgment no. 050/05). All participants were informed of the objectives of the study and provided written informed consent.

Study Population and Sample

The population of this study consisted of the participants of a physical activity program for senior citizens offered by the UFSC Sports Center. As of 2007, the program served 515 older adults of both genders, ranging in age from 55 to 91 years, with 480 of the participants being 60 or older.

A deliberate sampling strategy was used. The following criteria for inclusion were adopted: age >60 years; regular engagement in physical activity of at least 6 months' duration; and completion of all flexibility tests of the AAHPERD Functional Fitness Assessment, as well as assessment with the Leighton flexometer. The study sample comprised 330 older adults (278 female, 52 male) with a mean age of 69.45 ± 6.19 years.

Instruments

As many other universities, UFSC uses the AAHPERD Functional Fitness Assessment to evaluate functional ability in older adults. The reliability of this test battery was confirmed in a 1990 report of its internal consistency for flexibility, strength, coordination, and balance tests. The internal consistency of the flexibility component[10]. was r >0.90, and the stability coefficient, r=0.91.

The Leighton flexometer was used as the reference standard for validation of the AAHPERD Functional Fitness Assessment in Brazilian older adults.

The following sections describe the instruments employed in the study.

1) Flexibility component of the AAHPERD Functional Fitness Assessment[10] (validation target)
The test setup consists of a 20-inch (50.8 cm) length of masking tape placed on the floor and

a metal yardstick taped to the floor perpendicular to the masking tape line, with the 25-inch (63.5-cm) mark directly over the tape line. Two equidistant marks are drawn on the line, each 6 inches (15.2 cm) away from the center of the yardstick. The participant sits on the floor, barefoot, legs extended, with feet 12 inches (30.4 cm) apart, the toes pointing upward, and the heels centered against the tape line. The zero point of the yardstick points toward the subject. The subject then places his or her hands one on top of the other and slides the hands along the yardstick as far as possible, holding the final position for 2 seconds. During the test, the examiner holds the subject's knee down so as to prevent flexion. The participant is given two practice trials, followed by two test trials. The best of the two test trials is recorded as the final score. The reproducibility of this test in adults aged >60 years has been reported as 0.97 and 0.98 for male and female subjects respectively[11].

2) Leighton Flexometer flexibility testing5 (FLEXO) The reference ("gold") standard for flexibility assessment employed in this study was the Leighton Flexometer Flexibility Test[5]. This test can be used to measure the ranges of motion of a variety of joints. The instrument is watch-shaped, with the pointer operating freely under the control of gravity. The zero points of the two dials of the flexometer coincide when it is perfectly horizontal and at rest. The device is strapped to the subject, who then moves the joint being examined to its full range of motion, which is then recorded in degrees[5]. For the purposes of this study, the motion of interest was hip flexion.

Data collection

Tests were performed in December 2007, at the UFSC Sports Center Gymnasium, by a team of previously trained examiners.

AAHPERD Functional Fitness Assessment and Leighton Flexometer Flexibility Test data were collected simultaneously by two examiners. The recommended protocols for both tests were followed[5,10].

Statistical analysis

Data were organized in Microsoft Office Excel spreadsheets and analyzed with the SPSS 13.0® for Windows software package. All statistical analyses were stratified by gender.

Descriptive analysis was used to characterize the sample profile and the Student t-test for independent samples was used to detect any gender differences. Coefficients of variation were calculated to ascertain the variability of data. The Pearson correlation coefficient (r) was used to evaluate the association between the flexibility component of the AAHPERD Functional Fitness Assessment and the gold-standard comparator test. Regression equations for prediction of Leighton flexometer measurement values using the AAHPERD Functional Fitness Assessment flexibility test were calculated, using simple linear regression analysis coefficients of determination (R^2). Bland-Altman plots were used to analyze the concurrent validity of the flexibility test of the AAHPERD Functional Fitness Assessment[12]. To do so, we first had to calculate Z-scores for the results of both tests, as each uses a different unit of measurement (the Leighton flexometer measures in degrees, whereas the AAHPERD flexibility test yields a result in centimeters). Z-scores were thus used to eliminate the effect of the unit of measurement and enable construction of the Bland-Altman plot, and were calculated as follows:

$Z = (X - \mu) / SD$, where Z is the Z-score; X, the raw score; μ, the mean of the study population; and SD. the standard deviation of the study population. The significance level was set at 5% for all analyses.

RESULTS

The sample comprised 330 older adults: 278 women (84.24%) and 52 men (15.76%). Age ranged between 60 and 91 years. There were no statistically significant differences between age and gender (p=0.26).

Female participants had superior flexibility to male subjects in all tests (Table 1). The more consistent of the two tests analyzed was the AAHPERD Functional Fitness Assessment, which had the lowest coefficients of variation in female and male subjects alike (19.8% and 27.5% respectively).

Table 1. Means, standard deviations, and coefficients of variation of flexibility test results, stratified by gender.

Test	Female		Male	
	μ (95%CI)	CV	μ (95%CI)	CV
FLEXO (degrees)	33.7 (32.3-35.0)*	33.8%	25.1 (21.6-28.4)	48.2%
AAHPERD (cm)	58.1 (56.7-59.4)*	19.8%	47.2 (43.5-50.8)	27.5%

FLEXO, Leighton Flexometer Flexibility Test; AAHPERD, flexibility component of the AAHPERD Functional Fitness Assessment; μ, mean; 95%CI, 95% confidence interval; CV, coefficient of variation.
*p<0.05 (between-gender difference, t-test for independent samples)

The relationship between flexibility test variables in the female subset of the sample is shown as a scatterplot in Figure 1a. Each point on the plot corresponds to the ordered pair of correlated variables measured in each subject of the study. Our findings revealed a significant, positive association between Leighton flexometer test results and AAHPERD Functional Fitness Assessment results (r=0.86, p<0.01). Figure 1b illustrates the concurrent validity of the flexibility component of the AAHPERD Functional Fitness Assessment as compared to the Leighton flexometer test. Analysis of the plot shows that most observations were within the 95% limit of agreement (±1.96 SD), and that the mean difference between Z-scores for both tests was zero.

In turn, the relationship between flexibility test variables in the male subset of the sample is shown as a scatterplot in Figure 2a. Again, our findings revealed a significant, positive association between Leighton flexometer test results and AAHPERD Functional Fitness Assessment results (r=0.93, p<0.01). Figure 2b illustrates the concurrent validity of the flexibility component of the AAHPERD Functional Fitness Assessment as compared to the Leighton flexometer test. Analysis of the Bland-Altman plot shows that most observations were within the 95% limit of agreement (±1.96 SD), and that the mean difference between Z-scores for both tests was -0.01.

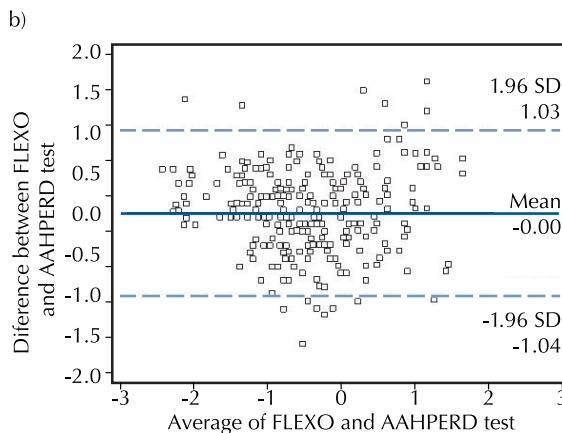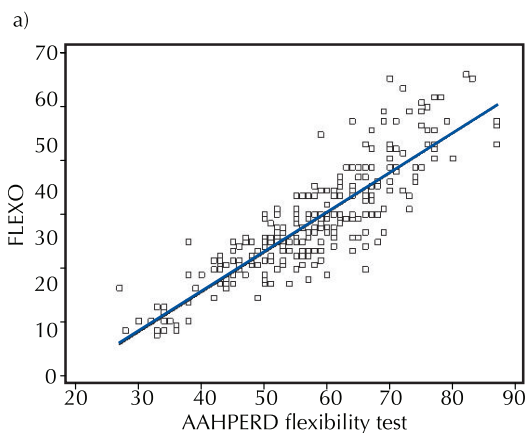Table 2 shows the regression equations for estimation of Leighton flexometer test results from

Female

Figure 1. Scatterplot (Figure 1a) of Leighton flexometer (FLEXO) and AAHPERD flexibility test results in the female subset of the study sample (r = 0.86, p<0.01). Bland-Altman plot (Figure 1b) of the concurrent validity for estimation of Leighton flexometer results from AAHPERD flexibility test findings. The upper and lower dashed lines represent the limits of agreement (mean ± 1.96 SD); the solid line represents the average difference between the two methods analyzed.
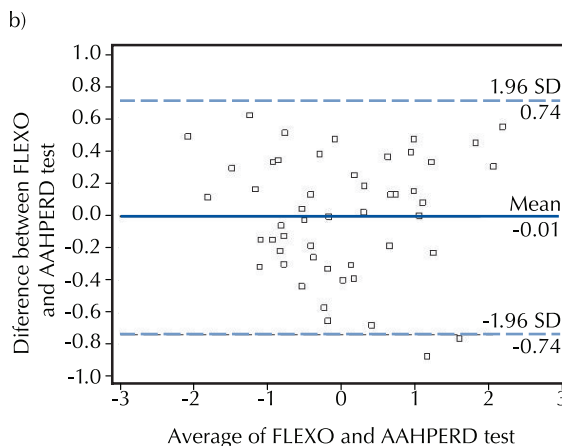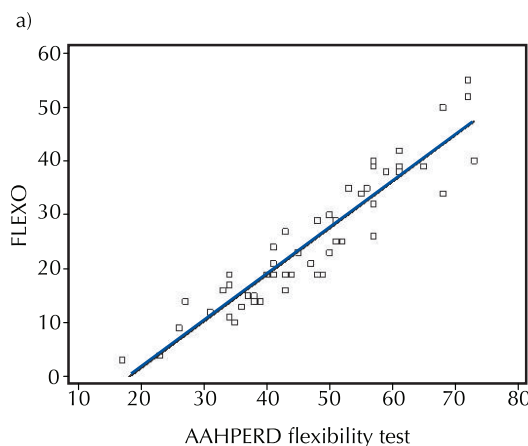
Male

Figure 2. Scatterplot (Figure 2a) of Leighton flexometer (FLEXO) and AAHPERD flexibility test results in the male subset of the study sample (r = 0.93, p<0.01). Bland-Altman plot (Figure 2b) of the concurrent validity for estimation of Leighton flexometer results from AAHPERD flexibility test findings. The upper and lower dashed lines represent the limits of agreement (mean ± 1.96 SD); the solid line represents the average difference between the two methods analyzed.

AAHPERD flexibility test findings, stratified by gender. In the female subset of the sample, the regression equation was able to explain 74.3% of Leighton flexometer test results, whereas in the male subset of the sample, the equation was able to explain 86.6% of Leighton flexometer measurement values.

Table 2. Linear regression equations for prediction of Leighton flexometer measurements from AAHPERD flexibility test results in Brazilian older adults.

	Regression equation	R^2	p-value
Female	FLEXO= -16.074 + 0.856 x FLEX	74.3%	<0.01
Male	FLEXO= -15.716 + 0.864 x FLEX	86.6%	<0.01

R^2, coefficient of determination; FLEXO, Leighton flexometer test measurement, in degrees; AAHPERD: AAHPERD flexibility test values, in centimeters.

DISCUSSION

The primary finding of this study was that the AAHPERD flexibility test showed satisfactory association and concurrent validity with the Leighton flexometer test in a sample of Brazilian older adults. This result suggests that this easy, quick, and low-cost test could be employed to assess flexibility in the elderly population of Brazil.

The flexibility test component of the AAHPERD Functional Fitness Assessment is based on the original sit-and-reach test developed by Wells and Dillon[6]. Some studies have reported satisfactory reliability and validity on comparison between the sit-and-reach test and other flexibility tests in adolescents[13], adults[14], and older adults[15,16]. Lemmink et al.[15] assessed the concurrent validity of the sit-and-reach test with goniometer-based testing in a sample of Dutch middle-aged and older subjects. The authors found a moderate association ($r = 0.57$) between the sit-and-reach test and the American Academy of Orthopaedic Surgeons-recommended Hamstring Flexibility Test in female participants and a strong association ($r = 0.74$) between the two tests in male participants. Analysis of the original Wells and Dillon sit-and-reach test[6] is outside the purview of the present study. Nevertheless, we found a strong, significant association between the sit-and-reach test and the Leighton Flexometer Flexibility test ($r = 0.84$ in women, 0.91 in men) and the AAHPERD flexibility test ($r = 0.97$ in women, 0.95 in men).

In the present study, the flexibility component of the AAHPERD Functional Fitness Assessment was significantly and strongly associated with Leighton flexometer (FLEXO) test findings, both in

male subjects ($r = 0.93$) and in female participants ($r = 0.86$), which suggests that the AAHPERD test is reliable enough to meet its proposed objectives. Jones et al.[16] investigate the validity of various adaptations of the sit-and-reach test, including the AAHPERD flexibility test[10]. The authors found that, in the study population (a sample of 76 U.S. older adults with a mean age of 70.5 years), the AAHPERD test had correlation coefficients of 0.71 and 0.74 in the female and male subsets of the sample, respectively.

The AAHPERD Functional Fitness Assessment was correlated with physical and cognitive tests in a sample of older Japanese subjects[18]. The authors found good reproducibility ($r = 0.805$) and low construct validity for the social and cognitive, activities of daily living, and intellectual fitness domains ($r = 0.012$, -0.001, and 0.010 respectively).

Jones et al.[16] were the first authors to report concurrent validity of the AAHPERD test in older adults, although they only used Pearson coefficients.

The Pearson correlation coefficient is a measure of linear association between quantitative variables. Coefficients range from -1 to 1, indicating the degree of association between the variables of interest. Traditionally, $r < 0.2/-0.2$ is indicative of very small correlation; 0.2/0.2 to 0.3/-0.3, small correlation; 0.4/-0.4 to 0.69/-0.69, medium correlation; 0.7/-0.7 to 0.89/-0.89, strong correlation; and 0.9/-0.9 to 1/-1, very strong correlation.[19] Therefore, the Pearson coefficient alone is not adequate for assessment of validity between tests, only of association.

The present study evaluated the degree of association between the chosen tests and their concurrent validity by means of Bland-Altman plots[12]. This method of analysis enables assessment of the agreement between two variables (X, Y), as well as evaluation of bias (the extent to which differences shift away from zero), error (dispersion of difference coordinates around the mean), outliers, and trends. According to our findings, there is good agreement between the two tests, as most observations were within the 95% limit of agreement and the average difference between the two methods was zero (in the female subset of the sample) or very close to zero (in the male subset of the sample).

The present study also sought to ascertain the degree of variability of findings from both tests, by means of coefficients of variation. The flexibility test of the AAHPERD Functional Fitness Assessment was less variable than the Leighton flexometer test. Direct measurement-based tests, such as use of the Leighton flexometer, are known

to provide more accurate estimation of flexibility. Therefore, it is very desirable that indirect tests, such as the AAHPERD flexibility tests, exhibit less variability in results than the reference standard, which is indicative of high accuracy of the indirect method. Had the coefficient of variation of the AAHPERD test been higher than that of the Leighton flexometer test, we would have been compelled to evaluate the former for poor accuracy.

The present study has some limitations, including: 1) the impossibility of ascertaining whether subjects indeed tried their best during the AAHPERD flexibility test; and 2) the comparison of two tests that use different units of measurement, which could jeopardize the accuracy of Bland-Altman analysis. On the other hand, calculation of Z-scores enabled concurrent analysis of the chosen tests despite their different units of measurement.

CONCLUSION

We conclude that the flexibility component of the AAHPERD Functional Fitness Assessment was significantly and positively associated with Leighton flexometer measurements in male and female subjects alive. Furthermore, the AAHPERD flexibility test exhibited indicators of satisfactory concurrent validity. Therefore, we consider it adequate for assessment of low back and hip flexibility in Brazilian older adults. In addition, the regression equations proposed herein may be used for estimation of hip flexibility on the basis of a quick, simple, low-cost test—namely, the flexibility test of the AAHPERD Functional Fitness Assessment.

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