Flexitest: inappropriate use of condensed versions*

Claudio Gil Soares de Araújo[1] and Denise Sardinha Mendes Soares de Araújo[2]

ABSTRACT

Background and objectives: Flexibility, defined as the maximal passive mobility of a given joint movement is one of the health-related physical fitness variables, representing an important factor for body and movement performance, either in sports or scenic modalities, where the gracefulness and beauty of movements is relevant. Among the several flexibility measurement and evaluation methods, one of the most used is the Flexitest that includes 20 joint movements graduated between 0 to 4 points. However, some professionals have used condensed versions of only four or six movements empirically selected. The objective of this study is to evaluate the practical and scientific validity of condensed versions use in replacement of the Flexitest full version.

Methods: Flexitest data were used in 3,116 individuals namely: 1,847 men and 1,269 women with ages ranging from 5 to 88 years. From step-by-step progressive regression analyses four and six movements that best estimated the Flexindex (sum of the 20 movements scores) separately for children and adolescents, young adults, adults and aged adults from both genders were selected.

Results: Despite the high determination coefficients obtained in the regression analyses, slightly better for six movements, standard errors of estimate ranged from 2.7 to 3.8 points (3.8 and 3.9, respectively, for men and women with no division by age group), exceeding what is expected as measurement error and similar to what is observed as result of a specific training program.

Conclusion: Except for very specific and unusual situations, the use of condensed Flexitest versions of four or six movements is not appropriate even if specific for age range and gender.

Key words: Flexibility. Evaluation. Physical exercise. Sports. Kinanthropometry.

INTRODUCTION

The gracefulness and beauty of movements of the human body just as seen in a dance exhibition or synchronized swimming primarily depend on the range of motion of body joints. This mobility is represented by flexibility that may be defined as the maximal passive physiological amplitude in a given joint movement[1,2]. Flexibility tends to vary inversely with age and to be higher in women with differences between gender starting to be more relevant from five or six year of age[1-4]. Although some authors consider flexibility as a general characteristic, Dickinson[5] and Harris[6] have already demonstrated in the past that flexibility is specific for each one of the body joint and different movements of the same joint may vary in relative magnitude. While in the recent past discussion on flexibility was aimed at the sports training, more recently it is considered that flexibility is one of the main variables of the health-related physical fitness[1,7-9], in such way that its increase resulting from physical exercise programs may represent improvements on quality of life related to health[10].

Recently, Araújo[1] proposed a classification system of the flexibility tests involving 18 items, emphasizing the possibility of obtaining a global flexibility index or score and the specific and isolated analysis of different movements and joints. The Flexitest[1,2,11-13] is a method for measurement and evaluation of the passive mobility of 20 joint movements (see description of movements in table 1) in which each movement is quantified in an ordinal scale from 0 to 4, involving these two important aspects as allowing concurrently the attainment of a global score called as Flexindex and the individualized and comparative analysis for each one of the 20 movements studied. In addition, the Flexitest is the only method of flexibility assessment that includes the study of the joint mobility variability indexes[14], allowing the identification of homogeneity degree in passive mobility of the several joint movements.

TABLE 1
Numbering and kinesiological description of the Flexitest 20 movements

Movement number	Description
I	Ankle dorsal flexion
II	Ankle plantar flexion
III	Knee flexion
IV	Knee extension
V	Hip flexion
VI	Hip extension
VII	Hip adduction
VIII	Hip abduction
IX	Trunk flexion
X	Trunk side flexion
XI	Trunk extension
XII	Wrist flexion
XIII	Wrist extension
XIV	Elbow flexion
XV	Elbow extension
XVI	Shoulder posterior adduction from 180° of abduction
XVII	Shoulder posterior adduction or extension
XVIII	Shoulder posterior extension
XIX	Shoulder lateral rotation at 90° of shoulder abduction*
XX	Shoulder medial rotation at 90° of shoulder abduction*

* with elbow flexed at 90°

Despite these positive characteristics and their utilization in many of our researches and by other authors'[19,20], some professionals complain about the time spent for the Flexitest application, arguing not to dispose the three or four minutes required for this purpose within their daily reality. Thus, in some situations, the condensed Flexitest versions have been applied or proposed, employing a smaller number of movements. Unfortunately, none of the condensed versions was statistically validated, either through

* Study performed at Exercise Medicine Clinics – Clinimex – Rio de Janeiro, RJ – Brasil.

1. Professor at Graduate Program in Physical Education – Gama Filho University, Coordinator of the Specialization Course in Exercise and Sports Medicine – Estácio de Sá University and Medical-Director of the Exercise Medicine Clinics – Clinimex.

2. Associate Professor at Department of Didactics, Coordinator of the Pedagogy Course for the First Years of the Elementary School and Rio de Janeiro State Federal University – Unirio.

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Correspondence to: Dr. Claudio Gil S. Araújo (cgaraujo@iis. com.br), Clínica de Medicina do Exercício (www.clinimex.com.br), Rua Siqueira Campos, 93/101 – 22031-070 – Rio de Janeiro, RJ – Brazil.

the non-application of the appropriate techniques or through the characteristics of the samples used, either too small, or limited to a narrow age range. Considering our theoretical and practical experience on the Flexitest and the large data availability in our laboratory, it is possible that we have a better opportunity to assess the merit of the condensed versions.

So, the objective of this study was to test the statistical and practical adequacy of the condensed versions use with four and six Flexitest movements in individuals from both genders and wide age range.

METHODS

For this analysis, data from 3,116 individuals (1,847 male and 1,269 female) between 5 and 88 years of age available in the data bank of our laboratory with all Flexitest[1] measurements were retrospectively considered. Most individuals were measured within formal medical-functional evaluation protocols for which the respective consent terms were obtained. A predominance of caucasian individuals and higher socioeconomical level, especially of those with over than 25 years of age, was observed. More details of sample and percentile slopes by gender and age ranges of the Flexitest are available in other publication[1].

TABLE 2
Sampling stratification by age ranges (number of cases)

	Male	Female
Total	1,847	1,269
Children and adolescents (5 to 15 years)	521	459
Young adults (16 to 35 years)	355	302
Adults (36 to 60 years)	669	376
Older adults (61 to 88 years)	302	132

TABLE 3
Step-by-step multiple regression analysis (4 to 6 movements)

Sample	Flexitest movements						r^2	SEE*
Male								
Total	XVI	X	VII	XX			0.906	3.81
	XVI	X	VII	XX	XIX	XII	0.940	3.04
5 to 15 years	IX	XIX	VII	XI			0.762	3.58
	IX	XIX	VII	XI	XX	XIV	0.844	2.88
16 to 35 years	XVIII	X	VII	XX			0.836	3.13
	XVIII	X	VII	XX	II	VIII	0.887	2.58
36 to 60 years	XVII	VII	X	XX			0.838	3.51
	XVII	VII	X	XX	XIII	XIX	0.900	2.76
61 to 88 years	XVIII	IX	VIII	XIX			0.831	3.74
	XVIII	IX	VIII	XIX	XIII	XVI	0.892	3.04
Female								
Total	XVII	XI	I	VII			0.872	3.90
	XVII	XI	I	VII	XX	VIII	0.920	3.10
5 to 15 years	XI	I	XIX	VI			0.727	3.79
	XI	I	XIX	VI	IX	XII	0.836	2.94
16 to 35 years	VII	XI	XVII	II			0.800	3.25
	VII	XI	XVII	II	XIX	VI	0.864	2.69
36 to 60 years	XVII	VII	VIII	XIX			0.878	3.31
	XVII	VII	VIII	XIX	XX	X	0.924	2.63
61 to 88 years	VI	XVIII	XIX	V			0.889	3.51
	VI	XVIII	XIX	V	XVII	III	0.924	2.97

* standard error of estimate

All subjects were measured by evaluators experienced in the Flexitest technique and most of them were measured by a single evaluator. Previous studies of our laboratory have demonstrated an excellent intra and interobserverreliability among experienced observers for the Flexitest with interclass correlation coefficient always above 0.9[2]. The typical error margin between two repeated measurements by the same experienced evaluator should not exceed two points in the Flexitest, in other words, disagreement in one or two movements of only one point in the scores scale[1,21].

With the objective of determining which would be the four and six movements that would most contribute for the Flexindex global score, a step-by-step progressive multiple regression was performed with the Statistica (StatSoft, United States) software using individual scores of the 20 movements as independent variables and the Flexindex as the dependent variable. The probability level of 5% for statistical significance was adopted. Considering that flexibility varies with age and gender, it was appropriated to perform the analysis separately for the global sample and by age ranges for each gender. Table 2 shows the several quantitatives for the age ranges selected – children/adolescents, young adults, adults and aged adults – according to gender.

RESULTS

The ages of the individuals studied were 36.5 ± 22.1 and 30.5 ± 20.9 (mean ± standard deviation) respectively for men and women with both samples varying between 5 and 88 years. Flexitest results were significantly higher for women – 49.4 ± 0.3 versus 40.6 ± 0.3 points (mean ± standard error of the mean) ($p < 0.001$) with a range around 65 points as follows: men varying between 7 and 71 points and women between 11 and 76 points.

The summary of the step-by-step progressive regression analysis is presented in table 3, listing movements by relevance order for prediction with the respective determination coefficients and standard errors of estimate (SEE) for global sample and for the four age ranges by gender. All regressions between variables were significant ($p < 0.001$) with SEE of 3.8 and 3.9 points, respectively, for the global sample of men and women. Analyzing the SEE, we found values between 2.76 and 3.74 in male age ranges and between 2.63 and 3.79 in female age ranges and a difference dependent on gender or age range ($p > 0.05$) was not possible to characterize, but the predictive models that included six movements ($p < 0.05$) presented reduced levels of SEE when compared to the four movements models.

Table 4 lists the movements in relevance order for each one of the predictive models. In a detailed analysis of the movements statistically selected through step-by-step regression for inclusion in the Flexindex prediction, it was observed that there were important differences according to gender and age range. In practice, the regression analysis included distinct movements for each age group analyzed and for global samples of both genders, where a clear pattern was not possible to be defined.

Some few movements appear in most Flexindex prediction models, especially the shoulder lateral rotation (movement XIX), shoulder medial rotation (movement XX) and hip adduction (movement VII), although with distinct weights. Except for the prediction model for the older female group, all six-movements models included at least one trunk movement, however, with low relevance. On the other hand, in the four-movements predictive models, the inclusion of trunk mobility is less evident and relevant. Analyzing by gender only, it was verified that around 20% of movements were not included in none of the prediction regressions of the flexibility global score. Interestingly, only two movements – IV (knee extension) and XV (elbow extension) frequently associated to joint hypermobility[4] did not have predictive value in both men and women. Analyzing by joint for all age ranges, it was observed that knee, wrist and elbow movements tend to be less important in the predictive models, although for the global male sample, i.e., with no distinction by age range, range of motion in wrist flexion is the most important. Hip and shoulder movements tend to be more often included.

TABLE 4
Movements included in the Flexindex predictive models by decreasing order of relevance for each one of the age ranges by gender

Movement	Male					Female				
	Age ranges					Age ranges				
	05-15	16-35	36-60	61-88	05-88	05-15	16-35	36-60	61-88	05-88
I						5				4
II		2					3			
III									1	
IV										
V									3	
VI						3	1		6	
VII	4	4	5		4		6	5		3
VIII		1		4				4		1
IX	6			5		2				
X		5	4		5			1		
XI	3					6	5			5
XII					1	1				
XIII			2	2						
XIV	1									
XV										
XVI				1	6					
XVII			6				4	6	2	6
XVIII		6		6					5	
XIX	5		1	3	2	4	2	3	4	
XX	2	3	3		3			2		2

DISCUSSION

As expected, the results of the step-by-step multiple regression analysis showed that the six-movements models tend to present higher coefficients and lower estimative errors than the four-movements models in all groups studied. Although the magnitude of coefficients of determination is in principle quite high, supporting the use of condensed versions, this analysis is simplistic and inappropriate. Considering that the typical error margin in the Flexindex evaluation and the effect usually resulted from an exercise program, respectively, one to two points and two to four points, a Flexindex SEE that exceeds two points may be considered as excessive and jeopardizing from the practical application point of view. Unfortunately, all four and six-movements predictive models in the several groups studied presented standard errors of estimative between 2.6 and 3.9 points even when the six most relevant movements for the prediction in each age range were used, suggesting that the adoption of condensed versions jeopardizes significantly the global flexibility of the individual as quantified through the calculation of the Flexindex. The gain obtained when using six movements instead of four movements is relatively modest in terms of SEE, thus not contributing significantly for a better Flexindex prediction.

The practical relevance of this error margin may be observed through a simple simulation. Considering that a 48-year old woman has an average Flexindex result (45 points) for gender and age, the use of four-movements condensed version (SEE 3.9 points) would produce scores between 41 and 49 points through the addition or subtraction of a SEE from the average Flexindex value or values between percentiles 35 and 75 when plotted in percentile curves[1]. Results with disagreements of such magnitude probably lead to distinct clinical and sports interpretations.

It is also supposed that these models present error margins even larger when applied to athletes or individuals with special needs, groups that tend to present higher heterogeneity in the flexibility expression and, therefore, higher variability indexes[1,14] or when the movements statistically more relevant are not selected for each age or gender group.

It is proper to emphasize that there is no movement or joint pattern defined for inclusion in predictive models. It is interesting to observe that in many cases, multiple joints and more than one movement of the same joint are included in the model, reinforcing the specificity concept of the flexibility for a given movement and for a given articulation[5,6,8]. Other important information is that should be considered the loss of specific and relevant information as result of the partial Flexitest application, when just some of the 20 movements are measured, eventually missing these movements that may demand higher attention, either by limitations or by mobility excess are not identified.

Finally, although the potential time reduction of the Flexitest application is potentially attractive, the use of condensed versions with four or six movements, even if adapted for age ranges or genders, did not seem to be an adequate alternative for the global flexibility analysis of a given individual. A small gain of time on the execution of movements probably does not compensate the significant loss of quantitative and qualitative information. The use of condensed versions should be therefore restricted to extremely special situations such as situations that might eventually occur in Ergonomics, Work Medicine or in sports training, when the range of motion of some few movements is priority.

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