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Original Article

AGREEMENT BETWEEN INSTRUMENTS FOR ASSESSMENT OF BODY BALANCE IN ACTIVE ELDERLY INDIVIDUALS

CONCORDÂNCIA ENTRE INSTRUMENTOS PARA AVALIAÇÃO DO EQUILÍBRIO CORPORAL, EM IDOSOS ATIVOS.

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RESUMO
O objetivo do estudo foi analisar a correlação entre instrumentos utilizados **à** avaliação do equilíbrio corporal e a predição do risco de quedas de idosos ativos. Estudo transversal, observacional, realizado com 41 mulheres (69,24±5,24 anos) praticantes de exercícios físicos, em Petrolina-PE. Os instrumentos utilizados foram a Escala de Equilíbrio de Berg (EEB), o Índice de Marcha Dinâmica (DGI), o "Timed Up and Go" simples (TUG), o "Timed Up and Go" motor (TUGm), o "Timed Up and Go" cognitivo (TUGc) e o Teste de Equilíbrio Corporal (TEC). Foi observada correlação significativa entre TEC-DGI (r=0,469; p=0,032), EEB-DGI (r= 0,513; p=0,021), correlação significativa negativa entre DGI-TUG (r= -0,454; p<0,017), DGI-TUGm (r= -0,516; p<0,006), DGI-TUGc (r= -0,547; p<0,003), MEEM-TUG (r= -,470; p=0,055), MEEM-TUGm (r= -,470; p=0,057) e correlação significativa e moderada entre TUG-TUGm (r=0,701; p=0,000), TUG-TUGc (r=0,713; <0,000) e TUGm-TUGc (r=0,761; <0,000). Conclui-se que os instrumentos são complementares. Recomenda-se sua aplicação conjunta à avaliação do equilíbrio corporal e à predição do risco de quedas em idosos ativos.
Palavras-chaves: Equilíbrio Corporal. Idosos. Avaliação do Equilíbrio.

ABSTRACT
The aim of this study was to analyze the correlation between the instruments used to assess body balance and prediction of the risk of falls of active seniors. Cross-sectional, observational study involving 41 women (69.24 ± 5.24 years) practitioners of physical exercises, in Petrolina-PE. The instruments used were the Berg Balance Scale (BBS), the Dynamic Gait Index (DGI), the "Timed Up and Go" simple (TUG), the "Timed Up and Go" motor (TUGm), the "Timed up and Go "cognitive (TUGc) and Body Balance Test (CET). Significant correlation was observed between TEC-DGI (r = 0.469; p = 0.032), BSE-DGI (r = 0.513; p = 0.021), a significant negative correlation between DGI-TUG (r = -0.454; <0,017), DGI -TUGm (r = -0.516; p<0,006), DGI-TUGc (r = -0.547; <0,003), MMSE-TUG (r = -, 470; p = 0.055), MMSE-TUGm (r = - 470; p = 0.057) and a significant and moderate correlation between TUG-TUGm (r = 0.701; p = 0.000), TUG-TUGc (r = 0.713; p = 0.000) and TUGm-TUGc (r = 0.761; p = 0.000). It is concluded that the instruments are complementary. It is recommended their joint application to the evaluation of the body balance and to predict the risk of falls in elderly active.
Keywords: Body Balance. Elderly. Balance evaluation.

Introduction

As people age, they go through a series of changes of biopsychosocial and cultural order, which will stand as barriers to their adaptation to the environment where they live[1,2]. Said changes, after 45 years of age, include a natural decline of their ability to control body posture, which is called balance[3]. The study of themes addressing balance is relevant, especially when it comes to the elderly population, since this deficit leaves people more prone to falls and fractures, which may lead individuals to even premature death[4].

Falls have serious consequences as they influence the quality of life (QL) of both those who fall and their family members. Additionally, falls raise outpatient care and hospitalization service costs[5]. Face that, science has been increasingly interested in factors associated with risk of falls among seniors[6], as well as in instruments that qualify the clinical assessment of balance[7].

Considering that balance results from a set of endogenous and exogenous factors[8], assessing it is a complex task. Thus, procedures are usually performed with the aid of different tests, which are applied jointly, since each instrument assess one or other factor related to postural deficit. According to Shumway and Woollacott[9], body balance is the human capacity to maintain the center of gravity in the stationary position on the limits of body support base. Human consciousness is oblivious of this regulation, which involves reception and integration of sensorial stimuli engaged in the planning and execution of movements responsible for muscle contractions necessary to the repositioning of the center of gravity on the support base[10]. Body posture information is captured by visual and vestibular receptors and by the somatosensory system, then sent to the central nervous system (CNS), where it is processed before returning to the unbalance region in the corrective form[11].

Falls result from associated factors related to both environmental conditions and loss of muscle strength[12], limitations in hip flexor muscles[13], deficient ankle stabilization[6], as well as gait pattern losses[14]. This means to say that falls are multifactorial events. In general, their risk factors are known; however, their inter-relations, as well as the weight of each factor still lacks greater understanding[7,15,16]. Thus, balance deficit assessment requires comprehensive and reliable instruments[17]. The most frequently employed instruments in gerontological assessment include the Berg Balance Scale (BBS)[18], the Dynamic Gait Index (DGI)[8], and the "Timed Up and Go" test (TUG)[19], which has two other versions, the TUG-motor (TUGm) and the TUG-cognitive (TUGc). Another instrument that was also used, but which is still not known in Brazil, is the GGT (*Gleichgewichtstest).* This instrument was developed in Germany by Wydra[20], having been introduced to the specialized literature in Portuguese by Nascimento, Coriolano Appell and Appell Coriolano[21] as *Teste de Equilíbrio Corporal* [Balance Body Tes) (TEC).

All these instruments present similarities, good reliability levels, low costs and convenience. Considering the existence of different instruments for assessment of balance deficit and prediction of falls among seniors, the present study aimed to investigate correlations between the BBS, the DGI, the TEC, the TUG, the TUGm and the TUGc, in addition to pointing at and discuss its characteristics when applied to elderly women that exercise regularly.

Methods

Participants

This is a cross-sectional, observational study. It involved 41 female seniors (69.24±5.24 years old), members of Pilates, water aerobics, swimming, general gymnastics and tennis groups of the Active Life Program [*Programa Vida Ativa*] (PVA), which is offered to the elderly community of the cities of Juazeiro, BA, and Petrolina, PE, by the undergraduate Physical Education course of the Federal University of Vale do São Francisco (UNIVASF). The participants were divided into four groups by age: G1 (60-64 years old); G2 (65-69 years old); G3 (70-74 years old); and G4 (75-79 years old). Inclusion criteria comprehended being aged ≥60 years old, exercising regularly – with minimum time of six months and 25% attendance to activities –, not having joint, muscle or bone injuries during the assessment period, history of ankle twisting or falls, neurological diseases such as Parkinson's or strokes, in addition to having signed an informed consent form. Individuals that did not complete all study phases were excluded.

Procedures

The participants were informed about the procedures. The study was approved by the Ethics Committee on Research Involving Humans of the Federal University of Vale do São Francisco /UNIVASF (CAAE: 44113715.3.0000.5196). The investigation comprehended four phases, with data collected by two duly trained students between September and November of 2015.

Instruments

Phase 1: Collection of sociodemographic information.

Phase 2: Application of the Mini-Mental State Examination (MMSE). The MMSE is a test that assess cognitive function. Its application takes around 10 minutes. The assessment allows tracking down dementia, without, however, substituting a detailed assessment of the case. Its seven items examine the following domains: spatial and temporal orientation, short-term and retrieval memory, calculation, language-naming, repetition, comprehension, writing and copying drawings. The test was translated and presented to the Brazilian population by Betolucci[22]. Its scores varied from zero to thirty and values lower than 18 indicated presence of light dementia; values between 10 and 18 meant moderate dementia; results inferior to 10 points, in turn, suggested serious dementia[22,23].

Phase 3: Anthropometric data: Body mass and height were determined with the aid of a mechanical scale, up to 300Kg (Welmy, Brazil), with a 2-meter anthropometric rule. Body Mass Index (BMI) was established through the formula: weight (Kg)/height(m^2).

Phase 4: Risk of falls was assessed by means of the BBS, DGI, TEC, TUG, TUGm and TUGc tests.

Berg Balance Scale (BBS): This instrument is widely used to assess the functional capacity of seniors, estimating the likelihood of falls. The BBS was translated into Portuguese and adapted transculturally by Miyamoto[18], possessing high intra and inter-observer reliability (0.99 and 0.98 ICC). Its items approach 14 situations/domains related to activities of daily living (ADL) such as: standing on one's feet, rising, walking, bending forward, transferring oneself and turning around, by level of difficulty. The system for task assessment ranges from zero points (incapable of performing it) to four points (normal); the highest score is six points. Its scoring criteria are based on the time a position is maintained, time necessary to perform a task and the distance the upper limb reaches ahead of the body. According to Berg[24], the limit of forty-five points indicates risk of fall. Shumway-Cook[8], in turn, proposes scores equal or inferior to fourth-nine points as risk of fall; results higher than forty-nine indicate normal balance.

Dynamic Gait Index (DGI): The scale assesses dynamic gait, predicting the likelihood of falls from eight functional tasks: walking on a flat surface, walking while changing gait speed, walking while performing horizontal movements with the head, walking while performing vertical movements with the head, overcoming an obstacle, walking and moving around a cone, turning around one's own body axis and, finally, climbing up and down stairs[8]. The execution of the DGI requires the demarcation of the floor surface with a tape on the starting point and 1.80 meters and 3.60 meters ahead, where the cones will be placed[25]. The test presents twenty-four points as maximum score and each is given from zero to three points. In seniors (≥60 years old), the interpretation of a value that is higher than or equal to nineteen points mean risk of falls; the safe gait indicative, in its turn, is presented by values greater than twenty-two points.

Body Balance Test (TEC): It was developed by Wydra[20], in Germany, named "*Gleichgewichtstest"* (GGT) and introduced to the Portuguese-speaking community by Nascimento, Coriolano Appell and Appell Coriolano[21]. In its validation with the German population (n=306), the instrument showed test-retest reliability (0.78), with a 0.92 Cronbach's alpha consistency, followed by a correlation of r=0.60 (<000) in postural radiography[20]. The TEEC is composed of 14 items; seven tasks assess static balance and, the other seven, dynamic balance. From item nine, the assessment is carried out on a wooden beam measuring (4) meters in length, 10 cm in width and 3 cm in height, with the examination of ankle reaction strategies, in addition to 180° and 360° turns and balance associated with the object. Six tasks assess the exteroceptive regulation (open eyes) of the static and dynamic balance, while eight assess interoceptive regulation (closed eyes). Its tasks are arranged in increasing level of difficulty. Results are interpreted according to success normatives categorized by age groups and gender. Its scoring is dichotomic, with the attribution of zero to goal unachieved and one to goal achieved[21].

Timed Up and Go (TUG): TUG-simple is used to assess mobility and functional balance. It requests postural self-control. The participant, sitting in a 45-centimeter arm chair, must rise and walk for (3) meters, performing a 180° turn around a cone, returning to the chair and sitting. The chronometer is activated the moment when the examiner says "go" and stopped when the individual returns to the starting position, with his or her back rested on the backrest. The displacement must be performed by walking as fast as possible, but without running[19]. The TUG correlates (r=-0.72) to the BBS. Bischoff et al.[26] consider, for independent adults, the completion of the test within up to 10 seconds as normal (without risk of falls). Results between 11 and 20 seconds, in turn, indicate partial independence (low risk of falls). Times above 20 seconds signal deficient physical mobility (high risk of fall).

TUG-motor (TUGm): It presents the very same guidelines of the conventional TUG. However, the individual carries with both hands a cardboard tray, with a 25-centimeter ray, on which there is an empty plastic glass measuring 12 cm in height. The tasks consist of carrying the tray without letting the glass fall. The scoring system considered the normative values of the TUG-simple[26].

TUG-cognitive (TUGc): it consists of performing the very same tasks and path of the conventional TUG but now with the examiner starting a countdown from 100 out loud. The test started the moment when the individual stood up from the chair and interrupted when the latter returned and sat down. For being a test that requires attention and cognition, an attempt was made for adaptation to the test, which was not taken into account. The scoring system for results considered the normative values of the TUG-simple[26].

Statistical analysis

Data normality was verified by means of the Shapiro Wilk test. Descriptive statistics (mean, frequency and standard deviation) was used for presentation of results. Kruskal Wallis' Anova test was adopted to determine significance between groups. Intra-group differences for gait and balance tests were processed by the Mann-Whitney test. Pearson's correlation was applied to the determination of the strength and direction of correlations between instruments. Data were tabulated and processed on SPSS, statistical program, for Windows®, version 19.0, and the confidence level adopted was 5%.

Results

Table 1 displays results of the participants' main characteristics by age group. It is possible to observe that younger elderly women show higher nutritional state (BMI) than older ones do. Physical capacity performance was inversely proportional to age:

Table 1. Study sample characteristics.

Variable	G1 (60-64 years old) (n=9)	G2 (65-69 years old) (n=12)	G3 (70-74 years old) (n=12)	G4 (75-79 years old) (n=8)
Age (years)				
Mean (SD)	61.89±1.26	67.08±1.62	72.33±1.15	76.13±1.12
Min.–Max.	60 – 63	65 – 69	70 – 74	75 – 78
BMI (kg/m^2)				
Mean (SD)	31.17±5.54	28.66±4.89	28.28±4.46	26.31±3.73
Min.–Max.	24 – 40	25 – 40	23 – 39	19 -31
MMSE				
Mean (SD)	26.11±2.20	25.90±4.44	26.00±2.00	21.80±4.32
Min.–Max.	26 - 26	19 – 29	23 – 28	21 - 28

Legend: SD = Standard Deviation; kg = Kilogram; m = meters; BMI = Body Mass Index; MMSE = Mini-Mental State Examination
Source: The authors

The TEC indicated significant results between septuagenarians and sexagenarians aged up to 64 years old. The BBS showed significance only among sexagenarians (Table 2). The assessment of gait associated to functional task, assessed by the DGI, showed significant difference from 70 years old. No differences were found for gait in simple task (TUG); however, about motor condition (TUGm) and cognitive condition (TUGc) there was difference (p≤0.050) between sexagenarians and elderly women aged ≥75 years old.

Table 2. Mean results obtained in gait and body balance tests.

Variable	G1 (60-64 years old) (n=9) Mean (SD)	G2 (65-69 years old) (n=12) Mean (SD)	G3 (70-74 years old) (n=12) Mean (SD)	G4 (75-79 years old) (n=8) Mean (SD)	p
TEC	7.86±3.71^{a,b}	5.50±2.82	4.45±3.20^{a}	4.43±3.04^{b}	0.079
BBS	53.43±1.81^{a}	50.67±1.86^{a}	50.42±3.84	50.33±3.72	0.155
DGI	19.50±2.12	19.33±2.73	19.13±2.03^{a}	18.00±1.51^{a}	0.219
TUG	9.99±1.35	8.91±1.88	9.76±0.85	10.56±1.39	0.281
TUGm	8.49±043^{a}	9.51±1.88^{b}	10.12±1.28	10.95±1.33^{a,b}	0.109
TUGc	9.72±0.18^{a}	10.46±3.92^{b}	10.62±2.12	12.21±3.56^{a,b}	0.719

Legend: TEC=Body Balance Test; BBS=Berg Balance Scale; DGI= Dynamic Gait Index; TUG= Timed Up and Go-simple; TUGm= Timed Up and Go- motor; TUGc= Timed Up and Go-cognitive; ^{a,b}p≤0.050.
Source: The authors

Correlation levels between the instruments applied to the gait exam (TUG, TUGm and TUGc, DGI) and the body balance test (BBS, TEC) are described in Table 3:

Table 3. Correlations between gait and body balance tests.

Variables	R	P
TEC-BBS	0.302	0.112
TEC-DGI	0.469*	0.032
TEC-TUG	-0.280	0.219
TEC-TUGm	-0.278	0.222
TEC-TUGc	-0.208	0.365
BBS-DGI	0.513*	0.021
BBS-TUG	-0.327	0.159
BBS-TUGm	-0.184	0.438
BBS-TUGc	-0.296	0.204
DGI-TUG	-0.454*	0.017
DGI-TUGm	-0.516*	0.006
DGI-TUGc	-0.547*	0.003
TUG-TUGm	0.701*	<0.001
TUG-TUGc	0.713*	<0.001
TUGm-TUGc	0.761*	<0.001
MMSE-DGI	0.481	0.051
MMSE-TUG	-0.473	0.055
MMSE-TUGm	-0.470	0.057

Legend: TEC=Body Balance Test; BBS=Berg Balance Scale; DGI= Dynamic Gait Index; TUG= Timed Up and Go-simple; TUGm= Timed Up and Go-motor; TUGc= Timed Up and Go-cognitive, MMSE= Mini-Mental State Examination, $^{*}p \leq 0.05$.
Source: The authors

Discussion

The BBS instrument classified the condition of functional balance as safe for all groups. However, this prediction was not corroborated by the DGI, which indicated risk of fall for the entire population assessed. The TEC normatives qualified the balance of all participants as good, ratifying the BBS results. The difference between the DGI, the BBS and the TEC predictions can be explained by the purpose and/or specificity of the tasks in each test. The finding is substantial as it verified that, in the population tested, gait pattern losses (DGI) did not mean impaired performance of static and dynamic balance tasks (TEC) and functional balance tests (BBS).

The participants' mobility was assessed by the TUG, TUGc, TUGm tests and the DGI as well. Considering that the elderly women assessed were healthy and exercised regularly, performance means ≤12 sec.[19] were expected. Thus, corroborating with a study by Carmelo and Garcia[27] conducted with active sexagenarian women, it was possible to observe a performance ≤10 sec. with the three TUG tests, which means no risk of fall. However, when assessed by the DGI, all the elderly women showed performances ≤19 points, which represents risk of fall. A possible explanation to the lack of agreement between the TUG and the DGI results may be due to the very constitution of these instruments because, while the DGI associates eight different tasks for gait adjustment[28], TUG tests assess the case in a single action, simples task.

Bischoff et al.[26] and Carmelo & Garcia[27] evidenced that mobility performance, which is measured in seconds, is inversely proportional to age. Corroborating with the specialized literature, in a comparison between age groups, significant difference was found for G4 (75-79 years old), when assessed by TUGm and TUGc. That group also showed the worst performance in the Mini-Mental State Examination – MMSE[22]. Santos et al.[29] found significant correlation between aging and attention and memory deficits. This means to say that older seniors, when subjected to dual-task situations need more time to complete tasks, since cognitive-level work interferes with gait speed, slowing people down, especially seniors. This finding is important for Physical Education professionals, since it highlights the importance of developing activities that put into operation an elderly individual's motor and cognitive components, simultaneously, in PE programs.

According to Barbosa et. al.[30], postural control deficit in seniors during gait derives from a contest between three natures: the secondary task, motor response efficacy and sensory afference to maintain balance. Santos et. al.[31], analyzing correlations between the cognitive performance and functional balance of institutionalized and physically-active seniors, found higher risk of fall among regular practitioners of PE.

Figure 1 allows analyzing, comparatively, the mean of completion of the BBS, DGI and TEC tasks. It is possible to observe that, regardless of age group, the results achieved for BBS and DGI tasks remain high, between 80% and 100%. On the other hand, even though TEC results have not indicate risk of fall (Table 2) for all age groups, the individual performance examination relating to the 14 tasks revealed worrisome results. This means to say that depending on the type of regulation required for static and dynamic balance, the participants' performance stood between 0 and 80%. This finding evidence the TEC as a differentiated instrument, as it provided detailed information on balance deficit, classifying it between visual (exteroceptive regulation) or vestibular/proprioceptive (interoceptive regulation):

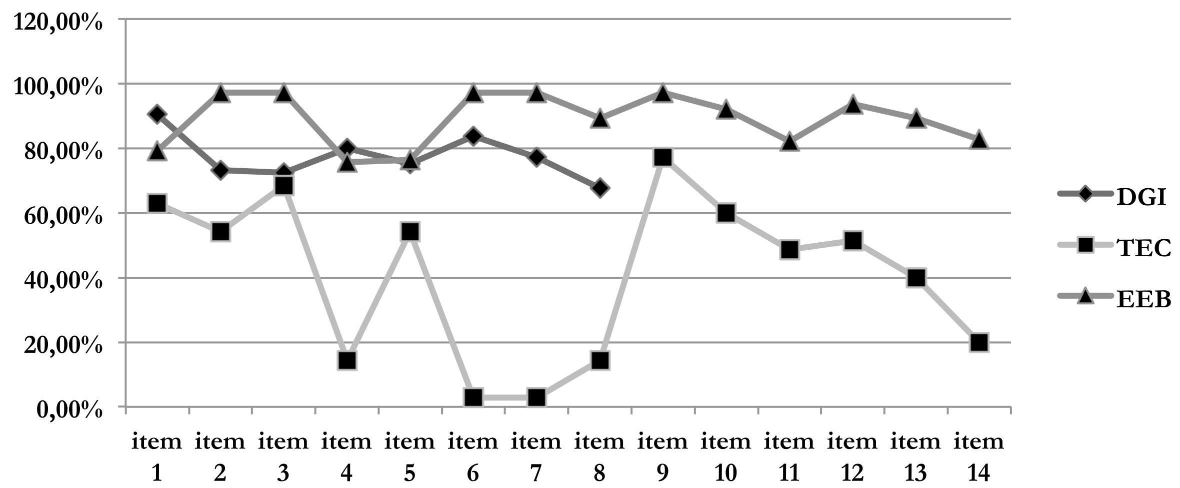

Figure 1. Means of completion of BBS, DGI and TEC tasks.
Source: The authors

Figure 1 shows that in only four of the 14 TEC items the population tested scored on average between 60% and 80%. An explanation to the case is that its tasks are arranged in a decreasing level of difficulty, in addition to the instrument having being validated with healthy individuals[20]. Comparatively, BBS completion rates were higher (80%-100%). In a study with seniors that practiced and did not practice PE, Santos et. at. [29] combined BBS results with self-report of falls, finding that the BBS would not be the best clinical instruments for balance assessment and fall prediction among seniors who exercised regularly. The examination of TEC tasks 4,6,7 and 8 also allowed identifying deficits within this population, especially when it comes to static balance.

According to Gazzola et. al.[28], the assessment of static and dynamic balance in the elderly population should examine different aspects in this matter. This means to say that the test has to incorporate factors such as postural response on reduced surface, neuromuscular reaction face external disturbances, ankle, hip, trunk reaction strategies, in addition to backward step ability. In its 14 tasks, the TEC assessed ankle reaction strategies, unipedal support with open and closed eyes, gait on reduced surface, balance after a 360° rotation, 180° and 360° translations, as well as the assessment of balance associated with the object. It is admitted that the TEC should not substitute clinical assessment of vestibular disorders but it can be useful in identifying the matter beforehand, since it is simple to apply, without need for many materials. In an experimental study in the Physical Education field[32], as well as in a recent systematic review in the Physiotherapy field, the efficiency of the TEC in relation to the assessment of the elderly's population balance was highlighted[33].

About the strength and direction of the correlation between the scales, the Mini-Mental State Examination (MMSE) showed moderate, but not significant, correlation with the TUG and the TUGm, indicating that the better the assessed individuals' mental state performance, the shorter the time required for the execution of gait tasks, which corroborated with the findings of Santos et. al.[29]. In relation to the DGI, the MMSE showed moderate and positive correlation, indicating, once more, that mental performance deficit interferes with a senior's gait and functionality, raising the risk of fall.

Corroborating with results of Gazzola et al.[35], in a study conducted with 20 seniors and which pointed that the greater the performance in the DGI, the higher the BBS score, there were significant and moderate correlations between these instruments. Moderate and significant correlation was also obtained between the DGI and the TEC, showing similarities between the goals of their tasks. Face these results, it can be stated that the BBS-DGI and DGI- TEC instruments are complementary. Thus, they should be applied together with the prediction of risk of falls in seniors who practice PE regularly.

Opposing to the findings of Podsiadlo and Richardson[19] and Miyamoto et. al. [18], the correlation levels found between the TUG-BBS were weak and not significant. The same happened between the TUG- TEC and the TEC-BBS tests. On the other hand, significant, moderate and negative correlations were found between DGI, TUG, TUGm and TUGc. This means to say that elderly women with poor DGI performance needed more time to execute the gait tests. A possible limitation of this study is the reduced size of the sample, which might have masked the body balance deficit and risk of fall between age group. Another issue is that exogenous factors were not controlled such as drug interactions and fear of falls, something categorical to this theme.

Conclusions

Measures that assess body balance deficits and risk of falls with the elderly population, in an efficient and reliable manner, are important to the development and qualification of services in the clinical area, as well as of physical and functional training. The findings of this study ratify the correlation between aging and worse attention and memory deficit and a person's slowness, which determines losses in postural control. The statistical analysis presented moderate correlation levels between the BBS, DGI, TEC, TUG, TUGc, TUGm tests, concluding that they are not complementary.

It is worth stressing that, in the population assessed, the DGI, TEC and TUGc instruments proved more sensitive to detect balance deficits. The TEC, in turn, proved efficient for the detailing of disorders together with the balance regulation system. New studies should be conducted with seniors who practice PE, including the instruments used in this investigation, but with a larger number of participants and male individuals.

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