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ORIGINAL RESEARCH

Comparison of postural control in five tasks of balance and relation of risk of falls between older and young adult women

Comparação do controle postural em cinco tarefas de equílibrio e a relação dos riscos de quedas entre idosas e adultas jovens

Comparación del control postural en cinco tareas de equilibrio y la relación de los riesgos de caídas entre ancianas y adultas jovenes

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ABSTRACT | Aging is a natural process, which involves intrinsic and extrinsic changes in the organism. The objective is to analyze five tasks of postural balance in older women through the strength platform, correlating them with risk of falls evaluated by the Timed Up and Go (TUG) test. Participants of this study were 43 older women and 40 young adult women. They were evaluated on a force platform with a standard protocol: barefoot with arms along the body in Semi-Tandem and bipedal stances, with both eyes open and then closed, unipedal support using the postural sway of the center of pressure (COP) and the velocities in the anteroposterior axis (AP) and medial-lateral (ML). After 5 minutes of rest, TUGT was applied. The results showed that older women had greater postural instability (p<0.05) than younger women. The most challenging task for balance was unipedal support COP: 10.02(cm^2); AP velocity: 3.00 (cm/s); ML velocity: 3.32 (cm/s). Older women needed a mean time of 9.01 seconds in the TUGT, considering a low risk of falls. Conclusion: Older women present a higher deficit in their balance compared with young women, so as Unipedal Stance Test (UPST) task was the most challenging for postural control of the two populations. Healthy older women presented a low risk for falls. No correlation was found between postural balance through the force platform and risk of falls during the TUGT.

Keywords | Postural Balance; Accidental Falls; Aging.

RESUMO | O envelhecimento é um processo natural que acarreta mudanças intrínsecas e extrínsecas ao organismo. O objetivo é analisar cinco tarefas de equilíbrio postural em idosas através da Plataforma de força, correlacionando com o risco de quedas avaliado pelo teste Timed Up and Go (TUG). Participaram do estudo 43 idosos e 40 adultos jovens, todos do sexo feminino, que foram avaliadas em uma plataforma de força com um protocolo padrão: descalças, com os braços ao longo do corpo nas tarefas bipodal e semitandem, ambos olhos abertos e fechados, apoio unipodal utilizando o centro de oscilação postural (COP) e as velocidades nos eixos anteroposterior (Vel AP) e médio-lateral (Vel ML). Após 5 minutos de descanso, realizou-se o TUG. Os resultados mostraram que as idosas tiveram maior instabilidade postural (p<0.05) em relação às adultas jovens, e a tarefa que mais desafiou o equilíbrio

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foi o apoio unipodal COP 10,02 (cm²) Vel AP 3,00 (cm/s) e Vel ML 3,32 (cm/s), e as idosas tiveram um tempo médio no TUG de 9,01 segundos considerando um baixo risco de quedas. Conclusão: Idosas apresentam um maior déficit no equilíbrio em relação às jovens, sendo a tarefa de apoio UNP a que mais apresentou desafios no controle postural das duas populações. Idosas saudáveis apresentaram um baixo risco para as quedas, nenhuma correlação foi encontrada entre o equilíbrio postural através da plataforma de força e risco de quedas do TUG.
Descritores | Equilíbrio Postural; Acidentes por Quedas; Envelhecimento.

RESUMEN | El envejecimiento es un proceso natural, lo cual conlleva cambios intrínsecos e extrínsecos en el organismo. El objectivo es analizar cinco tareas de equilibrio postural en ancianas por medio de la plataforma de fuerza, presentándose correlación con el riesgo de caídas evaluado por el Timed Up and Go Test (TUGT). Participaron del estudio 43 ancianas y 40 adultas jovenes, las cuales fueron evaluadas en una plataforma de fuerza con un protocolo patrón: descalzas, con los brazos al longo del cuerpo en las tareas bipodal y semi-tandem, ambos ojos abiertos y cerrados, apoyo unipodal utilizando el centro de oscilación postural (COP) y las velocidades en los ejes *anteroposterior (Vel AP)* y mediolateral (Vel ML). Después de 5 minutos de descanso, se realizó el TUGT. Los resultados presentaron que las ancianas tuvieron mayor inestabilidad postural ($p<0.05$) en relación a las adultas jovenes, y la tarea que más desafió el equilibrio fue el apoyo unipodal COP 10,02 (cm²) Vel AP 3,00 (cm/s) y Vel ML 3,32 (cm/s), y las ancianas tuvieron un tiempo medio en el TUGT de 9,01 segundos considerando bajo riesgo de caídas. La conclusión es que ancianas presentan mayor déficit en el equilibrio en relación a las jovenes, siendo la tarea de apoyo UNP la que más presentó desafíos en el control postural de las dos poblaciones. Ancianas saludables presentaron bajo riesgo para las caídas, ninguna correlación fue encontrada entre el equilibrio postural por medio de la plataforma de fuerza y riesgo de caídas del TUGT.
Palabras clave | Equilibrio Postural; Accidentes por Caídas; Envejecimiento.

INTRODUCTION

Aging is a complex and multifactorial process influenced by genetic and non-genetic factors[1]. During this process, functional, morphological and biochemical changes happen, which gradually modify the human organism, making it more susceptible to intrinsic and extrinsic aggressions, so falls are a major issue in the health of the older people[2]. Risk of falls have been a serious problem for this population. A third of adults over 65 years old experience falling situations and 60% out of these individuals are exposed to a musculoskeletal system injury[3,4]. Approximately 10% of falls result in serious problems and hospitalization, so that 50% of the hospitalization cases correspond to hip fractures and 13% corresponds to arm fractures. Over 90% of hip fractures are related to frequent falls[5] and usually females are more affected[6].

Due to this fall issue, several methods have been developed to evaluate balance; these methods include qualitative observations of the movement, questionnaires, measurement scales, functional tests and integrated systems for high complexity evaluation with use of force platforms. Each method has advantages and disadvantages. Therefore, each one of them provides a complementary information to the others[7]. Functional tests to analyze risk of falls are commonly carried out through the Timed Up and Go (TUG) test, widely used due to its easy applicability and low cost[8]. The use of high-tech equipment, such as the force platform, has been widely employed to determine biomechanical and neuromuscular mechanisms involved in the postural control system for balance maintaining and fall prevention. Its measures come from this system such as movements of the center of pressure, which are sensible and reliable to postural balance deficits[9].

Although some studies correlated force platform measures with functional tests of balance[10,11]; none so far conducted a representative analysis of the five tasks of balance within this relation and mainly for discriminatory comparison between older and young adult women. Characterization of evaluated conditions in the five tasks may contribute to various outcomes, assist evaluation and intervention programs for older women. However, it is quite pertinent to investigate differences on postural balance of women due to the neurophysiological changes imposed by the aging process and the appearance of diseases such as osteoporosis, which can impair balance and increase risk of falls[12].

This study aimed mainly to compare postural balance between older and young adult women through balance tasks on the force platform and risks of falls through the TUGT and determine the relationship between measures of the functional test, as well as the main balance variables resultant from five experimental tasks. Our first hypothesis is that there are differences between the age groups (older versus young adult women) for balance measures and functional tests, while the second one is associated with the existence of a relationship among some of these variables.

METHODOLOGY

The sample size was determined through BioEstat 5.0 program, using mean and standard deviation values in the TUGT reported in a study by Sabchuk et al. (2012)[8] 7.93±1.97 seconds for healthier adults and 5.22±0.67 for healthy young adults. Considering a 99% confidence interval, 5% alpha and 99% test potency, minimum sample was determined to be 22 in each group, in this case, selection took place with a larger sample in order to avoid sample loss.

All participants were volunteers and female. Participants were 43 physically independent older women aged older than 60, and 40 young adult women aged 18 to 30 who were selected in the academic community.

Eligibility criteria for inclusion of the older population was age 60 or older, who did not suffer falls in the past year, being physically independent and having cognitive status ≤19 as their educational background, according to the questionnaire of the Mini-Mental State Examination (MMSE)[13]. For the young group, the criteria were: aged 18 to 30 and and who did not perform any type of oriented physical activity over the past three months. Exclusion criteria apply to both groups: presenting any disabling injury in the lower limbs, ostheomyoarticular disorder of any type and not being able to perform any of the tests. Participants were guided through the study and after the explanations, all individuals signed the informed consent form. The project was approved by the Research Ethics Committee of the Institution under protocol number 276.702.

After signing, the participants answered the MMSE questionnaire, carried out the balance test on the force platform and then the TUGT after a 5-minute interval.

On the force platform (BIOMEC 400, EMG System do Brasil, Ltda SP), five conditions of postural balance were carried out, and the order of tasks were raffled by participants themselves. All participants were instructed on each balance condition. From the experimental protocol, three attempts of 30 seconds with 30 seconds of rest were accomplished and means of attempts were collected for analysis. Regarding the Unipedal Stance Test (UPST) with eyes open, preferable leg and bipedal stand, participants performed it with their eyes open (BEO) as well as closed (BEC), and also performed Semi-Tandem stand with the heel of the foot that was at the front away 2.5 cm of the hallux that was behind on the platform, with their eyes open (STEO) and closed (STEC)[14].

For all the balance conditions, signals of the ground reaction force proceeding from the platform measures were collected in a sample of 100 Hz. These signals were filtered with a Butterworth second order low-pass filter at 35 Hz, converted through a stabilographic analysis, which were compiled with routines of the MATLAB (The Mathworks, Natick, MA) in order to extract all balance parameters associated with movements of the feet center of pressure (COP).

These parameters were characterized in time and frequency as: 95% interval of the COP ellipse area (A-COP in cm^2), oscillation mean velocity of the COP (velocity in cm/s) in the anterior-posterior (AP) and medial-lateral (ML) direction movements[11].

Concerning risk of falls (TUGT), groups were divided after taking the test according to the time spent: less than 10 seconds: low risk of falls; 10 to 20 seconds: medium risk of falls and over 20 seconds: high risk of falls[15].

Statistical analysis

The normality of the data was verified through the Shapiro-Wilk test. To determine difference between anthropometric characteristics, independent t test was used and consequently, to analyze possible influence of BMI on the variables, one factor ANOVA was carried out. The two-way ANOVA test verified differences between the balance variables for the two groups and Bonferroni Post Hoc test determined the location of differences.

To observe whether there is a correlation between the platform variables and the TUGT, Pearson's

correlation was carried out for both groups (old and young women). The statistical package used was the GraphPad Prism version 5. Significance adopted for this study was (p<0.05).

RESULTS

Table 1 presents anthropometric characteristics between the two groups (old and young women), for age, weight, height and BMI, which demonstrates heterogeneity between the groups. After adjusting the model, no association was observed (p>0.05) between the BMI value and the balance platform variables on both groups (young versus old women).

Table 1. Anthropometric characteristics

	Older women (n=43) Mean (SD)	Young women (n=40) Mean (SD)	*p* value
Age (years)	68 (5.3)	21 (3.2)	0.001*
Weight (kg)	63.5 (11.8)	61.5 (12.0)	0.001*
Height (cm)	1.52±0.06	1.63 (0.05)	0.001*
BMI (kg/m²)	27.10 (4.03)	23.11 (4.66)	0.001*

SD: standard deviation; BMI: body mass index

A significant difference was observed in the comparison between older and young women postural balance in the tasks. Values of Table 2 show that older women have worse postural balance compared to young women. Older women obtained higher values in most experimental tasks, nevertheless, the most difficult task for both groups was the UPST, followed by STEC and STEO (Graph 1).

Table 2. Analysis of postural balance and two-way ANOVA

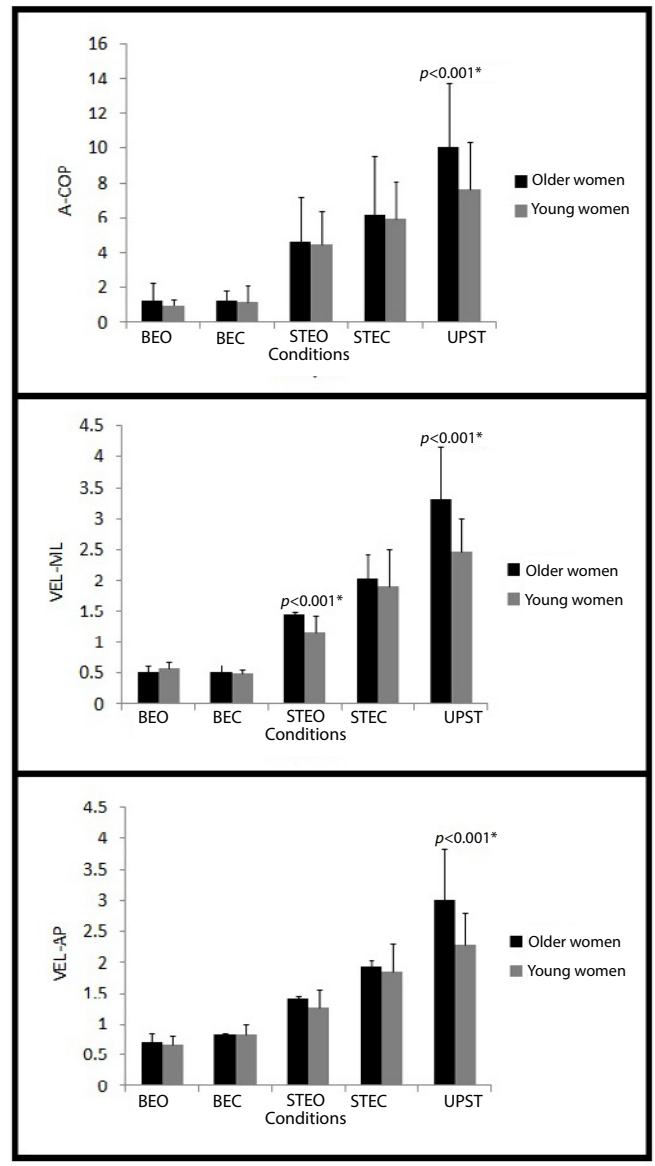
	Force platform Mean (SD)		Two-way ANOVA
Variables (Conditions)	Older women (n=43)	Young women (n=40)	*p* value
COP (BEO)	1.23 (0.99)	1.00 (0.36)	p>0.05
VEL AP (BEO)	0.71 (0.13)	0.68 (0.12)	p>0.05
VEL ML (BEO)	0.52 (0.10)	0.57 (0.12)	p>0.05
COP (BEC)	1.24 (0.61)	1.19 (0.90)	p>0.05
VEL AP (BEC)	0.82 (0.03)	0.82 (0.19)	p>0.05
VEL ML (BEC)	0.52 (0.11)	0.50 (0.06)	p>0.05

(continues)

Table 2. Continuation

	Force platform Mean (SD)		Two-way ANOVA
Variables (Conditions)	Older women (n=43)	Young women (n=40)	*p* value
COP (STEO)	4.65 (2.50)	4.48 (1.94)	p>0.05
VEL AP (STEO)	1.43 (0.04)	1.27 (0.29)	p>0.05
VEL ML (STEO)	1.45 (0.03)	1.17 (0.26)	p<0.001*
COP (STEC)	6.17 (3.37)	5.95 (2.10)	p>0.05
VEL AP (STEC)	1.93 (0.10)	1.83 (0.46)	p>0.05
VEL ML (STEC)	2.04 (0.40)	1.89 (0.63)	p>0.05
COP (UPST)	10.05 (3.73)	7.67 (2.65)	p<0.001*
VEL AP (UPST)	3.00 (0.84)	2.27 (0.53)	p<0.001*
VEL ML (UPST)	3.32 (0.73)	2.47 (0.67)	p<0.001*

AP: anteroposterior; BEO: bipedal eyes open; BEC: bipedal eyes closed; COP: center of pressure; SD: standard deviation; ML: medial-lateral; p>0.05: no significance; STEO: semi-tandem eyes open; STEC: semi-tandem eyes closed; UPST: unipedal stance test with eyes open; VEL: velocity of the COP



Graph 1. Comparison between two experimental groups

Regarding correlations between the two instruments in the older and young adult populations, no relationship was found. The biggest correlation found for older women was -0.21 and -0.17 for young women. Values of correlati ons between force platform and TUGT are presented on Table 3.

Table 3. Pearson's correlation between the Timed Up and Go test and the force platform variables

	r Pearson's (*p* value)	
Variables (Conditions)	Older women (n=43)	Young women (n=40)
COP (BEO)	0.09 (0.56)	0.12 (0.43)
VEL AP (BEO)	-0.08 (0.60)	0.02 (0.88)
VEL ML (BEO)	-0.21 (0.17)	0.03 (0.81)
COP (BEC)	-0.21 (0.16)	-0.09 (0.56)
VEL AP (BEC)	-0.17 (0.63)	-0.07 (0.63)
VEL ML (BEC)	-0.16 (0.29)	-0.02 (0.86)
COP (STEO)	0.01 (0.94)	-0.24 (0.12)
VEL AP (STEO)	-0.06 (0.69)	-0.17 (0.29)
VEL ML (STEO)	-0.08 (0.57)	0.15 (0.92)
COP (STEC)	-0.04 (0.79)	-0.20 (0.20)
VEL AP (STEC)	0.07 (0.63)	-0.17 (0.29)
VEL ML (STEC)	-0.10 (0.51)	-0.06 (0.70)
COP (UPST)	-0.06 (0.68)	0.08 (0.51)
VEL AP (UPST)	0.12 (0.42)	0.08 (0.60)
VEL ML (UPST)	0.04 (0.75)	0.13 (0.40)

AP: anteroposterior; BEO: bipedal eyes open; BEC: bipedal eyes closed; COP: center of pressure; SD: standard deviation; ML: medial-lateral; *P*>0.05: no significance; STEO: semi-tandem eyes open; STEC: semi-tandem eyes closed; UPST: unipedal stance test with eyes open; VEL: velocity of the COP.

Regarding risk of falls evaluated through the TUGT, mean time of older women was 9.01 against 7.71 of young women. Reference values indicate low risk of falls in both groups.

DISCUSSION

The results of comparison between the groups showed worse postural balance of older women compared with young women and low risk of falls in both groups; such results support our first hypothesis. However, weak relationship was found between the TUGT and the balance measures in both groups; such result refutes our second hypothesis. It is worth mentioning that greater instability in older women happens because the aging process itself changes organization of postural control (musculoskeletal system, somatosensory system and vestibular system) and at each new posture, decreasing information of these systems may compromise postural balance, which increases instability of older individuals[16,17]. However, differences between the groups for the investigated and explained variables, mostly by the aging process, did not generalize to a direct relationship between these variables (COP measures originated from biological signals versus TUGT derived from a single measurement domain that is equal to the time of performance).

Concerning balance conditions, we observed that the UPST was the most difficult task for the participants for both older and young women, followed by STEC, STEO, BEC and BEO in the variables of the COP. The study by Da Silva et al.[18] that evaluated older and young people, verified reliability of the UPST on the force platform to discriminate postural balance between these populations. In general, this study stated that this is a sensible tool and can tell the difference between these populations. In this way, the UPST causes more adversity, which makes more difficult for individuals to keep themselves on their support base[18].

This happens due to the maintenance of posture that is directly related to the gravity force, since it generates a torque on the ankle joint and accelerates the body, which causes more postural instability. The UPST intensifies it when the individual stands on just one limb, exploring postural control even more[19]. Michikawa and partners reported that UPST is the task that predicts fragility the most in the older population. The authors relied on three points: permanence time in the position, association of time in negative events such as falls and time improvement after intervention protocols[20].

Correlation between the TUGT and the force platform presented no relationship in both groups of women, older and young adults, which is consonant with some previous studies[21-23]. These studies showed diversity in functional outcomes such as tests and balance scales, correlating them with postural oscillations identified in high-tech equipment as force platform, verifying little or no relation, which can demonstrate that these functional tests are not able to deepen within the neuromuscular balance[24].

On the other hand, the study by Sabchuk[8] and partners contradicts our findings. They evaluated 21 young people and 18 older people, using TUGT and force platform. Such study presented a (r=0.45) correlation, concluding that it provides similar information between these evaluation methods. However, they reported that there is a difficulty regarding ability to identify small

postural adjustments, which can be verified with high-tech equipment as the force platform[25].

With 9.01-second values in the TUGT, older women presented a low risk of falls, agreeing with a meta-analysis study that verified twenty-one studies about reference values of the TGUT, testifying that normal values, i.e., low risk of falls in individuals over 60 years old is around 9.04 seconds[26]. In the absence of a high-tech instrument such as the force platform, the TUGT is a tool that can be used to evaluate risk of falls for postural balance analysis. It is important to highlight that there are several instruments that investigate postural balance besides the TUGT and the force platform. Therefore, these results help healthcare professionals improving decision making in the moment of choice in order to evaluate potential risks of falls that the older women may present, and thus, provide preventive solutions to decrease this phenomenon[27,28].

Under a future perspective, researchers can investigate the effect of cognitive tasks on performance of postural balance, risk of falls, analysis of the older women group with frequent falls and the dependent older women group, in order to have a wider view about aging and falls. With that in mind, they can study planning and prevention of falls for this population.

CONCLUSION

Older women presented a greater deficit in balance compared to young women. However, the unipedal support task presented bigger challenges for postural control of both old and young women. No correlation was found between postural balance (force platform) and risk of falls (TUGT) in both populations.

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