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Original Research Article

Surface Stability Affects Forward Reaction Time in Healthy Elderly Subjects

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ABSTRACT

Background: Falls are a major problem in the elderly population. Assessment of postural stability in elderly on different surfaces is a challenge for clinicians and practitioners.
Aims: Our main objective was to assess and compare healthy elderly reaction time on an unstable and a stable surface support of the limits of stability (LOS).
Materials and Methods: Ten healthy elderly performed the limits of stability of the Computerized Dynamic Posturography under 2 conditions of surface support; condition 1: with a foam pad (Neurocom foam pad) to simulate an unstable surface and condition 2: without foam pad to mean a stable surface. Subjects had to move their center of pressure on four directions: forward, right, back, and left for each condition.
Results: The results indicated that there is a significant difference ($p < 0.05$) in reaction time of the limits of stability only in forward direction between both surface support conditions.
Conclusions: Training elderly balance on an unstable surface using a foam pad seems to be effective to improve reaction time while preparing elderly falls protection strategy.

Keywords: Reaction time; Healthy elderly; Surface stability; Limits of stability.

INTRODUCTION

Balance is a reflex activity through which humans are able to maintain their body posture against gravity and natural inertia without falling. Maintaining balance requires a complex interplay between sensory and motor systems. [1-3] To maintain a stable upright stance, information processed through the somatosensory (70%), visual (10%), and vestibular (20%) system needs to be integrated. [4] With increasing age, the integrity of these systems declines, [3,4] resulting in sensory impairments and gait and balance disturbances. [5,6]

Recent years have shown a progressive increase in life expectancy, which means that general practitioners and specialists increasingly need to face a more elderly population in their daily appointments. [7] In order to adequately evaluate the presented conditions of these ageing patients, a good knowledge of the effects of age on postural control and balance is key, as only this will allow the ability to distinguish between age-related physiological changes and actual pathological changes. [8-11]

We are living in complex environments which consistently challenge us to adapt the control of our body position to new situations. Balance control is a primary requirement for successful mobility. It is a well-known phenomenon that elderly subjects are more likely to have balance disorders which is associated with a higher risk of falling. [4,12,13] Approximately 30% of community-dwelling elderly over 65 years of age experience at least one fall per year and this amount increases up to 50% by the age of 80. [14] As falls may lead to injuries, restriction of daily activities, [15] fear of falling, [16] and mortality, [17] their impact poses large economic and societal burdens to health care systems worldwide. [3]

A main rehabilitation goal after a fall is the return to a good postural stability. A traditional method to evaluate balance performance is to study the ability to stand quietly on the level ground with or without surface translations. Seldom, stance on a surface different from the level ground is analyzed. However, common real world situations often demand standing on various surfaces. [18] Hence, there is a need to study postural control in everyday situations to improve the ecological validity of posturography. [19]

Therefore, the aim of this study was to assess healthy elderly reaction time on stance balance in two conditions of surface support using or not a foam pad to simulate an unstable ground. In addition, we investigate any correlation between participant's height and surface support conditions.

MATERIALS AND METHODS

Design

This was a cross-sectional study investigation of whether there was a difference in reaction time of healthy elderly subjects in two surface support conditions. We also searched for any correlation between participant's height and surface support conditions.

Participants

Ten healthy elderly subjects (sex: 3 male, 7 female; age: 75.5 ± 9.5; height: 163.5 ± 11.0) with no history of balance pathologies participated voluntarily in the study. Participants were included if they had Mini-Mental State Examination (MMSE) scores ≥ 24, were free from neurological diseases and other comorbidity affecting postural instability, were able to stand upright independently, no records of unexplained falls in the previous 6 months and normal vision with glasses or contact lenses compensated. All subjects were recruited from an Extension Project of Universidade do Estado de Santa Catarina and all participants gave informed consent according to the Declaration of Helsinki. The study was approved by the Human Research Ethics Committee of Universidade do Estado de Santa Catarina (protocol number: 789272).

Postural study

In order to develop the study the Neurocom Smart Balance Master® posturography platform was used. Participants performed the test under two conditions of surface support; condition 1: with a foam pad and condition 2: without a foam pad (Figure 1 and Figure 2) respectively. The foam pad consists in a quadratic soft foam (46 x 46 x 13 cm) which has the same size and design as the base of support of the Neurocom.

To study the *Limits of Stability (LOS)*, subjects were asked to move their centre of pressure (represented by a pictogram on a screen in front of them) along the path of a moving circle through four different points in the space, always passing through the central starting position. In this study, we considered the four principal points, which are: Direction 1-Forward; Direction 2- Right; Direction 3-Backward; and Direction 4- Left.

Statistical analysis

The variable reaction time of the LOS in the four previously cited directions was analyzed. The collected data were recorded in the Microsoft Excel Microsoft Office 2013 package. They were subsequently imported into SPSS 20.0 for Windows for the inference statistical analysis. Data normality was tested performing the Shapiro-Wilk test. Wilcoxon signed-rank test was used to compare reaction time of the LOS means performed under both conditions (with and without the foam pad). Finally, to analyze correlations between participant's height and reaction time in the four directions for both conditions of surface support, Spearman's rank correlation coefficient was used. Significance level was set at 5% (p-value less than 0.05).

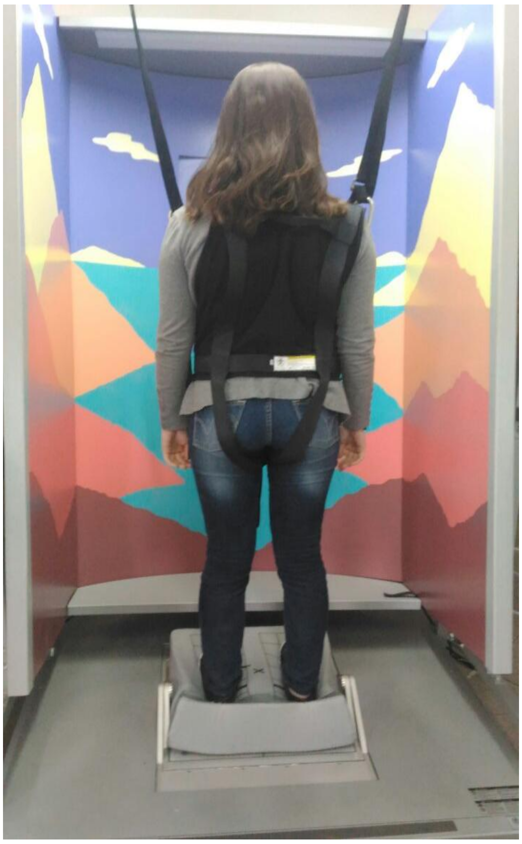

Figure 1. Computerized dynamic posturography: Neurocom Smart Balance Master® posturography platform with foam pad.

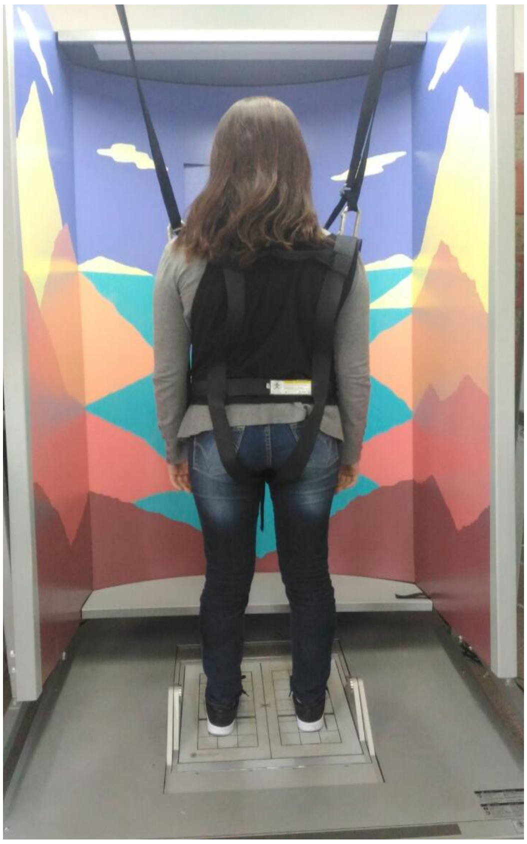

Figure 2. Computerized dynamic posturography: Neurocom Smart Balance Master® posturography platform without foam pad.

RESULT

Participant's characteristics in terms of sex, age, height and MMSE are presented in Table 1.

Table 1: Participant characteristics

Participant	Sex	Age (y)	Height (cm)	MMSE
1	M	63	170	30
2	F	88	148	27
3	F	65	163	28
4	F	60	166	28
5	F	60	164	30
6	F	81	154	28
7	F	76	166	30
8	M	76	153	30
9	F	75	145	25
10	M	77	181	25
Mean ± SD		**75.5±9.5**	**153.5±11**	

cm: centimeter; MMSE: Mini-Mental State Examination; SD: standard desviation; y: years

Limits of stability

The limits of stability quantify the maximum distance a person can intentionally displace their centre of gravity, lean their body in a given direction without losing balance, stepping, or reaching for assistance.

Reaction time

The reaction time (RT) is the time in seconds between the command to move and the participant's first movement. Table 2 shows the results of the participants under both conditions and the p-value of the comparison between their means. Reaction time shows significant difference between condition 1 (0.93 ± 0.6) and condition 2 (2.08 ± 1.14) only for forward direction (p= 0.022). For the other directions, significant difference was not found (p > 0.05) between the two conditions assessed.

Table 2: Mean ± Standard desviation of RT for both conditions and p-values of the mean's comparison.

Directions	Condition 1	Condition 2	Difference p-value
Forward	0.93 ± 0.6	2.08 ± 1.14	0.022 *
Right	1,11 ± 0.37	1.96 ± 1.54	0.327
Back	0.95 ± 0.76	1.07 ± 0.65	1.000
Left	1.35 ± 0.92	1.28 ± 0.55	0.959

* p< 0.05

On the other hand, participant's height presented low to moderate correlation ρ = (0.12 - 0.56) with the directions for both conditions. None of these correlations was statistically significant (p > 0.05) see Table 3.

Table 3: Correlation between participant's height and RT in condition 1 and 2 for the different directions.

	Forward		Right		Back		Left	
	Cond 1	Cond 2	Cond 1	Cond 2	Cond 1	Cond 2	Cond 1	Cond 2
Height	0.16	0.13	0.13	0.56	0.13	0.12	0.23	0.02
p-value	0.65	0.71	0.76	0.12	0.76	0.78	0.52	0.95

*p < 0.05, Cond 1= with foam, Cond 2= without foam

DISCUSSION

The aim of this study was to analyze reaction time of the Limits of Stability (LOS) considered as a principal parameter before and during falls in healthy elderly under a stable and an unstable surface support using the Computerized Dynamic Posturography (CDP). This later is a technique used to objectively quantify and differentiate among the wide variety of possible sensory, motor, and central adaptive impairments to balance control. It is widely used as a complementary to clinical tests to localize and characterize pathological mechanisms of balance disorders. [7,20,21]

With age increasing, falls during performing daily activities become one of the major health problem in elderly, which may lead to injuries, mortality and economic burden. [3,17] The reaction time since object impact until fall in any direction is an important parameter which can be trained and monitored by physical therapists as a way of improving protection strategy. Faraldo-García A et al. [7] observed that reaction time increases with age and this is more pronounced after 40 years old. This suggests that elderly present a delay at the start of the correction of the fall. This phenomenon can be explained by the physiological ageing of the body and slowing of reflex with age.

Regarding ground stability, we found that there is no statistically significant difference (p > 0.05) for reaction time when elderly performed LOS with a stable and an unstable surface support for right, back and left directions. These results are similar to those found by Faraldo-García A et al. [20] when they compared healthy subjects and patients instability where they did not find any statistically significant difference between both groups. However, in our study we found a significant difference in reaction time betweens table and unstable surface support for forward direction.

This may be explained by the fear of falling elderly feel when they are on an unusual ground and for forward direction, they are able to anticipate the center of pressure displacement. Okada S et al [22] observed that fear of falling have negative effects on balance ability on elderly women showing that a fear of falling increases the co-contraction of antagonist muscles in the lower extremity muscle group but they did not analyze the effect on different directions separately. It was also hypothesized that aged subjects with these fears tend to stiffen their bodies when stance is perturbed. [23] Therefore, the delay on the reaction time at the start of the fall correction in unstable surface may be explained by the stiffness of the lower extremity muscle group which need to release before individuals start correcting fall in forward direction.

On the other hand, it is well documented in the literature that the anticipatory postural adjustments (APA) during dynamic equilibrium are highly important because they reveal the capacity of the central nervous system to anticipate the perturbation associated with the upcoming movement and to compensate for it [24] The decrease with aging of the potential of the internal feed forward or predictive model, suggests that elderly are not able to anticipate the perturbations generated by the displacement of the limb and to counter for its destabilizing effects. [25] Instead, they react afterwards: they behave more in a reactive rather than in a predictive manner. [26] This motor control theory may also explain the overall delay in reaction time that occurs in elderly. Thus, while performing LOS in an unstable ground, elderly previously activate their somatosensory, visual, and vestibular systems in forward direction, which is the easiest direction to move on, and consequently reduce their reaction time when compared with a stable ground. Because of the difficulty to move on the other directions (right, back, and left), even with all this previous mechanism activation, no significant difference was observed for these directions.

Regarding participant's height and LOS reaction time, we did not find any correlation ($p > 0.05$) for the directions assessed independently of the ground condition, stable and unstable. This means there is no relation apparently between the body center of gravity and ground stability in term of reaction time.

Hirase T et al. [27] in a recent randomized controlled trial showed that older adults who underwent a training balance program with a foam rubber pad improved physical function, fall risk and number of additional falls during intervention at 1 to 4 months when compared with older adults trained on a stable surface. In our knowledge, this is the first study analyzing in details elderly reaction time under a stable and an unstable surface simulated by a foam pad specifically designed for the LOS. This information may be used to optimize neuro rehabilitation exercises specifically targeting the update of feed forward models and training in different ground stability which is a reality in elderly daily activities. The number of participants in our study is low to certify the results. Future studies should explore these results in a major participant's number.

CONCLUSIONS

In this study, we simulate an unstable ground with the use of a foam pad specifically designed for the LOS of the computerized Dynamic Stability. Unstable ground affects forward reaction time in healthy elderly. Thus, elderly's height does not relate with reaction time independently of the ground condition. The use of foam pad in training balance is feasible and effective to improve reaction time in healthy elderly.

Conflict of interest: None.

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