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The Influence of Upper Limb Elevation on Balance in Elderly Women

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Abstract

Background: The aging process is progressive and dynamic, and it makes organisms susceptible to adverse conditions.

Purpose: The study was designed to analyze the influence of upper limb elevation on the balance of elderly women through baropodometry, considering the presence of postural, somatosensory and balance dysfunctions and the negative impact caused by such changes on the quality of life.

Methods: It is a cross-sectional study with 42 elderly women. Anthropometric aspects as well as baropodometric and stabilometric data were evaluated regarding the body balance under three circumstances: Standing position (T1), upper limb elevation (T2) and a second upper limb elevation (T3). Data were processed using SSPS®, version 18.0. The Shapiro-Wilk test was used to evaluate the normality. Then, Kruskal-Wallis with post-hoc Student-Newman-Keuls was used for the differences among means and the Spearman correlation. The p-value was set at 0.05. Results: A significant increase in the total plantar area (p=0.006) was observed in T2 and in a comparison between T3 and T1. The total displacement oscillation (mm) was smaller in T2 when compared to T1 (p=0.044). A reduction in the total average speed (mm/s) was observed in T2 and in a comparison between T3 and T1 (p=0.034). A positive correlation could also be found between age and displacement (r=0.313) and average oscillation speed (r=0.319) in T3 as well as with the amplitude of oscillation in the anterior-posterior direction in T1(r=0.362), T2(r=0.409) and T3(r=0.470).

Conclusion: The elevation of the upper limbs in older women led to an increase in the total plantar area and a reduction in body sway, therefore increasing postural stability.

Keywords Postural balance; Aging; Physical therapy

Introduction

Aging is a dynamic and gradual process involving morphological, biochemical and functional changes that alter the organisms and leave them susceptible to aggressions and deformities [1]. Both the ability of the central nervous system to process vestibular, visual and proprioceptive signs, responsible for maintaining body balance, and the capacity to modify adaptive reflexes are compromised.

Balance is the ability to maintain [2] and control the projection of the center of gravity within the limits of the support base, preventing accidents and falls. Meereis et al. [3], indicate balance as an important factor to perform functional movements with a lower energy expenditure.

According to the International Classification of Diseases (ICD-10), falls [4] represent the leading cause of injuries in the elderly, causing bruises, fractures, hospitalization, institutionalization, incapacity and even death [5].

Thus, the capacity to maintain balance is important for elderly people, and it should be measured and assessed [6,7]. However, researchers and therapists who work with balance struggle with the lack of instruments to quantify body sway accurately [8].

Several assessment tools have been developed to identify the probability of falls [9]. Some examples are qualitative and objective methods. Scales, tests, questionnaires, among others, are examples of the first, while the latter is represented by posturography, in which a force platform measures body sway and center of pressure variables [10].

In general, this platform consists of a plate under which piezoelectric or load cell sensors are positioned to measure three strength components, Fx, Fy and Fz (x, y and z are the anterior-posterior, mid-lateral and vertical directions) and the three moments of force, Mx, My and Mz acting on the platform. It is referred to as six component platform because it measures six physical quantities [11].

Some studies have already verified a positive correlation between aging and oscillation in the elderly persons [12-15].

The elevation of the upper limbs, a very common movement in daily activities, causes postural disturbance and, therefore, balance needs to be reinstated.

Several studies have been conducted to verify how motor strategies emerge from different disturbance parameters and populations, such as in the elderly. However, there are not many studies in the literature correlating baropodometric and stabilometric parameters with the elevation of the upper limbs and its importance when evaluating the risk of falls.

The degenerative processes that affect elderly people jeopardize their autonomy, directly affecting motor balance. The high rates of falls reflect these changes.

Baropodometric and stabilometric parameters provide the necessary data to evaluate the treatment efficacy in terms of improving balance and, thus, directing rehabilitation types.

The study was designed to analyze the influence of the elevation of upper limbs on balance in elderly women using baropodometry, to better comprehend the postural deficiencies among this population and individualize rehabilitation programs, considering the presence of postural, somatosensory and balance dysfunctions, and the negative impact caused by such changes on the quality of life.

Methods

Study design and ethical aspects

This is a cross-sectional study with a quantitative approach performed with older women who are members of a social project in the Physical therapy department of a public hospital in Teresina-Piauí. The trial followed the ethical criteria stated in resolution 466/2012 of the National Health Council – CNS and was approved by the local ethics committee (Universidade Estadual do Piauí, approval number 63586). All women provided written informed consent to participate.

Participants

A simple random sample of 42 individuals was studied. The women included were aged 65 to 80 years, did not perform physical activities regularly (twice or more than twice a week), and explicitly agreed to participate. The women who could not perform the proposed activities or understand instructions were excluded.

Outcome measures

An anthropometric evaluation was executed: Weight, height and body mass index – BMI. An electronic scale Filizola®, for up to 150 kg was used to measure weight. Participants wore light pieces of clothing and were barefoot. An anthropometer measured height while they stood barefoot in the upright position, feet together, facing forward. The weight was checked in grams and the height in centimeters [15].

The baropodometric and stabilometric data were collected using an electronic baropodometer (S-PLATE), comprising a force platform with 1600 sensors, active surface of 400 × 400 mm measuring 610 × 580 × 4 mm and 6.8 kg, connected to a VAIO Intel Pentium laptop, 1.86 GHz processor, 0.99 GB RAM, Windows XP. The participants were instructed to stand on the platform, barefoot, with bipedal support and feet hip-width apart. Furthermore, they were oriented to keep their eyes open while staring at a specific point marked on the wall at eye level, arms relaxed on their sides, for 30 seconds.

The evaluation was divided into three phases: T1: Participant kept a static posture for 30s. T2: Participant kept a static posture and after 15s, they received a visual sign from the examiner to flex their upper limbs at 90º and hold this position until the clock showed 30s. T3: The procedure T2 was repeated.

The volunteers using corrective lenses wore them during the test. The platform was marked on the first attempt of each participant, as a support base, and repeated on the others to assure the same basis throughout the tests, as suggested by Teixeira et al. [14].

The study assessed total plantar área in cm2 (AREA) and the following kinetic variables: total displacement oscillation (TDO), total average speed (TAS), amplitude of displacement of the center of pressure in the anterior–posterior plane (ACPap), amplitude of displacement of the center of pressure in the mid-lateral plane (ACPml).

Statistical analysis

Data were processed and analyzed using SSPS®, version 18.0. First, the Shapiro-Wilk test was used to evaluate the normality of the variables. Then, Kruskal-Walliscom test with post-hoc Student-Newman-Keuls was used to verify the differences among means; Spearman was used to correlate the variables. A p-value of $p<0.05$ was considered statistically significant.

Results

Forty-two women took part in the trial. The age average was 68.7 ± 6.6 years. Table 1 shows the data referring to the anthropometric measurements of the participants.

	Mean	S.D	Minimum	Medium	Maximum
Age(years)	68.7	6.6	59.0	68.0	86.0
Weight (kg)	60.4	9.7	44.0	59.3	80.8
Height (m)	1.53	5.2	1.39	1.53	1.65
BMI (kg/m²)	25.9	3.8	18.3	25.3	34.5

Table 1: Age and anthropometric characterization of participants (n=42). Kg= kilograms; m= meters; S.D= standard deviation

After a comparative analysis, the following results were observed: a statistically significant increase of the plantar area (p=0.006) between T2 and T3, a decrease in total displacement oscillation (TDO) when comparing T1 to T2 with p=0.044 (Table 2).

	Standing (T1)	Elevation 1 (T2)	Elevation 2 (T3)	P*
	Mean (S.D)	Mean (S.D)	Mean (S.D)	
Area (cm²)	299.3 (28.0)	313.8 (28.4)a	320.2 (29.3)a	0.006
TDO (mm)	115.0 (55.9)	94.4 (34.8)a	97.0 (49.9)	0.044
TAS (mm/s)	3.5 (1.7)	2.9 (1.0)a	2.9 (1.5)a	0.034
ACPml (mm)	11.5 (7.3)	9.9 (9.1)	9.8 (7.2)	0.127
ACPap (mm)	13.5 (8.8)	13.1 (11.1)	12.7 (6.1)	0.958

Table 2: Comparative data of baropodometric and stabilometric data means in different positions (n=42). Same letters in a line represent significant difference for Student-Newman-Keuls after Kruskal-Wallis (p<0,05). TDO: total displacement oscillation, ACPap: amplitude of displacement of the center of pressure in the anterior–posterior plane, ACPml: amplitude of displacement of the center of pressure in the mid-lateral plane, TAS: total average speed.

There was also a considerable decrease in TAS (mm/s) when comparing T1 and T2 (p=0.034). The same result was observed for the second elevation. ACPm-l and ACPa-p had a slight reduction in a comparison between T2 and T3, although not statistically significant (Table 2).

A positive correlation could also be found between age, displacement and average oscillation speed in T3 as well as with the amplitude of oscillation in the anterior-posterior direction in T1 and T2. In T3 the correlation was higher (Table 3).

Discussion

Postural balance is the result of a complex interaction among the sensory, nervous and musculoskeletal systems. It requires a constant adaptation of the muscular activity, sense of articular positioning and other sensory information in order to maintain the center of mass of the body on the support base [16].

Studies involving posture control and balance [12-14] have been using the force platform to measure the strength and moments generated by movements and body posture sway [3]. This assessment method has proven to be adequate to qualify small losses and provides precise data and more efficient results than subjective methods [10].

The platforms determine the location and temporal evolution of the center of pressure (COP), the main parameter analyzed in postural balance studies [17], representing the application point of the vertical resultant forces over the support area [3]. In turn, COP is influenced by the center of gravity (CG). The movement of the body segments causes the CG displacement. And the COP displacement is generated by the ground reaction force, CG acceleration, body inertia and the muscular strength applied in the ankle. In other words, it is the neuromuscular answer to the CG oscillation [17].

A significant increase of the plantar area as well as a displacement and average oscillation speed reduction were observed due to the upper limbs elevation, which is an important factor to improve support base and balance maintenance. According to Toledo and Barela [5], the somatosensory system has an important role maintaining balance in older individuals because the other sensory systems, such as the vestibular and visual systems, are altered by senescence, and cannot provide information with enough quality to control and keep an upright position.

Thereby, it is safe to deduct that the CNS prefers somatosensory afferences to readjust posture, given they inform the CNS about the different segments of the body through proprioceptors (muscle spindles, neurotendinous organs and articular receptors) and mechanoreceptors (Pacinian corpuscles and Merker´s discs) [18,19].

Moreover, some studies point out the importance of the somatosensory component, showing that the decrease of plantar sensibility resulting from the aging process is related to postural unbalance [20,21]. Thus, the elevation of the upper limbs stimulated this afferent system (the proprioceptive system), increasing the plantar area and, consequently, reducing postural oscillation.

The postural alterations in the elderly people associated to articular instability, muscular weakness and changes in the support base [22], moved the CG forward [23]. The shortening of the flexors and hip adductors and abductors in an attempt to lower the CG closer to the support base to keep body balance and prevent falls corroborate this fact [24].

Yiou et al. [25] suggest the horizontal elevation of the upper limbs can induce internal forces and torques at the shoulder level, which is initially directed downward. Additionally, the center of gravity is relocated when the arms are elevated, disturbing the initial balance conditions.

So, the elevation of the upper limbs in older people moves the center of gravity to a physiological location. Hall [26] points out the displacement of the center of gravity may occur due a repositioning of the body segments at a given moment. Every time an arm, a leg, a finger, the torso moves, CG shifts towards the weight change. Therefore, it is important to say the weight is equally distributed in all directions around the CG. Thus, the smaller the displacement oscillation the better the body balance.

The anticipatory postural adjustments could also have contributed to reduce body sway in the women evaluated after elevating the upper limbs. For instance, the experimental data obtained using the force platform showed a series of dynamic phenomena occurred right before the upper limb elevation, including the acceleration of the center of gravity forward and upward [27,28].

A decrease in the total average speed oscillation was observed when comparing the upright position to elevation 1, and also in elevation 2.

Wieczorek et al. [17] mention a previous study that evaluates speed and amplitude of oscillation in a population of elderly people. It showed a significantly higher speed for those who fell at least once in a one-year period, demonstrating postural instability. Based on these data, the best balance achieved was with the upper limbs elevated.

Seniors oscillate more than young adults when standing upright, especially in situations demanding a stronger postural control. And the increase in sway is proportional to age [12-14]. This explains the correlation among age, displacement, speed, and amplitude of displacement of the center of pressure in the anterior–posterior direction found in the second upper limb elevation (T3), when a stronger postural control is necessary. This can be attributed to the fact that there is greater muscle activation to maintain postural control, since the elevation of the upper limbs is a postural disturbance.

The amplitude of oscillation in the anterior-posterior direction was the only parameter that showed a correlation with age in the three phases studied (T1,T2, and T3). Júnior Freitas and Barela [13] investigated in which life period postural control changes occur in a sample composed of youngsters, adults and older people. The authors observed an increase in the amplitude of oscillation in the anterior-posterior direction after the age of 60, inferring the aging process influences the maintenance of postural balance, especially in this direction.

Conclusion

The voluntary elevation of the upper limbs in older women lead to an increase in the total plantar area and a reduction in body sway, therefore increasing postural stability. Furthermore, the tool used to be useful to analyze postural oscillation, demonstrating an increase in the positive age correlation with body sway when performing the voluntary movement (upper limb elevation). More studies about posture control are suggested to better understand how balance is controlled during voluntary movements and how this control adapts to postural impairments in elderly people, hence individualizing rehabilitation programs.

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