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Static Balance in the Elderly: Comparison between Elderly Performing Physical Activity and Fine Motor Coordination Activity

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Abstract**—**Senescence changes include postural balance, inferring the risk of falls, and can lead to fractures, bedridden, and the risk of death. Physical activity, e.g., cardiovascular exercises, is notable for improving balance due to brain cell stimulations, but fine coordination exercises also elevate cell brain metabolism. This study aimed to verify whether the elderly person who performs fine motor activity has a balance similar to that of those who practice physical activity. The subjects were divided into three groups according to the activity practice: control group (CG) with seven participants for the sedentary individuals, motor coordination group (MCG) with six participants, and physical activity group (PAG) with eight participants. Data comparisons were from the Berg balance scale, Time up and Go test, and stabilometric analysis. Descriptive statistical and ANOVA analyses were performed for data analysis. The results reveal that including fine motor activities can improve the balance of the elderly and indirectly decrease the risk of falls.

Keywords**—**Balance, barapodometer, coordination, elderly.

I. Introduction

ALL over the world, more and more people are getting older. The population of people aged 60 years and over increases at a rate of 3% per year and estimations show that some 85% of seniors report with balance complaints [1], [2]. Different age group studies report a loss function of organ systems at a rate of 1% per year from 30 years [2]-[4]. The body balance changes are one of the most affected functions resulting from the senescence process. The body's motor control and coordination process use postural stability to preserve balance during static and dynamic activities [5]-[8].

Postural control originates from motor control, related to the motor skills learning processes, divided into two main groups. The gross motor function or global motor behavior corresponds to the activity of large muscles, which control posture and large movements. The fine motor skills (also assigned adaptive motor behavior) are responsible for accurate and precise movements and associated with the activity of small muscle groups [9]. Fine motor control or psychomotor has its full-grown with gross motor control. Psychomotor development involves the functional establishment of the whole body, initially motor (reflex or voluntary) afterwards mental [10]. The interconnection maintained between fine and gross motor control occurs from conception to senescence. In senescence, psychomotricity interacts with cognitive and affective areas to modify motor behavior. Balance involves the reception and integration of sensory stimulus, the planning, and the execution of movements to control the center of mass. Senescence causes a deficiency in this system and can eliminate several stages of postural control, reducing the compensatory capacity of the system, leading to increased instability. The reduction in balance with senescence is due to a reduction in proprioception, slower postural correction reflexes, decreased muscle strength of postural control, and increased postural sway, consequently, increased risk of falls [4], [11]-[13].

Falling is the most dangerous consequence of a change in balance for an older person. However, a deficit of balance starts as a decrease in general function, a difficulty in performing daily tasks, which will only be evident after the fall of the individual [14], [15]. The fall of an elderly can lead to fractures, the possibility of bed rest, and the risk of death. These factors decrease their independence, autonomy, and quality of life, and significantly increase the costs associated with looking after the elderly population [13].

Physical exercise is the most efficient way to prevent a decline in the functional capacity of the subject. Activity helps in the prevention and management of certain chronic diseases and conditions, improving balance and flexibility [1], [4]. Besides, cardiovascular exercises act on the hippocampal metabolism, where memory and spatial location (body location) are a primary function. Both functions are vulnerable to deterioration due to senescence [2]. Similarly, the effects of fine coordination exercises on the improvement of activity are increasing, as these movements elevate brain cell metabolism and have an impact on the speed of action, reaction speed, and balance [16]. Therefore, it is relevant to study how fine motor coordination activities are efficient to maintain balance and prevent falls in the elderly. The objective of this work is to verify the similarity between the balance of the elderly in performing fine motor coordination activities and regular physical activity in elderly groups.

II. Methodology

The regional ethics committee, according to Protocol No. 3.204.004, approved this study. All subjects were volunteers and informed of the research procedures before signing the Informed Consent Form.

Sample and Recruitment: The research sample consisted of

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51 people divided into three groups as follows:

a) PAG - exercise twice per week for at least three months;
b) MCG - do not perform any physical activity, only fine motor activities like painting, chess, arts, knitting, or crochet;
c) CG – regular daily activity, no workout or fine motor coordination activities.

Eligibility Criteria: Volunteers underwent anamnesis and answered the International Physical Activity Questionnaire (IPAC). Inclusion criteria were senescence from 60 to 90 years old, both sexes, and not using medication that could influence postural balance. The exclusion criteria were a vestibulopathy, orthopedic, cardiovascular, psychiatric, and neurological impairment that does not allow the execution of all study tasks and sensory disorders in the lower limbs caused by diabetes.

Evaluation Procedure: Berg Balance Scale [17] and the Time Up and Go test (TUG) [18], [19] were the qualitative balance assessments used. Also, individuals stand on the baropodometer for 30 seconds, positioned at a distance of 1.5 m from the front wall, as suggested by [7].

Data collected for static analysis were total oscillation displacement, oscillation amplitude, the average global oscillation velocity (VCoP), and area (ACoP). The equipment was an S-Plate baropodometer, which consists of 1600 sensors with an active matrix of 400 mm × 400 mm, and has a frequency acquisition of 100 Hz used for balance assessment.

Statistical Analysis: Descriptive statistical analyses were performed the calculation of mean, standard error, median, and quartiles for quantitative variables, frequencies, and percentages for qualitative variables. Analysis of variance (ANOVA) followed by Tukey test for variables with the symmetrical distribution compared the balance between groups. For non-symmetrical distribution variables, the comparisons used the Kruskall-Walis test, followed by Dunn's multiple comparison test. Lastly, t-Student and Wilcoxon paired tests were taken for statistical moment analyses. All tests use the significance level of 5% or the corresponding p-value with program SAS for Windows, v.9.2.

III. Results

The subjects who participated in the study were 17 from CG, 17 from MCG, and 17 from PAG. There was no statistically significant difference concerning the anthropometric data described in Table I.

TABLE I
DESCRIPTIVE ANALYSIS OF THE ANTHROPOMETRIC DATA BETWEEN GROUPS

Anthropometric data	CG	CGM	PAG
Age	74.18 ± 2.1	71.88±1.84	69.94±1.76
Body Mass	74.18±3.016	65.41±2.065	63.35±2.26
Height	163 ± 2.48	157.4 ± 1.45	159.4±2.13

GPA: Physical Activity Practicing Group; EP: Standard Error

The stabilometric evaluation performed by baropodometer refers to the descriptive values, as shown in Table II.

TABLE II
DESCRIPTIVE ANALYSIS OF BAROPODOMETRIC VARIABLES DURING ASSESSMENT BETWEEN GROUPS

Variables	CG	CGM	PAG	p Value
Oscillation Length (mm)	200.96 ± 29.35	61.71 ± 3.41	57.90 ± 2.05	< 0.0001
Oscillation Area (mm^2)	799.84 ± 71.91	24.49 ± 5.44	18.48 ± 2.55	< 0.0001
Average Speed (mm/s)	6.17 ± 0.63	1.86 ± 0.07	1.75 ± 0.04	< 0.0001
Oscillating Speed Latero – Lateral (mm/s)	4.08 ± 0.78	1.32 ± 0.083	1.22± 0.038	< 0.0001
Antero Oscillation Speed - Posterior (mm/s)	3.98 ± 0.59	1.28 ± 0.079	01.23 ± 0.07	< 0.0001
Latero-Lateral Standard Deviation (mm)	5.29 ± 1.18	0.92 ± 0.08	0.84 ± 0.077	< 0.0001
Antero-posterior Standard Deviation (mm)	4.51 ± 0.63	1.59± 0.17	1.49 ± 0.1813	< 0.0001
Amplitude of Oscillation Latero - Lateral (mm)	29.48 ± 8.44	4.44 ± 0.49	3.71 ± 0.29	< 0.0001
Antero Oscillation Amplitude - Posterior (mm)	22.35 ± 13.41	6.67 ± 3.035	6.11 ± 2.64	< 0.0001

GPA: Physical Activity Practicing Group; EP: Standard Error; $p \leq 0.001$

The Berg Balance Scale test shows a high risk of falling for the CG. The CG obtained 39 ± 1.98 points, and it is statistically significant ($p \leq 0.0001$) compared with the MCG (53 ± 0.79 points) and PAG (54 ± 0.4 points). In the literature, values equal to or lower than 45 already represent a risk of falling [17], [20], [21].

In TUG, participants in the CG group performed the test with an average time of 17.4 ± 2.01 seconds, which predicts moderate risk of falling, while participants in the CGM group performed the test with an average time of 9.14 ± 1.59 seconds and participants in the PAG group performed the test with an average time of 7.8 ± 0.47 seconds, showing a statistically significant difference ($p = 0.0006$).

Fig. 1 shows the graphs obtained in the evaluations performed. It can be noted that the CGM and PGA groups present relevant results when compared to the CG.

IV. Discussion

The elderly who performed physical activity present better postural balance than the CG, as the studied variables show. Results endorse the benefits of physical activity and the importance of a workout guidance practice for the elderly [1], [2].

The qualitative evaluation results of the Berg Scale and TUG evaluations showed a strong correlation between the tests performed, similar to [17] in a validation study of the Brazilian version of the Berg scale, and demonstrating the high sensitivity to detect the risk of falls in the elderly.

The length, area, and velocity of the Center of Pressure (CP) of the CG group measurements had significantly higher values compared to the other groups, demonstrating their fragility of static balance. Those variables represent the average of body sway, so higher values mean an imbalance on volunteers, as [22] and [23] find. With this greater amplitude, the body needs greater strength to move it away from the limit of stability, in an attempt to keep it in its center. This excess force results from greater acceleration. The acceleration acts directly on the speed towards the center, implying a speed towards the acceleration. However, due to the magnitude of the acceleration, the speed quickly reaches a high value, crossing the central point and approaching the stability limit again. When, in delay, this phenomenon is perceived by the body because of the inefficient mechanoreceptors due to senescence, for example, the body urgently seeks to correct the trajectory of the COP, restarting the cycle to decelerate it by applying a very large force again.

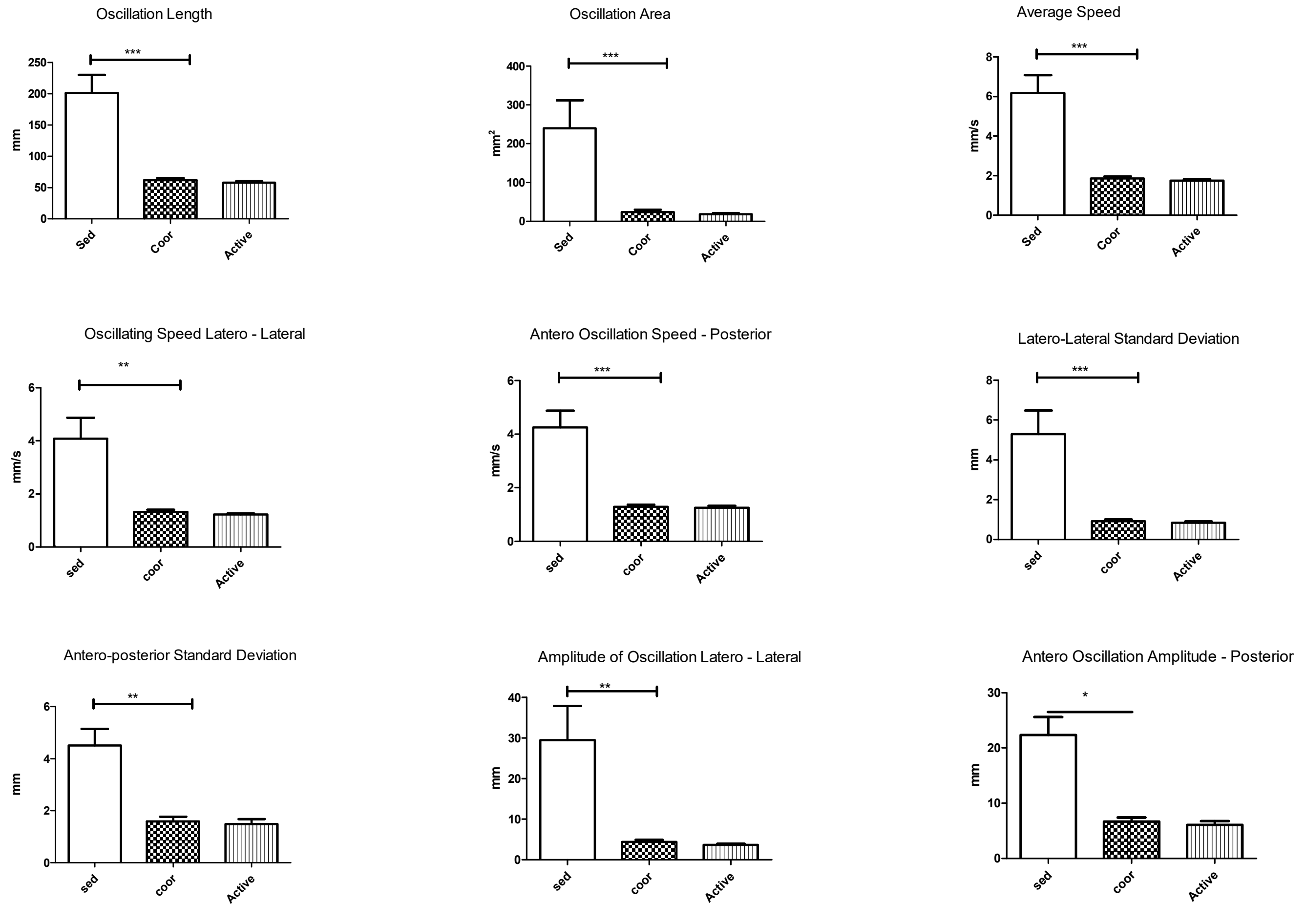

Fig. 1 Presents the graphs representative of the variables analyzed by the baropodometer in the open eyes condition

Baloh et al. [22] conducted research comparing the global oscillation speed of adults with that of the elderly and found that even the healthy elderly already had a significantly higher oscillation speed than adults, this difference increased even more when compared to the elderly who had complaints of imbalance. The oscillation area also increases proportionally to the oscillation speed.

MCG volunteers have a better balance than CG. Probably due to brain interactions, that fine motor coordination activity provides because it requires attention and focuses on the practitioner. Corresponding to [3] demonstrations when performing activities with focus, it is easier to move, resulting in an improvement of balance.

Anteroposterior balance data also present an increased body sway of volunteers from MCG comparatively with a GPA. Baloh et al. [22] studied a larger population of elderly and obtained improved anteroposterior and laterolateral oscillation.

The result of this study would influence other ways to prevent falls, mainly focusing on older people who do not practice physical activity due to unhealthy reasons, socioeconomic, cultural, or institutionalized.

V. Conclusion

The static balance evaluations among the elderly of the different groups, we conclude that the elderly classified as sedentary have a large balance deficit. The elderly who performs only fine motor coordination activity presents a balance similar to the balance presented by the group of elderly who perform physical activity. The competitive neural statokinesigram (CNS) technique comes about to be an alternative to determine the CP in real-time as well as to compute a fall risk displacement rate according to a geometric equilibrium intensity. Such an approach enables to find out a degree of oscillation which enables to obtain a robust body sway and postural equilibrium analysis.

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