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Original Article

EFFECT OF VISUAL OCCLUSION AND LIGHT TOUCH ON DYNAMIC POSTURAL BALANCE ON AN UNSTABLE PLATFORM IN ELDERLY AND YOUNG ADULT WOMEN

EFEITO DA OCLUSÃO VISUAL E DO TOQUE SUAVE NO EQUILÍBRIO POSTURAL DINÂMICO EM PLATAFORMA INSTÁVEL DE IDOSAS E DE ADULTAS JOVENS

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ABSTRACT

Aging causes the detriment of sensory information that reflects the quality of postural control. The use of light touch has been suggested as a strategy to reduce postural sway even in the absence of vision. However, the effects of this strategy in unstable situations on the support base are unclear. The aim of this study was to analyze the effects of visual occlusion and light touch on the balance of elderly and young adult women on an unstable platform. Twenty elderly women (69.4±6.7 years) and twenty young adult women (20.6±3.2years) performed three attempts at the task which consisted of maintaining balance on an unstable platform on a bipedal base for twenty seconds, with medial-lateral perturbation, in four conditions. The Mann-Whitney U test showed that the elderly women presented worse balance compared to the young adult women in all conditions ($p<0.05$). The Friedman and Wilcoxon tests demonstrated worse balance with visual occlusion in both groups ($p<0.05$). On the other hand, there was an improvement in balance using light touch for both vision and no vision conditions ($p<0.05$). Both groups were able to use the haptic sensory information through light touch to assist in balance maintenance.

Keywords: Haptic information. Sensory information. Postural balance. Aging.

RESUMO

O envelhecimento causa detrimento nas informações sensoriais que refletem na qualidade do controle postural. O uso do toque suave tem sido sugerido como estratégia para diminuir a oscilação postural mesmo na ausência de visão. Porém, ainda não está claro este efeito em situação de instabilidade da base de suporte. O objetivo do presente estudo foi analisar o efeito da oclusão visual e do toque suave no equilíbrio em plataforma instável de idosas e adultas jovens. Vinte idosas (69,4±6,7 anos) e vinte adultas jovens (20,6±3,2 anos) realizaram três tentativas da tarefa que consistiu em manter o equilíbrio postural dinâmico em plataforma instável, em base bipodal durante vinte segundos, com perturbação médio-lateral em 4 condições. O teste de Mann-Whitney U demonstrou que as idosas apresentaram pior desempenho no equilíbrio em comparação às adultas jovens em todas as condições ($p<0,05$). Os testes de Friedman e Wilcoxon demonstraram pior desempenho no equilíbrio com a oclusão visual em ambos os grupos ($p<0,05$). Por outro lado, houve melhora no equilíbrio com o toque tanto na condição com visão quanto sem visão ($p<0,05$). Ambos os grupos foram capazes de utilizar as informações sensoriais hápticas por meio do toque suave para auxiliar na manutenção do equilíbrio.

Palavras-chave: Informação háptica. Informações sensoriais. Equilíbrio postural. Envelhecimento.

Introduction

Postural control has two behavioral goals, denominated postural balance and orientation, which are achieved through a dynamic relationship between sensory information and muscular activity[1]. Postural balance can be defined as the state in which all forces acting on the body are balanced, thus allowing control of body mass center projection within the limits of the supporting base[1,2]. Postural balance is usually analyzed in a static/orthostatic condition, characterized by the maintenance of a particular posture of the body with minimum oscillation[1,3], on a force platform[3]. However, this paradigm of analysis has been questioned, as falls rarely occur from stable/static conditions[4]. In this way, analysis of postural balance in dynamic conditions has been proposed[5–7]. Dynamic postural balance refers to the maintenance of posture during a disturbance in the support surface[1] and can be measured through a dynamic equilibrium platform[5,6,8]. In addition, small disturbances in the supporting surface can alter the reorganization of sensorial information[9].

Sensory information from the visual, vestibular, and somatosensory systems is preponderant for postural control. This information is used by the system to provide an internal reference of the environment through the position and movement of parts of the body. The abundance of this information ensures the stability of postural control even with the deficiency of a system[10]. The dominance of a sensory system is dynamic and is related to the changes arising from the relation of the individual to the environment, that is, depending on the context in which a task is performed, the postural control system prioritizes a type of sensory information in order to respond in the best way to the purpose of the task[11,12] thus avoiding conflict of information between the different systems. From this, the use of additional information, for example, light touch, can allow integrative information between the postural and haptic systems[13], thus helping in the maintenance of balance and reintegration of the elderly in their functional activities, as inefficient or inadequate control is one of the major risk factors of falls in the elderly population[14–17].

The haptic system is derived from tactile-kinesthetic information with exploratory acts, and its purpose is the detection of size, shape, and texture[18], moreover, it can be an efficient way of assisting the postural control system in the reorganization of sensory information. Moreover, it has already been shown that haptic information, such as light touch on a rigid and stationary surface, can improve postural control in the absence of vision[19]. In addition, the use of light touch can superimpose the effect of the manipulation of the visual information in certain contexts and tasks, being preponderant for the system of postural control[20]. In fact, the benefit of the light touch system has already been verified in young adults[21], in the sedentary and active elderly and in young people[22] and in children and adults[23]. However, all these studies analyzed the postural balance only in orthostatic posture by means of a force platform. Thus, the use of the light touch system as a tool to improve balance in the elderly in a situation of instability in the support base, a fact that increases even more the difficulty in maintaining balance, has not been the focus of study.

Considering the above discussion, the present study analyzed the effects of visual occlusion and light touch on dynamic postural balance on an unstable platform in elderly and young adult women. The hypotheses raised were that (H_1) the group of elderly women would demonstrate worse dynamic postural balance than young adult women in all experimental conditions, (H_2) visual occlusion would cause a decline in the performance of dynamic postural balance in both groups, and (H_3) the light touch would improve the performance of dynamic balance in both groups. This investigation has potential for understanding the benefits that using light touch can provide to postural control in situations of vision occlusion and instability in the supporting base.

Methods

Participants

Participants were selected for convenience. The study was composed of a group of elderly women (GE) and another group of young adults (GA). The GE was formed by 20 elderly women aged 69.4 ± 6.7 years, body mass 70.69 ± 13.13 kg, and height 1.58 ± 0.07 m, all practitioners of walking and/or stretching, with a practice frequency greater than twice per week. The GA was formed by 20 youngadult women, aged 20.6 ± 3.2 years, body mass 60.9 ± 7.96 kg, and height 1.65 ± 0.07 m, all undergraduate students, regular practitioners of different modalities of activities such as: dance, ballet, futsal, gymnastics, bodybuilding, and Pilates. Prior to beginning the tasks, all participants signed a free and informed consent of participation. The experimental procedures were approved by the Ethics Committee of the local university (process nº.216/10, CAAE nº.0198.0.268.000-10, nº.368590).

Instrument and Task

An unstable platform[24] was used for data collection, composed of a wooden plank (40 cm x 40 cm) 1.5 cm high, with electronic sensors coupled underits side border, responsible for capturing the moments when the border touches the ground, supported on a semicircular wooden base 4.4 cm high, and 6.5 cm in diameter (Figure 1), in addition to a notebook (ACER – 4349-ZQR), an electronic weighing device (*Casíta*), coupled onthe base of a tripod (VF – WT-3750) using double-sided tape, used for the light touch of the right hand fingers, and a black color band for the no vision conditions. The performance in the task was analyzed by means of the following variables: Balance Time, Average Balance Time, Longest Balance Time, and Number of Imbalances, which were sent through an analog-to-digital adapter (v. 1.5) tothe Dynamic Balance Task software (v. 1.0). Body mass and height measurements were obtained using a WISO (W721) digital weighing device and a WISO (E210) compact stadiometer, respectively.

The task consisted of maintaining balance on the unstable platform for 20 seconds, with the arms extended alongside the body in the condition without light touch, on a bipodal base with the feet parallel approximately shoulder-width apart with disturbance in the medial-lateral direction. In order to ensure the same positioning of the feet in all conditions, a mark was tagged using a tape under the platform for each participant. The tasks were performed in four different conditions: 1st condition – with vision and with light touch (V + T) (Figure 1B); 2nd condition –with vision and no light touch (V + NT); 3rd condition – no vision and with light touch (NV + T); 4th condition – no vision and no light touch (NV + NT).

A) **B)**

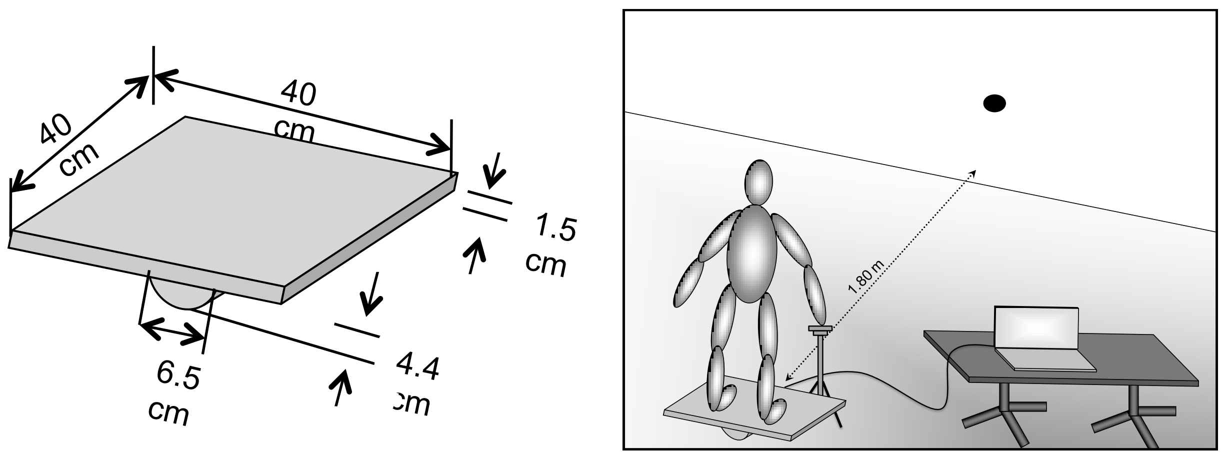

Figure 1. Schematic representation of the (A) Unstable Platform and the (B) Task (back view) in the V + T condition
Source: The authors

Procedures

In the experimental session, the participants were instructed to maintain balance on the platform, and to perform one attempt to familiarize themselves on the balance platform, another attempt with the light touch, and two more attempts to familiarize themselves with the lighttouch and unstable platform concomitantly.

Participants were barefoot during the 20 seconds on the unstable platform, with the arms extended alongside the body in the condition without light touch, on a bipodal base with the feet parallel approximately shoulder-width apart with disturbance in the medial-lateral direction. Thereafter, participants positioned themselves behind the balance platform and, after authorization from the experimenter, were instructed to step on to the platform keeping the right side supported on the ground. Next, participants were instructed to maintain balance for 20 seconds, in order to avoid contact of the borders of the platform with the ground. In the vision condition, participants were instructed to look at a fixed point tagged on the wall 1.80m away from the platform and at the height of their eyes. In the non vision condition, a band was placed on the eyes of the participants, however, participants were instructed to maintain the positioning of the head as if they were looking at the fixed point ahead. In the light touch condition, participants touched the electronic weighing device with the index finger of the right hand, which was positioned at the front and slightly to the right of the platform, with the height adjusted to the iliac crest of each participant. The maximum force exerted on the weighing device was 2N, and when the participant exceeded this force, the attempt was canceled and the task repeated. Three trials were performed for each condition, with an interval of one minute between trials. The order of the conditions was randomized between the participants using the Williams Square method[25,26].

Variables of Study

The independent variables of the study were: group (elderly *vs.* young adults); visual condition (V *vs.* NV), and light touch (T *vs.* NT). The dependent variables analyzed were: (a) Balance Time (in seconds), which represents the sum of the times which each participant remained on the platform without the border touching the ground; (b) Average Balance Time (in seconds), which represents the average of the balance times which each participant remained on the platform; (c) Longest Balance Time (in seconds), which represents the longest time of staying balanced without the borders of the platform touching the ground; and (d) Number of Imbalances (in absolute frequency), which represents the total number of touches of the platform border (right and/or left side) on the ground.

Statistical Analysis

Initially, the average of the three attempts at each measure of balance for all conditions was calculated. Next, the Shapiro-Wilk normality test ($p<0.05$) was performed for all analyzed variables. As the assumptions for performing the parametric tests for the analyzed dependent variables were not met, nonparametric descriptive and inferential statistics were used. The descriptive statistics of the data are represented as median and interquartile interval ($1^{st}$and 3^{rd}intervals). Inferential statistics were performed using the Mann-Whitney U test for comparisons between the groups (elderly *vs.* young adults) and the Friedman test to compare the effect of conditions (vision/light touch) for the group of young adults and the elderly. When the condition effect (vision/lighttouch) was found, the Wilcoxon test was applied. Statistical analyzes were performed using Statistica software (v.8.0) with significance established at 5%.

Results

Balance Time (seconds)

The GE presented lower Balance Time compared to the GA in all conditions V+T (Z=-5.28, p<0.001), V+NT (Z=-5.21, p<0.001), NV+T (Z=-5.06, p<0.001), and NV+NT (Z=-4.90, p<0.001). Both the GE ($X^2_{20.3}$=34.68, p<0.001) and GA ($X^2_{20.3}$=53.52, p<0.001) presented longer periods of Balance Time in the V+T condition in comparison to the V+NT, NV+T, and NV+NT conditions (p<0.05), in the V+ NT condition compared to NV+NT (p<0.05), and NV+T compared to NV+NT (p<0.05) (Figure 2).

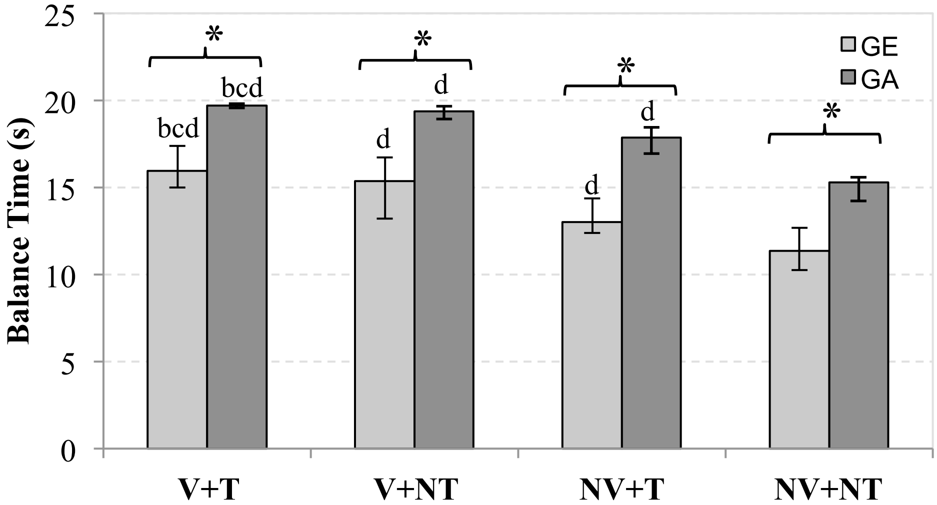

Figure 2. Balance Time (in seconds), expressed in median and interquartile ranges (1st and 3rd), of the groups (GE, GA), in function of analyzed experimental conditions (V+T, NV+T, V+NT, NV+ST)

Legend: *Difference (p<0.05) between the groups (GE; GA) in the same condition. Difference (p<0.05) between the conditions within the same group (GE; GA), being b difference for V+NT, c difference for NV+T, d difference for NV + NT.
Source: The authors

Average Balance Time (seconds)

The GE presented lower Average Balance Time compared to the GA in all conditions V+T (Z=-5.17, p<0.001), V+NT (Z=-5.07, p<0.001), NV+T (Z=-4.98, p<0.001), and NV+NT (Z=-4.19, p<0.001). Both the GE ($X^2_{20.3}$=26.64, p<0.001) and GA ($X^2_{20.3}$=53.52, p<0.001) presented higher Average Balance Time in the V+T condition in comparison to the V+NT, NV+T, and NV+NT conditions (p<0.05), in the V+ NT condition compared to NV+NT (p<0.05), and NV+T compared to NV+NT (p<0.05) (Figure 3).

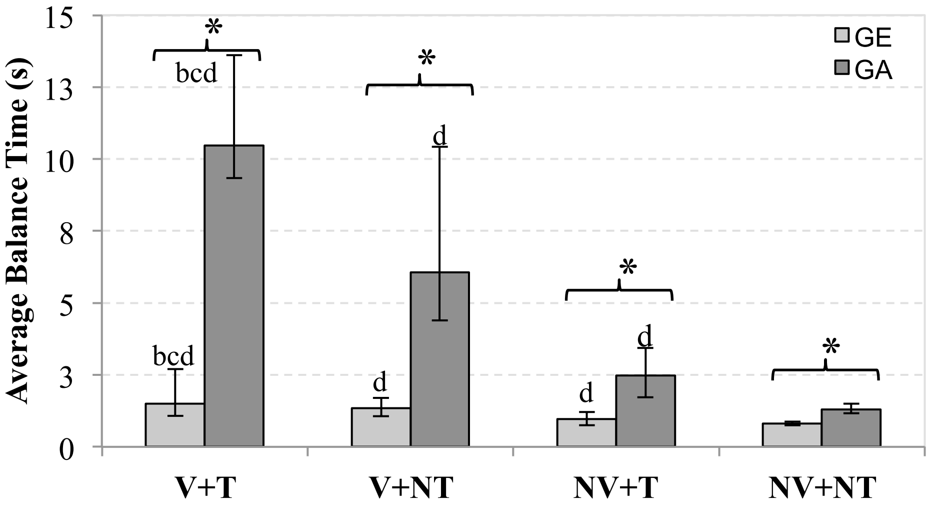

Figure 3. Average Balance Time (in seconds), expressed in median and interquartile ranges (1st and 3rd), of the groups (GE, GA), in function of analyzed experimental conditions (V+T, NV+T, V+NT, NV+ST)

Legend: * Difference ($p<0.05$) between the groups (GE; GA) in the same condition. Difference ($p<0.05$) between the conditions within the same group (GE; GA), being b difference for V+NT, c difference for NV+T, d difference for NV + NT.
Source: The authors

Longest Balance Time (seconds)

The GE presented lower performance in the variable Longest Balance Time compared to the GA in all conditions V+T (Z=-5.08, p<0.001), V+NT (Z=-4.98, p<0.001), NV+T (Z=-4.60, p<0.001), and NV+NT (Z=-4.13, p<0.001). Both the GE ($X^2_{20.3}$=25.62, p<0.001) and GA ($X^2_{20.3}$=48.90, p<0.001) presented higher values of the variable Longest Balance Time in the V+T condition in comparison to the V+NT, NV+T, and NV+NT conditions (p<0.05), in the V+ NT condition compared to NV+NT (p<0.05) and NV+T compared to NV+NT (p<0.05) (Figure4).

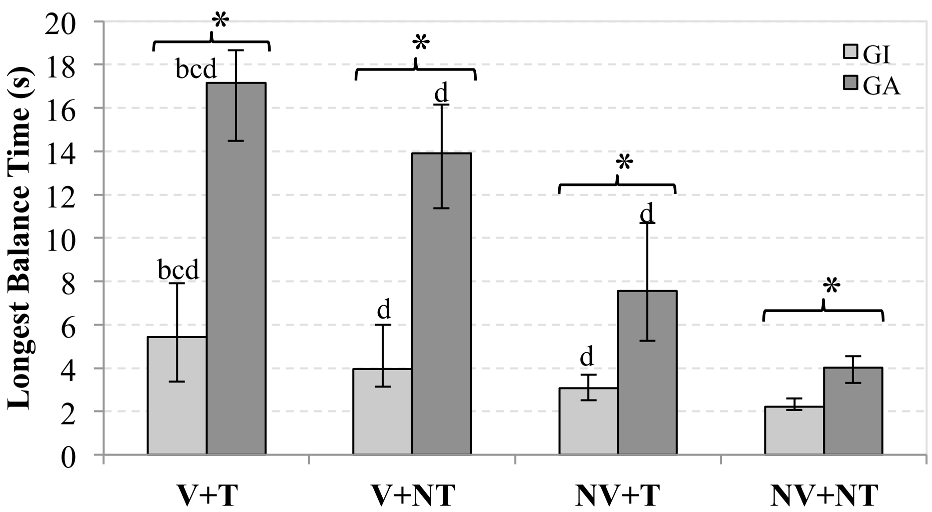

Figure 4. Longest Balance Time (in seconds), expressed in median and interquartile ranges (1st and 3rd), of the groups (GE, GA), in function of analyzed experimental conditions (V+T, NV+T, V+NT, NV+ST)

Legend:* Difference ($p<0.05$) between the groups (GE; GA) in the same condition. Difference ($p<0.05$) between the conditions within the same group (GE; GA), being b difference for V+NT, c difference for NV+T, d difference for NV + NT.
Source: The authors

Number of Imbalances (absolute frequency)

The GE presented higher Number of Imbalances compared to the GA in all conditions V+T (*Z*=5.40, p<0.001), V+NT (*Z*=4.85, p<0.001), NV+T (*Z*=4.15, p<0.001),and NV+NT (*Z*=2.00, p=0.045). Both the GE ($X^2_{20.3}$=13.97; p=0.029) and GA ($X^2_{20.3}$=52.01; p<0.001) presented lower Number of Imbalances in the V+T condition in comparison to the NV+T and NV+NT conditions (p<0.05) and also in the V+NT condition compared to the NV + NT (p<0.05). However, only the GA presented lower Number of Imbalances in the V+T condition when compared to the V+NT (p<0.05), and NV+T condition compared to NV+NT (p<0.05) (Figure 5).

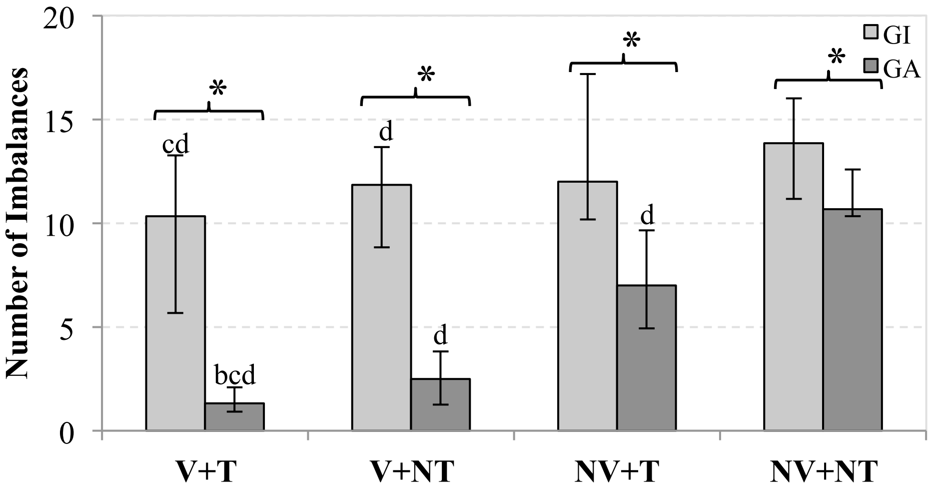

Figure 5. Number of Imbalances (in absolute frequency), expressed in median and interquartile ranges (1st and 3rd), of the groups (GE, GA), in function of analyzed experimental conditions (V+T, NV+T, V+NT, NV+ST)

Legend:* Difference (p<0.05) between the groups (GE; GA) in the same condition. Difference (p<0.05) between the conditions within the same group (GE; GA), being b difference for V+NT, c difference for NV+T, d difference for NV + NT.

Source: The authors

Discussion

The present study analyzed the effects of visual occlusion and light touch on dynamic postural balance on an unstable platform in elderly and young adult women. For this, an unstable platform was used, with disturbance of the support base in the medial-lateral direction, with manipulation of visual information (visual occlusion) and haptic information (light touch). The results indicated that the young adult women demonstrated better dynamic balance compared to the elderly women. Thus, the hypothesis (H_1) affirming that the group of elderly women would have worse dynamic balance than the young adults in all experimental conditions was accepted. In fact, a decline in dynamic postural balance occurs with increasing age. Ferraz et al.[22] compared postural oscillation in the orthostatic posture with light touch on the force platform between active elderly, sedentary elderly, and young adults. The results indicated that the sedentary group presented greater body oscillation than the other two groups. However, in the same study, the group of active elderly did not differ from the group of young adults in body oscillation, evidencing the importance of physical activity. However, in the present study the GE presented inferior performance to the GA even though it was an active group. This difference between the groups can be explained by the combination of the difficulty of the task due to an unstable support base and the effects resulting from the aging process, as, with advancement in age, there are verified structural and functional changes in the sensory and motor system, sensory information integration problems[27,28], and a reduction in the quality of sensory information[29–31].

The visual system influenced the dynamic balance of both groups, as they presented lower values of Balance Time (s), Average Balance Time (s), Longest Balance Time (s), and greater Number of Imbalances with the occlusion of vision. Thus, the hypothesis (H_2) affirming that visual occlusion would cause a decline in dynamic balance in both groups was accepted. This decrease in performance due to visual occlusion demonstrates that the visual system not only provides exteroceptive information about the environment, objects, and external events, but also offers proprioceptive information on the relative position of the body parts movement and on the position and movement of the body as a whole in relation to the environment[32]. Therefore, it was demonstrated that on an unstable support base, visual information can occupy a more relevant role forbalance regulation[8]. This idea corroborates with Peterka[9], who demonstrated that small disturbances in the supporting surface reorganize the importance of sensory information, that is, the proprioceptive system is 50% relevant, vision 35%, and the vestibular system 15%. In stable situations, the somatosensory system is 70% relevant, the vestibular system contributes 20%, and visiononly 10%. Consequently, the results support the theory of sensory relevance, in which the postural control system is able to reconsider and redistribute sensorial stimuli to ensure postural stability[12].

The importance of visual information in postural control has also been demonstrated in situations such as: with or without visual information and light touch in the analysis of young adults through the paradigm of the moving room, which implies having the vision manipulated by the movement of the room, thus inducing body oscillation corresponding to the optical flow[20]; manipulation of vision in different supporting bases in active elderly and sedentary young adults[33], with or without visual information; and an anchor system in the elderly and active young adults[13], with and without vision and sensory manipulation of the supporting surface with the use of a cushion in active elderly women[34]. The results of the present study, together with these studies, highlight the importance of visual information in the regulation of postural control.

The use of light touch improved dynamic balance for the elderly and young adult women, demonstrated by the better performances found in the variables with both open and closed eyes. Thus, the hypothesis (H_3) affirming that light touch would improve the dynamic balance performance for both groups was accepted. In fact, it has been suggested that somatosensoryinformation from light touch provides an external reference that can be used to improve postural control[35,36] and decrease the postural oscillation of active and sedentary elderly, and young adults in an orthostatic posture[22]. This light touch effect was also verified in the control of standing position in young adults using a moving room. The results indicated a reduction in postural oscillation resulting from the use of light touch in all analyzed conditions[20]. Furthermore, Jeka and Lackner[35] analyzed young adults in a tandem position, which consists of keeping their feet aligned one in front of the other with the toes of one foot touching the heel of the other on a force platform and verified that the light touch on a stable surface reduced the magnitude of the postural oscillation by 50% when compared to the no touch situation. According to the authors, this occurred due to the information obtained by the fingers combined with proprioceptive trunk-arm signals, which provided information about body oscillation, used to improve stability. The improvement in dynamic balance with the use of light touch can also be explained by the supplemental haptic information provided on the relative position of the body[19]. According to Jeka and Lackner[19,35], individuals use light touch information in the form of anticipation (feedforward).Therefore, it is possible to use the changes in the force exerted by the touch of the finger on a stationary surface with the intention to receive information about the direction of the postural oscillation, thus being able to attenuate the oscillation by means of more adequate muscular activation[35].

The results of the present study demonstrated that the group of young adults presented better dynamic balance in relation to the group of elderly women in all analyzed conditions. The use of visual information and light touch enabled the best performance in the balance task for both groups. Occlusion of visual information was demonstrated to impair dynamic postural balance, whereas the addition of haptic information (light touch) was demonstrated to be a potential tool for maintaining balance even in situations of visual occlusion and instability of the supporting base. This fact also indicates the importance of this tool in dynamic situations, since the majority of light touch studies demonstrated this effect in the orthostatic posture. Moreover, generalization of the results based on the interpretation of previous studies should be performed with caution, as the majority of previous studies were performed with different methods and manipulations, in the orthostatic posture using a force platform. The present study presents limitations regarding the convenience selection of the sample and the non collection of participants' physical activity level. In this way, we suggest further studies that analyze the importance of haptic information in balance on an unstable platform with the manipulation of other sensorial sources.

Conclusions

The results indicated that the elderly women presented worse performance when compared to the young adult women. These results were explained by the difficulty in accomplishing the task due to the instability of the base of support, added to the aging process. In addition, visual occlusion caused a decline in the participants dynamic balance, which can be explained by the disturbance of the supporting surface, as in more unstable situations vision gains a greater relevance for the maintenance of postural stability, due to the information it provides on the environment and on the individual's own movements. However, the light touch provided additional haptic information to the postural control system, improving task performance even with vision occlusion, that is, participants were able to choose the preponderant sensorial information to achieve the task goal. Therefore, light touch maybe an important information source used by the postural control system for sensorial reorganization, allowing postural maintenance even in situations in which sensory information is altered and the supporting base is instable.

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