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original article

Effects of the anchor system on postural control in older adults

Efeitos do sistema âncora sobre o controle postural de idosos

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Abstract – Falls are common during aging, and can have drastic consequences. Within this context, maintaining the ability to balance plays an essential role in enabling older adults to continue to perform their daily activities. Therefore, the use of interventional and treatment tools for development of balance becomes essential. The objective of this study was to analyze the anchor system as a potential tool for decreasing body sway in older and young adults. Older adults had more postural sway than their young counterparts. The absence of visual information led to larger instability in both groups. The anchor system improved postural stability of both groups. Thus, it may be a useful tool for posture stabilization in old and young adults.

Key words: Aging, Motor activity; Posture; Vision.

Resumo – *O número de quedas durante o envelhecimento é alto e suas consequências podem ser drásticas. Neste contexto, a manutenção da capacidade de equilíbrio exerce papel fundamental para que o idoso tenha possibilidade de realizar suas atividades cotidianas. Por conseguinte, a utilização de ferramentas de intervenção e de tratamento para o desenvolvimento do equilíbrio torna-se essencial. Neste estudo, foi analisado o sistema âncora como possível ferramenta, em potencial, para diminuir a oscilação corporal em idosos e adultos jovens. Os idosos apresentaram maior oscilação corporal que os adultos jovens. A ausência da informação visual provocou maior instabilidade postural para ambos os grupos. O sistema âncora demonstrou proporcionar maior estabilização no controle da postura. Deste modo, o sistema âncora pode ser uma ferramenta útil para o auxílio na estabilização da postura.*

Palavras-chave: Atividade motora; Envelhecimento; Postura; Visão.

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INTRODUCTION

In Brazil, approximately 30% of older adults fall at least once a year[1]. According to Pereira et al.[1], 5% of falls in this age range lead to fractures, and 15% to 50% of older adults hospitalized due to falls die within the next year[1]. Therefore, investigation of postural control strategies designed to support maintenance of balance is essential, particularly to the elderly population. Within this context, there has been a search for alternatives that could reduce the number of falls and, consequently, improve balance in older adults.

We recently proposed the use of a tool (method) that explores haptic information to supplement the postural control system and thus improve balance[2]. This tool, called the anchor system, would enable cooperative integration between the postural and haptic systems, leading to a reduction in body sway. The anchor system is composed of two flexible cables, each held in one hand, tipped by loads (weights) of varying mass that are kept in contact with the ground. These handheld weights resting on the ground would serve a purpose analogous to that of anchors stabilizing a ship. In broad terms, establishing a sequence of contacts between skin and object enables exploration, perception, and use of this information to optimize body stability. Thus, the anchors would allow the haptic system to provide more information capable of aiding body stability.

The haptic system works by means of active exploration of the environment, be it static or dynamic[3]. A haptic system can be understood as one of active touch, and involves the interpretation of stimuli with complex spatiotemporal patterns to integrate several classes of mechanoreceptors[4]. This system provides information on shape, texture, motion, and forces (inertial, gravitational, and acceleration), that is, it involves mechanical perception of the environment through the efforts of the kinesthetic and integumentary systems. For instance, light touch with a finger (less than 1 N) on a stationary surface is enough to decrease body sway[5]. This is explained by the supplementary haptic information on body position provided to the posture control system[6].

Similarly, the anchor system enables use of haptic information on one's surroundings[3], as dynamic exploration between body segments and the tool that mediates contact with the ground permits detection of information from the environment in conformity with the dynamics of the body. In case of postural changes, the body will seek out information that fulfills its immediate adaptive needs. Changes in the environment are perceived by the body, which entails further adaptation. Thus, a non-biological extension (i.e., tool) coupled to a body segment constantly measures information on what is occurring in the environment. Despite potential similarities, there are differences between the use of haptic information, the use of the anchor system and the use of light touch on a stationary surface. The information provided by the anchor system is obtained by means of haptic exploration mediated by a nonrigid tool[3]. Conversely, light touch on a supporting surface is direct and unmediated. Furthermore, the force vectors of gentle touch are directed downward, whereas the force vector of the anchor system is oriented upward, as the system loads are resting on the ground. These distinctions have particular implications for the use and benefits of haptic information.

The benefits of the anchor system have been shown in adults[2], children[7], and mentally disabled adults[8], including as part of a routine physical activity program for mentally disabled adults[9]. Therefore, it is to be expected that the anchor system would contribute to improved balance in older adults. Nevertheless, the use of the anchor system as a potential tool for improving balance in the elderly has not been the object of study. Hence, this study assessed the effect of the anchor system on postural control in young and older adults. This investigation will enable analysis of the potential benefits of this tool for postural control.

METHODS

Sample

The study sample consisted of 30 healthy, active individuals, subdivided into two groups: older adults (n=15, mean age 68.13 ± 6.09 years) and younger adults (n=15, mean age 20.20 ± 1.61 years). Participants in the older adults group provided written informed consent. All subjects stated that they had no physical conditions that could jeopardize their participation in this experiment. The study was approved by the Universidade Estadual Paulista, Rio Claro Research Ethics Committee with protocol no. 6125 (17 October 2006).

Instrument and task

Data collection was performed with a force platform (AccuGait, AMTI, Watertown, MA) and the anchor system, which was composed of two flexible cables, each with a 125-g load tied to one end; these weights remained in contact with the ground (Figure 1). The anchor task consisted of remaining barefoot, in the semi-tandem stance (medial aspect of the big toe of one foot touching the medial aspect of the heel of the other foot) while holding on to the anchor system and gazing fixedly at an orange circle placed at eye level. The height of the anchor cables was self-adjusted by participants so as to maintain a comfortable posture while making sure that cables always remained stretched slightly ahead of the body.

All participants performed postural control tasks with and without the anchor system. The duration of the task was 40s for each condition and attempt, but only 30s were used for analysis. The initial and final 5s were used to synchronize the force platform and video cameras. Synchronization was performed manually with a flashlight, which was lit as one of the corners of the force platform was tapped. The resulting peak in platform signal and light pulse were used for kinematic and kinetic synchronization of the instruments. The following experimental conditions were tested with the participant on the force platform: (1) Standing in the semi-tandem position while gazing fixedly at a circle projected onto the center of a white screen placed 1.20 m from the participant, without using the anchor system (vision/no anchor condition) and while using the anchor system (vision/anchor condition); (2) Standing in the semi-tandem position while blindfolded and not using the anchor system (no vision/no anchor condition) and while using the anchor system (no vision/anchor condition). The no vision condition was included as it has been shown to magnify the effects of body sway[10,11,12], and thus enables analysis of the anchor system in scenarios of even greater postural instability.

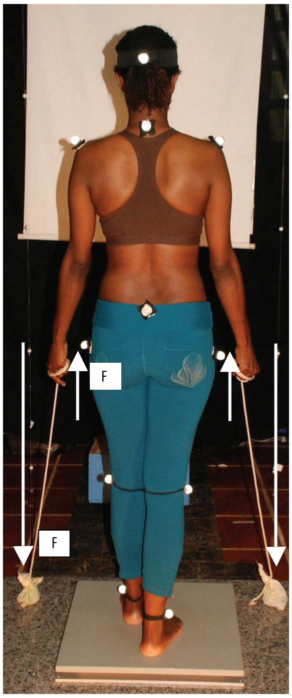

Figure 1. Schematic of the anchor system and forces (F) acting on the system.

Procedures

Participants were monitored by means of two video cameras throughout the experiment. Furthermore, participants were always aided by an investigator, who helped them position themselves onto the force platform and provided a measure of safety during the experiment. For the no vision conditions, participants blindfolded themselves, with the aid of the assisting investigator, only after standing on the force platform. The assisting investigator remained close by throughout all attempts to provide security in case of loss of balance. Participants made three attempts for each condition, with 1-minute breaks between attempts. The overall duration of the experiment was approximately 1 hour. Experimental conditions were performed in random order.

Data treatment

Data pertaining to the study variables were analyzed in software applications written in the MATLAB 5.3 environment (Math Works, Inc.). The variables *dispersion of mediolateral postural sway* and *amplitude of mediolateral postural sway* were analyzed after data "windowing". Windowing was carried out on the basis of previous studies (cf.[13]). Data for each attempt were divided into 40-window intervals with a duration of 0.75 s (or 45 frames) each. The means of these intervals were calculated and used for statistical analyses. Data were processed with the Butterworth filter, using a cutoff frequency of 3Hz. Forces in the mediolateral, anteroposterior, and vertical directions and the moments of force about these axes were recorded with a sampling frequency of 60Hz. Center-of-pressure (COP) displacement was calculated online with the Balance Clinic data collection program.

Statistical analysis

Comparisons between dependent variables were carried out using three-way analysis of variance (ANOVA), with the factors being the two groups (young vs. older adults), two task conditions (with vs. without the anchor system), and two vision conditions (no vision vs. vision), with repeated measures for the latter two factors. Tukey's post-hoc test was used for a posteriori analysis. The significance level was set at $P<0.05$.

RESULTS

According to ANOVA, significant effects on the *dispersion of mediolateral sway* variable were exerted by the Group factor ($F_{1,28}$=22.95; P<0.001) (Figure 2), with post-hoc tests showing greater sway in older adults (0.219cm) as compared with young adults (0.162cm) (Figure 3); by the Task Condition factor ($F_{1,28}$=8.845; P<0.01), with greater sway when participants did not use the anchor system (0.200cm) as compared with conditions in which the anchor system was used (0.181cm) (Figure 3); by the Vision Condition factor ($F_{1,28}$=89.90; P<0.001), with greater sway in the no vision condition (0.232cm) than in the vision condition (0.149cm) (Figure 3); and by the interaction between the Group, Task Condition, and Vision Condition factors ($F_{1,28}$=9.12; P<0.01). Tukey's post-hoc test showed that the anchor system effectively minimized postural sway, both in the absence and in the presence of visual information. However, in most experimental conditions and in both groups, the absence of visual information had a greater impact on postural sway than the absence of the anchor system.

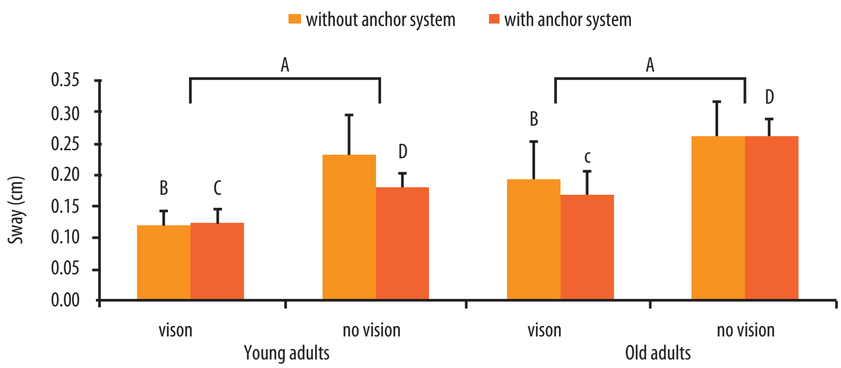

Figure 2. Dispersion of mediolateral body sway in the vision and no vision conditions, with or without the anchor system, in young and older adults.
Legend: A à Difference between vision and no vision conditions (P<0.05). B, C, and D à Difference between age groups (P<0.05).

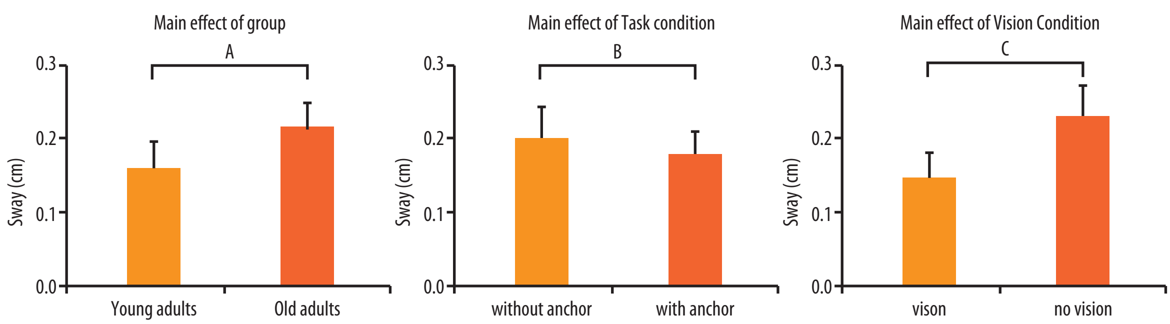

Figure 3. Dispersion of mediolateral body sway. Main effect of factors: A – Group (young vs. older adults); B – Task Condition (without vs. with anchor system); and C – Vision Condition (vision vs. no vision) on the *dispersion of mediolateral body sway* variable.

Significant effects on the *amplitude of mediolateral sway* variable were exerted by the Group factor ($F_{1,28}$=32.35; P<0.001) (Figure 4), with post-hoc tests showing greater sway in older adults (0.487cm), as compared with young adults (0.347cm) (Figure 5); by the Task Condition factor ($F_{1,28}$=10.35;

P<0.005), with less sway when participants used the anchor system (0.396cm) than when they did not (0.437cm) (Figure 5); and by the Vision condition factor ($F_{1,28}$=135.42; P<0.001), with post-hoc tests showing greater sway in the no vision condition (0.506cm) than in the vision condition (0.327cm) (Figure 5).

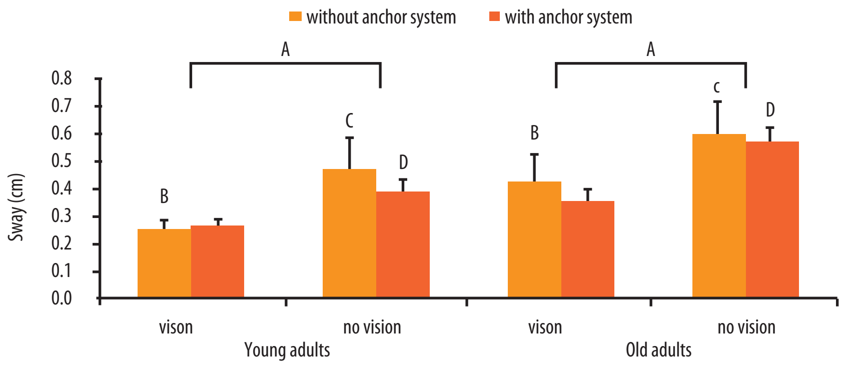

Figure 4. Amplitude of mediolateral body sway in the vision and no vision conditions, with or without the anchor system, in young and older adults.
Legend: A à Significant difference between the vision and no vision conditions. B, C, and D à significant difference between age groups.

The interaction between the Group, Task Condition, and Vision Condition factors also had a significant effect on amplitude of body sway ($F_{1,28}$=8.69; P<0.01). More specifically, the interaction of analyses in each group showed that, in young and older adults alike, sway amplitude increased in the no vision condition; however, in most conditions, use of the anchor system (Ps<0.05) minimized this amplitude. The exceptions were conditions in which no vision plus use of the anchor system were compared with conditions of normal vision and no use of the anchor system (in these comparisons, the effect of Vision Condition overlapped with the effect of the Task Condition factor). Thus, overall results showed a positive effect of the anchor system in both age groups.

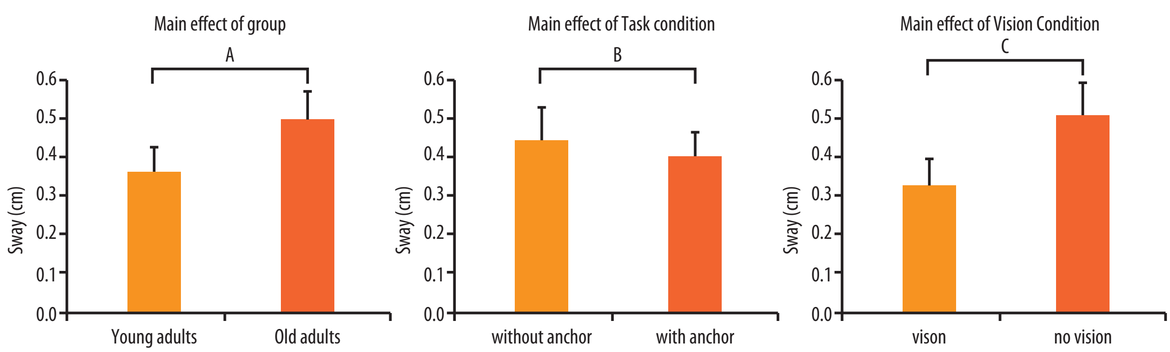

Figure 5. Amplitude of mediolateral body sway. Main effect of factors: A – Group (young vs. older adults); B – Task Condition (without vs. with anchor system); and C – Vision Condition (vision vs. no vision) on the *amplitude of mediolateral body sway* variable.

DISCUSSION

Older adults exhibited greater body sway than young adults, as expected and previously reported in the literature[10,14]. In the present study, this greater sway was explained by the degenerative effects of aging[15,16]. In view of the known benefits provided by physical activity[17,18,19], its practice has been suggested as a tool for improving balance and as a factor capable of delaying the effects of aging.

The occlusion of visual information increased body sway in young and older adults alike. These results are consistent with previous studies that showed the importance of visual information to postural control[11,20]. In older adults specifically, changes in how sensory information is used to control balance may be associated with the process of acquisition or refinement of sensory information and muscle activation. More specifically, maintenance of stable posture requires flexibility on the part of the postural control system, that is, the system must be capable of continual adaptation to the demands of the environment[21]. Vision plays a particularly essential role in postural regulation, as it provides information on the individual and on his or her surroundings[22]. In addition to the importance of vision, the contribution of the haptic system to the regulation of balance has been demonstrated[2,6].

Light touch can reduce body sway due to the contribution of the haptic system to balance regulation[6]. When light touch is used, visual information may not be the predominant source of data for postural control, but rather a source that can provide the most accurate, correct information at a given point in time[23]. Therefore, reduction of body sway by means of light touch should be possible in young and older adults alike[24]. Muscle-based perception (awareness of the magnitudes and directions of the extremities and of implements by means of muscle effort) enables continuous modification and maintenance of posture and, consequently, maintenance of the orientation of the body, extremities, and wielded implements[25]. When someone grasps an object and moves it about (wields it), muscle-based perception enables collection of data on the physical properties of the object, torque production, angular motions, and muscle deformations that change over time. These parameters constitute important information on one's perception of the unchanging dimensions of the object[25].

Older adults exhibit global losses of the muscle-based perception system. Compared to those of a younger adult, the functional gains of an older adult will always be insufficient in tasks that hypothetically privilege haptic exploration. However, from an adaptive standpoint, competing with the high dependence of postural control on visual information would subject the haptic system to double duty: first, inhibiting the effects of postural deterioration due to the absence of visual information; and second, maximizing the intrinsic information generated at the muscles and tendons as they respond to the gravitational and inertial forces produced by wielding a non-rigid tool—the anchor system.

The older adults assessed in this study may have swayed more in an attempt to obtain better information from the rope-based anchor system. However, this strategy led to greater instability than that exhibited by younger adults. The older adults also exhibited a potential need for time to adapt to the disturbance produced by the no vision condition, as well as some time to learn and optimize the use of haptic information provided by the anchor system. Young adults are able to regulate posture simultaneously or with very minor lag in response to touch on a rigid surface[24]. Conversely, older adults need more time to adapt to manipulative stimuli, as the coupling of sway to visual stimuli is temporally ahead of the sensory stimuli provided by light touch on a rigid surface[24].

Overall, the anchor system proved helpful as a tool for improvement of postural control. In this study, the base of support, vision, and anchor system were all manipulated in a single session. Only when all of these manipulations were taken into account was the effect of the anchor system positive. This positive effect of using the anchor system could perhaps have been maximized by a larger study sample or by exposing both groups to a training period. For instance, Carello et al.[25] have proposed a line of work based on training individuals to use their preserved sensitivity (that unaffected by injury) to obtain more information from the inertial properties of objects. Training based on the exploration and use of objects with varied mass distributions might increase individual awareness of the different muscular force patterns that occur in response to different task requirements. Carrying out tasks using muscles of the whole body, rather than solely with the affected limb, could increase the distributed deformation response and, consequently, better attune this response to the inertial properties of objects and limbs that are relevant to the control of action. In addition to interventions that stimulate the body, investigators could also focus on interventions that act on organism-environment interaction; for example, designing implements that maximize tissue deformation relevant to controlling objects.

CONCLUSION

We may suggest that the anchor system is an important tool for improvement of postural control, as it provided useful haptic information for the postural system and its use was associated with greater stability. Therefore, the anchor system is suggested, in combination with practical intervention, as a means of enabling better exploration and use of haptic data. Further studies are warranted to analyze the potential benefits of the anchor system after discrete periods of intervention, both in older adults and in other populations in whom balance may be compromised.

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