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ORIGINAL RESEARCH

The benefits of the anchor system on different parts of the body for posture control in older adults

A contribuição do sistema âncora em diferentes segmentos corporais para o controle da postura em idosos

La contribución del sistema de anclaje en distintos segmentos corporales para el control de la postura en adultos mayores

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ABSTRACT | The anchor system is a nonrigid tool that provides additional haptic information. It consists of two malleable cables with 125g loads resting on the floor, whereas the hands hold the other end of the cable (hand anchor). If we consider that light touch of different parts of the body reduces body sway, it is also possible that the use of the anchor system on different parts of the body might be effective. Therefore, this study aimed at investigating the effect of using the anchor system on different parts of the body on older adults' body sway. Thirty older adults participated in this study. Participants stood on a force platform in a semi-tandem position and maintaining an upright posture for measuring deviations in the location of the center of pressure (CoP). Each participant was exposed to five experimental conditions: no anchor, hand anchor, anchors in hands fastened with straps, anchors in forearms fastened with straps and anchors in shoulders fastened with straps. The results showed a reduction in the area of the ellipse adjusted to the deviation of the CoP and mean sway amplitude in the anteroposterior direction with the anchors positioned on the hands (traditional and strap) and forearms, compared with the condition without the anchor. Thus, the use of the anchor system was effective when the anchors were positioned on the forearm as well as when they were fastened/held in hands. The improvement observed with the use of anchors does not seem to be related to the amount of tactile receptors at the point of contact with the anchor cables.

Keywords | Older Adults; Stereotypic Movement Disorder; Postural Balance.

RESUMO | O sistema âncora é uma ferramenta não rígida que fornece informação háptica adicional, consistindo de dois cabos maleáveis com 125 g de massa repousando no solo, devendo-se segurar a outra extremidade com as mãos (âncora-mão). Considerando que o toque leve em diferentes partes do corpo reduz a oscilação corporal, é possível, da mesma forma, que o uso do sistema âncora em diferentes partes do corpo seja efetivo. Portanto, o objetivo deste estudo foi investigar o efeito do uso do sistema âncora em diferentes segmentos corporais sobre a oscilação corporal de idosos. Trinta idosos participaram do presente estudo. Eles ficaram na postura ereta com os pés na posição semi-tandem sobre uma plataforma de força para a obtenção do deslocamento do centro de pressão (CP). Cinco condições experimentais foram realizadas: sem âncora, âncora-mão, âncoras nas mãos presas com presilhas, âncoras nos antebraços presas com presilhas e âncoras nos ombros presas com presilhas. Os resultados mostraram uma redução da área da elipse ajustada ao deslocamento do CP e na amplitude média de oscilação na direção anteroposterior nas condições com as âncoras posicionadas nas mãos (âncora-mão e presilha) e antebraços em comparação à condição sem âncora. Assim, o uso do sistema âncora foi efetivo quando as âncoras foram posicionadas no antebraço da mesma forma que quando foram seguras pelas mãos. A melhora observada com o uso das âncoras parece não estar relacionada com a quantidade de receptores táteis no ponto de contato dos cabos das âncoras.

Descritores | Idosos; Transtorno de Movimento Estereotipado; Equilíbrio Postural.

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RESUMEN | El sistema de anclaje es una herramienta no rígida que brinda información adicional háptica, formada por dos cables maleables con 125g de masa que reposan en el suelo y otra extremidad en que se sostiene en las manos (anclaje de mano). De la misma forma que un simple contacto en distintas partes del cuerpo reduce el equilibrio corporal, es posible que también tenga eficacia el empleo del sistema de anclaje. Así el propósito de este estudio es examinar el efecto del empleo del sistema de anclaje en distintos segmentos corporales sobre el equilibrio corporal en adultos mayores. Del estudio participaron treinta adultos mayores, quienes mantuvieron en postura erecta con los pies en posición semi-tandem sobre una plataforma de fuerza para que se obtenga el desplazamiento del centro de presión (CP). Se llevaron a cabo cinco situaciones experimentales: sin las anclas; anclaje de mano; anclas en las manos sujetadas con abrazaderas; anclas en los antebrazos sujetadas con abrazaderas y anclas en los hombros sujetadas con abrazaderas. Hubo una reducción del área de elipse ajustada al desplazamiento del CP y en la amplitud media del equilibrio en la dirección anteroposterior en las situaciones con las anclas sujetadas en las manos (tradicional y con abrazaderas) y con los antebrazos cuando comparada a la situación sin las anclas. Así se obtuvo eficacia en el empleo del sistema de anclaje cuando las anclas se las pusieron en los antebrazos, semejante al momento en el que se las fijaron/sujetaron en las manos. La mejora resultado del empleo de las anclas no parece relacionarse con la cuantidad de receptores táctiles en el punto de contacto de los cables de las anclas.

Palabras clave | Adulto mayor; Trastorno de Movimiento Estereotipado; Balance Postural.

INTRODUCTION

Almost 30% of people over 65 years fall at least once within one year period[1,2]. Aging brings progressive sensory, motor and central processing losses, which are associated with an increased number of falls[3]. These changes directly affect posture control, contributing for older adults' unstable posture. Older adults have an increased body sway when they stand upright[4], especially when the body support base is reduced[3].

Body sway in older adults may be reduced by adding sensory information[5,6]. Adding haptic information by fingertip light touch (<1N) of a hard or non-hard surface decreases body sway in young and older adults[7-9]. Moreover, light touch of different parts of the body (forearm and neck) reduces body sway, indicating the effectiveness of additional haptic information provided by different parts of the body[10,11].

It is also possible to add haptic information for postural control using the anchor system[12]. The anchor system consists of flexible cables held by the participants, which have small loads on their other end resting on the floor. Individuals must keep the cable tensioned and try not to lift the loads from the floor. Changes in body orientation relative to the support surface are detected by variations of pressure exerted on the skin by the anchor cable. Adults with intellectual deficiency benefited from additional haptic information provided by the anchor system, and reduced body sway[13,14]. Older adults, likewise, have reduced body sway with the anchor system[3,15,16]. The anchor system advantages are noticed not only during its use[3,16], but also and more importantly after its use[15], making it a tool with potential for clinical and training application.

Despite these advantages, the necessity of holding the anchor in one's hands limits its use to tasks that do not require the use of the hands. Therefore, it is interesting and important to evaluate whether the use of the anchor system fastened on different parts of the body reduces body sway in the same way that when people hold it in their hands, as found in the studies on light touch in different parts of the body[10,11]. This study aimed at evaluating the effect of using the anchor system at different points of contact (hand, forearm and shoulder) on older adults body sway while they maintained an upright posture. As observed in studies that adopted a paradigm of light touch, we expected that the use of the anchor system on the forearm and shoulder would result in a decreased body sway equivalent to that observed when the anchor system was used in the hands. This change in the position of the anchors can make the use of this tool clinically applicable, because if the same benefit is observed for different points of contact, the hands would be free for some functional activities such as picking up and manipulating an object.

METHODOLOGY

Participants

Thirty older adults, between 65 and 85 years old and standing independently in an orthostatic posture, participated in this study (11 M and 19 W; age: 73.3±4.7 years; body mass: 69.4±14.7 kg; height: 1.60±0.07 m). Exclusion criteria were: individuals unable to understand the instructions, dementia, uncorrected vision problems, vestibular changes, orthopedic injury, cerebrovascular accident, use of drugs that could affect task execution, as well as any other that could affect their capacity of standing independently. Criteria were evaluated using a questionnaire applied before data collection. Cognitive function in older adults was assessed through the Mini Mental State Examination[17], functional balance through MiniBEST Test[18] and physical activity level through the modified Baecke questionnaire for older adults[19].

All participants were informed about the procedures involved in the study and signed an informed consent form. All experimental procedures have been approved by HCFMRP-USP Research Ethics Committee (Process No 6123/2014).

Procedures

Participants were instructed to held semi-tandem stand (the heel of one foot touching the side of the big toe of the other foot) on a force platform (AccuGait, AMTI, Watertown, USA). The force platform measured forces applied to it in anteroposterior (AP), mediolateral (ML) and vertical directions, as well as the moments of force around these axes with a 100 Hz sampling frequency. The values of the center of pressure were directly calculated by Balance Clinic data acquisition software.

Each participant was exposed to four experimental conditions using the anchor system and one condition without the anchor system. We employed in the trials using the anchor system two flexible cables with 125g loads fixed to the distal extremities. The four conditions using the anchor system were: hand anchor, hand-strap anchor, forearm anchor and shoulder anchor. Figure 1 presents the conditions when the anchor system was used. In the hand anchor condition, participants were instructed to hold one anchor in each hand. The anchor cable was rolled up once or twice around the palm of the hand and participants held the cable with their fingers. They were asked to keep the anchor cable stretched, but without lifting the 125g load from the ground. As in the conditions that the anchor was on the forearm and shoulder, the anchors were fixed with a strap (Naigell Botões, São Paulo) and we have also included a condition with the anchors fastened with straps in the hands (hand-strap anchor). In the forearm anchor condition, the anchors were positioned bilaterally in the middle-third forearm so that the anchor cable passed once around the forearm, fastened then with the strap and the cable exerted a small pressure on the skin (the process was controlled to cause minimal skin deformation). In the shoulder anchor condition, the anchors were positioned bilaterally around the shoulder and fastened with the strap on the posterior aspect of the humerus under the acromioclavicular joint. The process was also controlled to cause minimal skin deformation. Based on the pilot studies, the anchors on the shoulders were fastened with the strap on the posterior region of the humerus, with the anchor positioned approximately 15 cm from the shoulder axis, so that the anchors were apart from each other at a distance equivalent to the participant's chest width.

Participants were asked to attend the trial session wearing a sleeveless shirt to make anchors fastening on the shoulders easier. In all experimental conditions, the participants kept their elbows bent at a 90-degree angle, so that their forearms were almost parallel to the ground. In conditions with the anchors fastened with straps, anchor cable lengths were adjusted to remain stretched and during the entire collection period in contact with the soil. For each experimental condition, participants made three 60-second trials (15 trials). All trials were completely randomized and made in a single day.

Data analysis

Data regarding the center of pressure (CoP) were filtered using a 4th order Butterworth digital filter with a cutoff frequency of 5 Hz. After this procedure, we calculated the area of the ellipse adjusted to the deviation of the CoP, mean sway amplitude (MSA) and mean sway velocity (MSV). To calculate the area of the ellipse, we adjusted an ellipse containing 95%

of CoP displacement data to CoP values[20]. Mean sway amplitude was calculated as the standard deviation of the time series of CoP displacement in AP and ML directions, after we excluded any trends in data[20]. To calculate mean sway velocity, first we calculated sway amplitude subtracting average CoP position of each point recorded in the time series in AP and ML directions. Mean sway velocity was calculated as the average of the first derivative of each trial sway amplitude in AP and ML directions[7].

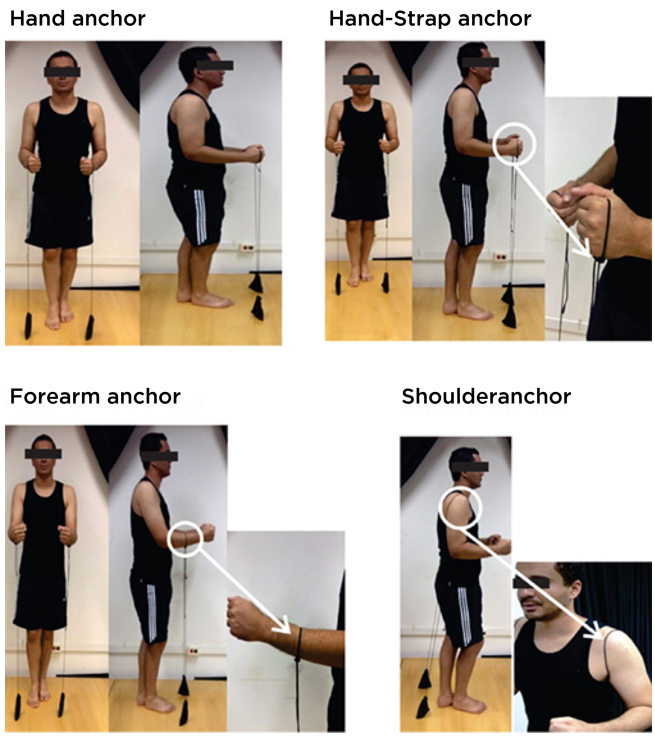

Figure 1. Photos illustrating different experimental conditions using the anchor system. Circles and arrows were placed to highlight the details of anchor fastening. (A) Hand anchor; (B) hand-strap anchor; (C) forearm anchor; (D) shoulder anchor

Statistical analysis

For the area of the ellipse, we performed a one-way ANOVA (five experimental conditions) with repeated measures. For the other dependent variables, we performed a one-way MANOVA (five conditions) with repeated measures, having as dependent variables AP and ML directions of each variable calculated, i.e., MSA, MSV and F80). Bonferroni post hoc tests have been used to identify differences between levels if any effect was identified. We calculated the power of ANOVA and MANOVA analyses. We adopted a 0.05 significance level.

RESULTS

Characterization of the sample

Older adults who participated in this study presented no signs of cognitive impairment according to Mini Mental State Examination score (25.6±1.4 pts), they were considered physically active by the score obtained in the modified Baecke questionnaire for older adults (13.4±7.3 pts) and had a good functional balance according to MiniBEST Test score (25.3±3.1 pts).

Area of the ellipse

ANOVA identified a main effect of condition ($F_{4,116}=6.599$; $p\leq0.0001$; power=0.990). The area of the ellipse was greater in the condition without anchor than in the hand anchor condition ($p=0.026$), hand-strap anchor ($p\leq0.0001$) and forearm anchor ($p=0.007$) (Figure 2A).

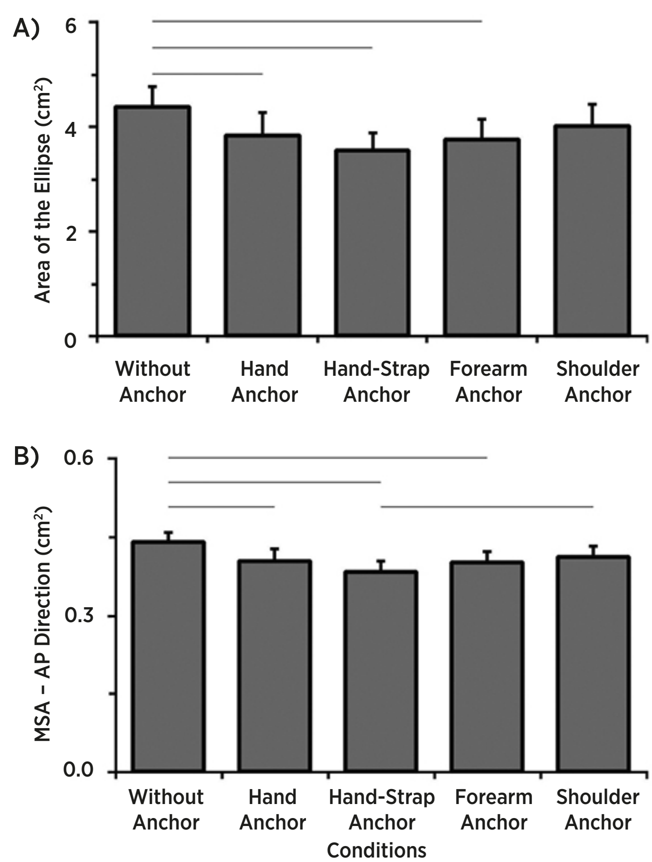

Figure 2. (A) Mean and standard error of the mean for the area of the ellipse; (B) mean sway amplitude in AP direction. Horizontal lines indicate the differences among pairs

Mean sway amplitude

MANOVA indicated a main effect of condition (Wilk's Lambda=0.753; $F_{8,230}$=4.390; p≤0.0001; power=0.996). Univariate analysis showed an effect only for AP direction ($F_{4,116}$=8.547; p≤0.0001; power=0.999). Mean sway amplitude was greater in the condition without anchor than in hand anchor (p=0.037), hand-strap anchor (p≤0.0001) and anchor forearm (p=0.030) conditions. Mean sway amplitude was greater in the anchor shoulder condition than in hand-strap anchor condition (p=0.028) (Figure 2B).

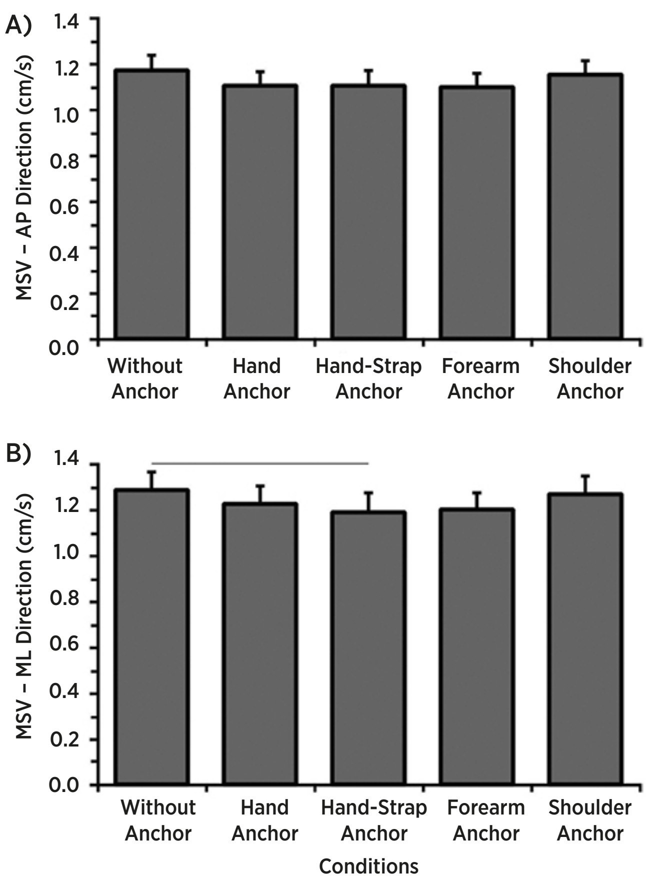

Figure 3. Mean and standard error of the mean for average sway velocity in AP (A) and ML directions (B). The horizontal line indicates the difference among pairs

Mean sway velocity

MANOVA indicated a main effect of condition (Wilk's Lambda=0.844; $F_{8,230}$=2.544; p=0.011; power=0.910). Univariate analysis showed an effect in both directions (AP: $F_{4,116}$=3.726; p=0.007; power=0.874 | ML: $F_{4,116}$=4.065; p=0.004; power=0.904). For AP direction, the *post hoc* analysis did not identify differences among the conditions (Figure 3A). Mean sway velocity in ML direction was greater in the condition without anchor than in hand-strap anchor condition (p=0.003) (Figure 3B).

DISCUSSION

This study aimed at evaluating the effect of using the anchor system at different points of contact (hand, forearm and shoulder) on older adults body sway while they maintained an upright posture. Results showed that using the anchor on the forearm resulted in a reduction in body sway equivalent to the hand anchor condition. Fastening the anchor on the shoulder, however, reduced body sway. Moreover, using the strap did not affect the anchor system contribution to reduce body sway. These results, except for the anchor on the shoulder, are in accordance with our previous studies, in which we showed that the anchor system reduced older adults' body sway while maintaining an upright posture[3,15] and during tandem gait[16].

This study's results partially confirm its hypothesis, for fastening the anchor on the shoulder did not reduce body sway. Krishnamoorthy et al.[10] argued that the effect of light touch does not depend on tactile receptor density at the contact region, but on the point of contact in relation to the torso. Points of contact closer to the torso approximate to the body vertical and seem more effective at reducing body sway, because they inform more directly about changes in body orientation than the vertical. These authors observed that light touch of the neck region reduced more body sway in young adults than fingertip light touch. When using fingertip light touch, the postural control system must distinguish information on body sway in relation to the vertical, from arm movement in relation to the shoulder and elbow. An argument that could be used is that the receptor density is smaller in the shoulder than in the hands. The beginning of two-point discrimination, however, is similar for the forearm and the shoulder[21]. Results showed a reduction in body sway when the anchors were fastened on the forearm as discussed below. Therefore, it is not likely that the quantity of receptors would cause no effects when anchors are fastened on the shoulder. The main factor that must have contributed for this lack of effect of the anchor system at the point of contact closest to the body vertical in this study may be the difficulty of fastening the anchors on the shoulders. During data collection, precisely fastening the anchors on the shoulders on the acromioclavicular joint was the most complex condition, because this is a region with many bone structures. In few conditions it was necessary to repeat the shoulder anchor condition at the end of randomized conditions, because the anchor moved from the right position during data collection. This limitation thus should be explored in future studies.

The use of the anchor on the forearm, however, was as effective as the use of anchor on the hand. This result is in agreement with a study involving light touch of the forearm[11]. Norrsell et al.[11] showed that light touch of the forearm region reduced young adults body sway. This study results strengthen the fact that receptor density is not the most important factor to add haptic information to the postural control system. One novelty of this study is its applicability to older adults. Older adults' performance is indeed comparable to young adults' during tasks requiring haptic perception of object's properties such as shape and length. The haptic exploration of three-dimensional objects and recognizing thus shapes and surface characteristics of the objects is not influenced by aging[22,23]. Besides, the perception of a wooden staff or tennis racket lengths through haptic exploration also is not affected by aging[24,25].

This lack of difference in haptic perception between young and older adults may be related to active exploration in haptic perception tasks. Gibson[26] showed that active exploration of objects lead to a correct identification in 95% of trials, while passive stimulation of the same objects resulted in a correct identification in only 49% of trials. This effect of active exploration may also help explaining why anchors fastened on the shoulders had no effect. It is possible to more actively explore the anchors if they are positioned on the forearms, instead of positioned on the shoulders. With anchors on the forearms, the subtle movement of the elbows allows to actively explore the anchors and obtain better quality sensory information as suggested by Gibson[26,27]. For the shoulders, the active exploitation depends more on torso movement in relation to the pelvis or even on the whole body in relation to the ankle. In this case, active exploration may greatly increase the displacement of the center of mass, reducing the individual's margins of stability. In this regard, haptic information is not restricted to one or few receptors that are passively stimulated, but is fundamentally present in perception-action cycles characterizing the exploration of the object.

In summary, using the anchor system on the forearms reduced body sway in the same way traditional anchor does. The use of the strap did not compromise the anchor system functioning. The advantage of using the anchor system instead of light tough is because it is easy to use in different contexts such as physical education classes and in clinical practice. Unlike the light touch paradigm that requires a rigid and stable support surface, which limits its use in more dynamic situations, the anchor system has a low cost and a high flexibility of use, and it can be used during dynamic tasks.

In physical therapy clinical practice, the anchor system can be used in balance training programs for older adults, individuals with vestibular deficits or cerebral palsy, among others. Moreover, to complement physical therapy sessions the physical therapist can also prescribe unsupervised use of the anchor system at home due to its simplicity. Future studies should indicate, however, the amount of practice needed, as well as the best activities that can be used with the anchor system to enhance these patients rehabilitation.

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