

Effect of age, dual task and vision on the sense of ankle positioning

O efeito da idade, da dupla tarefa e da visão no senso de posicionamento do tornozelo

Efectos de la edad, doble tarea y visión en el sentido de posicionamiento del tobillo

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ABSTRACT | The objective of this research was to measure objectively the proprioception in different situations (with and without the aid of vision, with or without a concomitant cognitive task, and actively and passively), in elder and adult individuals. Ten healthy adults and ten healthy seniors participated in the study. The effects of different restrictions were studied in the development of movement through absolute (accuracy) and relative (consistency) errors. The sense of ankle positioning was measured with a Biodex System 3 isokinetic dynamometer. Four-factor analysis of variance and the Tukey *post hoc* test were used to analyze the parameters. The results showed that the subject factor interferes in the absolute error, since the groups showed significant difference: the elderly make more mistakes when compared with adults. The other factors (vision, cognitive task and type of movement) did not show significant difference. In the relative error, results showed that the cognitive task concomitant to movement was capable of producing significant difference; however, the other factors (individuals, vision and type of movement) were not. Age affects the accuracy of the proprioceptive sense, regardless of the situation. There was no difference between performing the movement with and without the aid of vision, and the double task (motor associated with cognitive) affects the consistency of the movement.

Keywords | Proprioception; Elderly; Adult; Postural Balance, Accidental Falls.

RESUMO | O objetivo desta pesquisa foi mensurar de forma objetiva a propriocepção, em diferentes situações (com e sem o auxílio da visão, com e sem tarefa cognitiva concomitante e de forma ativa ou passiva), em indivíduos idosos e adultos.

Participaram do estudo dez adultos saudáveis e dez idosos saudáveis. Foram estudados os efeitos de diferentes restrições no desempenho do movimento por meio dos erros absoluto (precisão) e relativo (consistência). A mensuração do senso de posicionamento do tornozelo foi realizada com o dinamômetro isocinético Biodex Sistem 3. A análise de variância de quatro fatores e o teste *post hoc* de Tukey foram utilizados para analisar os parâmetros. Os resultados mostraram que o fator sujeito interfere no erro absoluto, pois os grupos apresentaram diferença significativa: os idosos erram mais quando comparados com os adultos. Os demais fatores (visão, tarefa cognitiva e tipo de movimento) não apresentaram diferença significativa. No erro relativo os resultados mostraram que a tarefa cognitiva concomitante ao movimento foi capaz de produzir diferença significativa; entretanto os demais fatores (indivíduos, visão e tipo de movimentação) não foram capazes de produzir uma diferença significativa. A idade afeta a precisão do sentido proprioceptivo, independentemente da situação. Não houve diferença entre a realização do movimento com e sem o auxílio da visão, e a dupla tarefa (motora associada à cognitiva) afeta a consistência do movimento.

Descritores | Propriocepção; Idoso; Adulto; Equilíbrio Postural; Acidentes por Quedas.

RESUMEN | En este estudio se propone medir objetivamente la propiocepción en situaciones diferentes (con y sin la ayuda de la visión, con y sin la tarea cognitiva concomitante y de forma activa o pasiva), en adultos y adultos mayores. Del estudio han participado diez adultos sanos y diez adultos mayores sanos. Se analizaron los efectos de diversas restricciones en

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Corresponding author: Angelica Castilho Alonso – Rua Taquari, nº 546 – Mooca – São Paulo (SP), Brazil – CEP: 03166-000 – E-mail: angelicacastilho@msn.com – Finance source: Nothing to declare – Conflict of interest: Nothing to declare – Presentation: Jun. 12th, 2017 – Accepted for publication: Sept. 28th, 2017 – Approved by the Ethics Committee: Protocol no. 060/06.

el funcionamiento del movimiento por medio de los errores absoluto (precisión) y relativo (consistencia). La medición del sentido de posicionamiento del tobillo se llevó a cabo por medio del dinamómetro isocinético *Biodex System 3*. Se utilizaron el análisis de varianza de cuatro factores y la prueba *posthoc* de Tukey, para analizar los parámetros. Los resultados demostraron que el factor sujeto interfiere en el error absoluto, ya que los grupos presentaron una diferencia significativa: los adultos mayores cometen más errores que los adultos. Los otros factores (visión, tarea cognitiva y tipo de movimiento) no demostraron diferencias significativas. En el error relativo, los

resultados desvelan que la tarea cognitiva y el movimiento fueron capaces de producir una diferencia estadísticamente significativa; sin embargo, otros factores (personas, visión y tipo de movimiento) no fueron capaces de producirla. La edad afecta a la exactitud del sentido propioceptivo, independientemente de la situación. No hubo diferencias entre el rendimiento del movimiento con y sin la ayuda de la visión, y la doble tarea –motora relacionada con la cognitiva– impacta en la consistencia del movimiento.

Palabras clave | Propiocepción; Adulto Mayor; Adulto; Balance Postural; Accidentes por Caídas.

INTRODUCTION

The aging process is accompanied by a decline in the sensory motor system, which is responsible for transmitting stimuli to the central nervous system (CNS), regarding position and movement of the body in relation to support surfaces, information relative to muscle strains, tension in the joints and deep vibration, as well as static joint position and movement, in addition to its direction and intensity.

Postural control depends on sensory information provided by vision, proprioception and by the vestibular system, which are integrated and centrally processed by several areas in the brain, including the cerebellum, brainstem, basal ganglia, sensory and motor cortexes. Through medullary signs, the postural control is effected by activating muscles of limbs and upper body. Musculoskeletal components for postural control include: amplitude and flexibility of the joints, coordinated muscle activations and a good alignment between body segments²⁻⁴.

Functional effects are affected by the number of lost receptors. Their decrease leads to a deficit in neuromuscular control, motor coordination and in postural balance, consequently increasing the risk of falling^{5,6}. According to Ribeiro and Oliveira⁶, elderly people depend more on sensory-motor information than on vision to keep balance. In addition, proprioceptive deficits may lead to biomechanical abnormalities during functional activities that, over time, result in degenerative articular diseases.

There are a few techniques to assess the sensory-motor system. One of them assesses the sense of positioning, documenting the individual's ability to produce a predetermined angle of range of articular motion, well studied in world literature.

In recent years, studies on functional capabilities in different conditions—such as visual, multitasking⁸, vehicular

direction⁹, postural balance^{10,11}, walking¹³—included a double task, defined as simultaneous accomplishment of a primary, usually motor, task, associated with other tasks, called secondary, which may be cognitive, motor or motor-cognitive. These activities are linked to the executive function that occurs in cortical level, and it is possible that a task will interfere in the other, reducing automatism and consequently increasing motor demand.

As most everyday tasks occur in double task conditions, and even though sensory information and their lack/alteration are related to falls of elderly people, there are still doubts regarding the proprioceptive conditions of these individuals. The great incidence of falls and their disabling consequences increase the need for researches aimed at investigating its probable causes.

For this reason, the objective of this study was to measure and compare the sense of positioning during ankle dorsiflexion motion with and without a cognitive task and without the aid of vision in healthy elderly people and adults.

METHODOLOGY

This is a controlled cross-sectional study, performed in the biomechanics of human movement laboratory at the Universidade São Judas Tadeu and was approved by its Ethics Committee.

Casistry

Twenty individuals participated in this study, divided in two groups: a group of healthy seniors (n=10) and a control group of adults (n=10). Inclusion criteria were: being healthy individuals; absence of the referred vestibular,

proprioceptive or neurological disorders; not using medications that could impair the understanding of the task; not having a limitation in the joints of lower limbs, especially in the ankle. Exclusion criteria: referring pain or any discomfort during data collection or being incapable to perform the additional cognitive task for any reason.

Procedures

The individuals that fulfilled the inclusion criteria were invited to participate in the study and signed the informed consent form. The following data were recorded during an interview: age, dominance of lower limbs, health-related data, body weight and stature, and the body mass index was calculated. Each test took about one hour.

Measurement

The sense of positioning of the ankle was measured by a *Biodex System 3* isokinetic dynamometer (Biodex Medical Systems). This measurement mechanism was connected to a system of data acquisition and interpretation stored in a *Pentium 4* computer of 2.66MHz. The acquisition frequency of measured signs was of 1KHz.

Initially, the subjects were accommodated in the dynamometer chair, which was adjusted for each individual. The proximal body segment was fixed with the straps available in the chair, according to the specifications of the device. The evaluation protocol of the right ankle unilateral proprioception was performed and, after adjusting the range of motion achieved by each subject, a dorsiflexion of 5° was defined as a target angle for all, using the speed of 10°/s.

The test of ankle dorsiflexion movement started passively to the subject, and a time of three seconds was established to memorize the target angle. This task was repeated six times for each situation: (1) in silence; (2) without the aid of vision; and (3) with a cognitive task, in which the reading task from the Stroop test was used, which consists in reading names of colors printed in incongruous color. This type of task requires selective attention, ability to focus in an activity and inhibit the tendency to provide impulsive responses. After passive collection, the subject was requested to redo the test actively, using the same protocol.

Statistical analysis

The parameters were compared through analysis of variance (Anova). The following factors were examined for

this analysis: subjects (control group and elderly group), vision (with or without its aid), cognitive task (with or without performing it) and movements (passive and active). The Tukey *post hoc* honestly significant difference (HSD) test was used.

To measure the movement performance, absolute and relative errors were assessed. To calculate them, it is necessary to obtain the directional tendency of error, which is estimated through constant error (CE) – or algebraic error. This variable is calculated through simple arithmetic average of error values, with attribution of a sign (+ or -), in a series of attempts. With this strategy, it is possible to calculate the average response accuracy (absolute error or quadratic error) and the variability of responses along these attempts (variable or relative error). The absolute error is the representative value of the magnitude of temporal errors committed in the series of attempts, regardless of the error direction.

To be considered a skilled performer, the participant should present accurate responses on most attempts. If the performance errors were concentrated around a value, typically close to zero, it was considered that the performed was consistent in their performance. It is worth mentioning that the accuracy and consistency are conceptually unrelated: while accuracy corresponds to performance errors close to zero, consistency is the concentration of errors in a series of attempts around any value, not necessarily zero.

For all statistical analysis, the significance level adopted was $p < 0.05$. The tests were performed in the *Statistica* software (*Statsoft, Inc., Tulsa, OK, USA*).

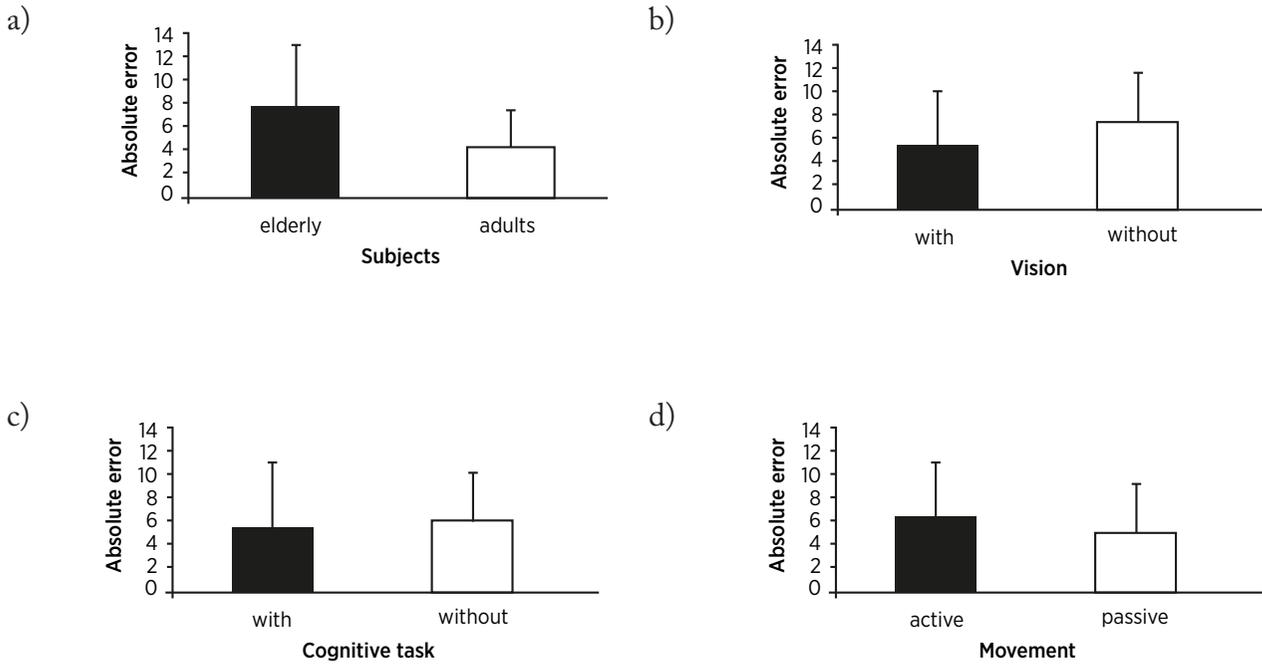
RESULTS

Ten healthy seniors participated in the study with an average of 65 years, 55 kg and 1.6 m of height. Ten adult individuals participated of the control group, with an average of 21 years, 50 kg and 1.62 m of height.

Figure 1 shows absolute error (accuracy). The analysis of variance (Anova) showed significant difference for the subject factor (Figure 1a – $F_{(1,118)} = 19.5$; $p < 0.0001$), in which the Tukey *post hoc* test pointed greater errors in the elderly group ($p = 0.0001$). However, regarding the other factors, such as vision (Figure 1b – $F_{(1,118)} = 21.9$; $p < 0.05$), cognitive task (Figure 1c – $F_{(1,118)} = 22.4$; $p < 0.26$) and motion (Figure 1d – $F_{(1,118)} = 22.0$; $p < 0.05$), there was no significant difference.

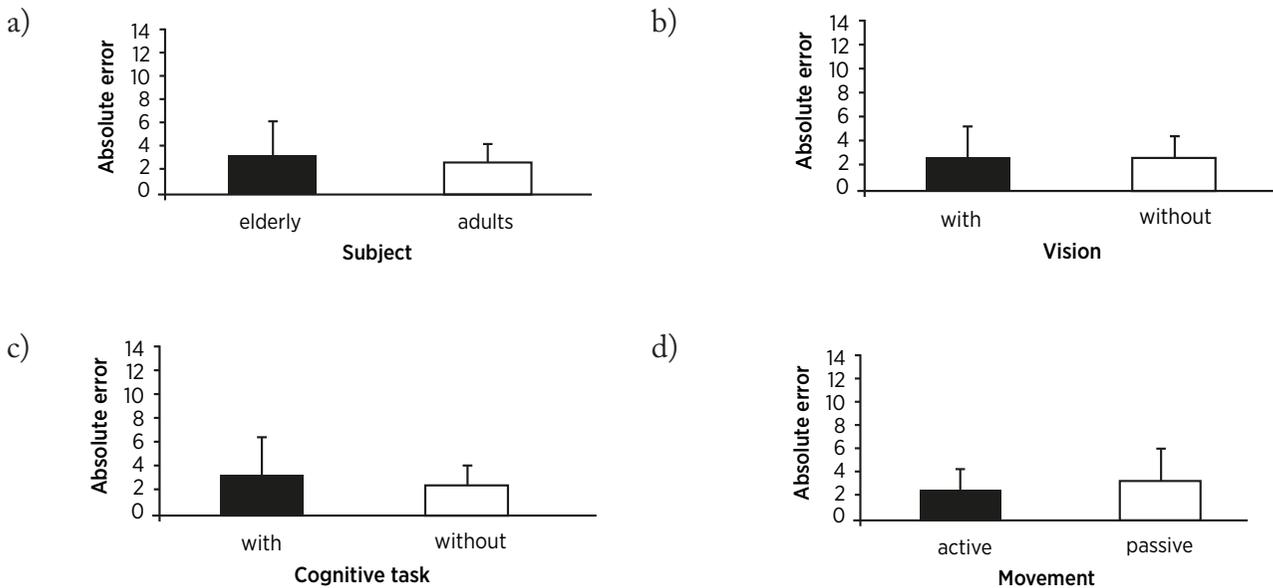
Figure 2 shows the relative error (consistency). For the factors subject (Figure 2a – $F_{(1,118)}=2.8$; $p=0.09$), vision (Figure 2b – $F_{(1,118)}=0.1$; $p=0.68$) and motion (Figure 2d – $F_{(1,118)}=2.1$; $p=0.14$) there was no significant difference.

But, regarding the cognitive task (Figure 2c), according to the Anova, there was a significant difference ($F_{(1,118)}=5.2$; $p=0.04$), in which the Tukey *post hoc* test pointed major errors in the elderly group.



(a): difference between seniors and adults; (b): values found while performing the task with and without the aid of vision; (c): results obtained while performing the cognitive task concomitant to motion; (d): values found between the different ways to execute the movement

Figure 1. Mean and standard deviation of the absolute error during the task of reaching the 5° target angle of ankle dorsiflexion in the isokinetic dynamometer



(a): difference between seniors and adults; (b): values found while performing the task with and without the aid of vision; (c): results obtained while performing the cognitive task concomitant to motion; (d): values found between the different ways to execute the movement

Figure 2. Mean and standard deviation of the relative error during the task of reaching the 5° target angle of ankle dorsiflexion in the isokinetic dynamometer

DISCUSSION

The main findings of the study were that age is related to sensory-motor deficits and to the consequent reduction of the proprioceptive sense, and that cognitive tasks interferes with the reproduction of movement.

Our results showed that, when compared to adults, regardless of the situation, elderly people show a significant difference in the absolute error of the sense of articular position, which is related to accuracy. However, there was no change in the relative error, which is related to consistency. Therefore, although seniors miss more, they are as consistent as an adult.

In the study by Pupo et al.⁷, seniors without osteoarthritis showed results similar to this study. However, the results were worse when elderly people were diagnosed with osteoarthritis. This suggests that the aging of muscular and articular tissue may affect the individual's sense of position, since the important proprioceptors to this task are located in the muscles and articulations. Muscle mass degradation, sarcopenia and its posterior replacement by connective tissue occur throughout aging, and the area of contact between axon and cell membrane decreases. Maybe this is one possible cause for this difference.

Unlike other authors, our results regarding vision show that there was no significant difference between performing the movement with or without its aid, both concerning the absolute and relative error. The discrepancy between the results found in this and previous studies may have occurred due to methodological differences concerning the instrument of proprioceptive assessment. In studies by Jamet et al.⁸, the assessment was performed with the individual standing – unlike the form adopted in this study, in which all individuals remained seated. This suggests that vision is more requested to obtain postural control while standing.

Regarding the cognitive task added concomitant to movement, it was not able to significantly change accuracy; however, regarding consistency, it was decreased in elderly people. This is a type of task that is related with executive function and, according to Asimakopulos et al.¹⁰, it is a determinant component of different functional capacities, including complex tasks, such as driving a car^{10,11}. Literature shows that, in elderly people, there is a risk of physical integrity regarding the execution of a double task—for example, walking and performing another cognitive task—since this interferes with walking performance of healthy elderly people, increasing the

risk of falls and fractures in this population^{12,13}. Barbosa et al.¹⁴ and Deshpande et al.¹⁵ stated that the decline of proprioceptive acuity is directly linked to the induced challenge and that including a double task in the evaluation and clinical practice should be considered.

Regarding the way of moving, both accuracy and consistency showed no significant change, possibly because the sense of proprioception is related to movement, regardless of whether it occurs passively or actively.

CONCLUSION

Age affects the accuracy of the proprioceptive sense, regardless of the situation. There was no difference between the performance of movement with and without the aid of vision, and the double task (motor associated with cognitive) affects movement consistency.

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