ORIGINAL ARTICLE

ISSN 1413-3555
Rev Bras Fisioter, São Carlos, v. 13, n. 6, p. 549-54, Nov./Dec. 2009

Comparing static sitting postural sway of healthy young and older adults

Comparação da oscilação postural estática na posição sentada entre jovens e idosos saudáveis

Patrícia S. Melo[1], Tárcia P. Ferreira[1], Taiza E. G. Santos-Pontelli[1], José A. O. Carneiro[2], Antonio A. O. Carneiro[3], José F. Colafêmina[1]

Abstract

Objectives: To describe a new method to analyze the static sitting postural sway and to compare the results of healthy young and older adult subjects. Methods: Thirty-eight healthy subjects took part in the study, including 17 young adults (mean age 23±2.38 years old) and 21 older adults (mean age 67±2.42 years old). The device used to quantify trunk sway was the magnetic field sensor Polhemus® 3Space Isotrack II. The measurements were taken in the eyes-opened (EO) and eyes-closed (EC) condition with the subjects seated first on a wooden stable surface (SS) then on a foam unstable surface (US) without back or foot support. Each sensory condition was assessed for 90 seconds. The analyzed parameters were: maximum amplitude (Amp), total trajectory (Traj) and mean velocity (Vel) in the sagittal (X) and frontal (Y) planes. Results: In the EO and EC conditions on SS, young adults presented greater postural sway in the X and Y planes on the Traj and Vel parameters. In the US, young adults showed greater Y Traj and Y Vel in the EO and EC conditions, and there was no significant difference between the groups with regard to X Traj and X Vel in the EC condition. The young adults presented greater Amp only in the EOSS condition in the X plane. Conclusions: The young adult subjects presented greater sway in the sitting position than the older adult subjects. In addition, the Polhemus® device was a useful tool to analyze static sitting postural sway and can be used in future studies that associate static sitting postural sway with the effect of various motor tasks.

Key words: postural sway; sitting balance; older adults; young adults.

Resumo

Objetivos: Descrever uma nova metodologia de análise da oscilação postural estática sentada e comparar os resultados de jovens e idosos saudáveis. Métodos: Participaram do estudo 38 indivíduos saudáveis, 17 jovens (idade média 23±2,38 anos) e 21 idosos (idade média 67±2,42 anos). A oscilação postural foi mensurada por meio do sistema eletromagnético Polhemus® 3Space Isotrack II. As avaliações foram feitas nas condições olhos abertos (OA) e fechados (OF), com os voluntários sentados sem apoio plantar e sem encosto em suportes de madeira (superfície estável-SE) e de espuma (superfície instável-SI). Cada condição sensorial foi avaliada durante 90 segundos. Os parâmetros analisados foram: deslocamento máximo (Dmáx), trajetória total (Traj) e velocidade média (Vel) nos planos sagital (X) e frontal (Y). Resultados: Nas condições OA e OF em SE, foram encontradas oscilações nos planos X e Y dos parâmetros Traj e Vel maiores em jovens que em idosos. Em SI, foram observadas maiores Traj Y e Vel Y nos jovens, sem diferença significativa entre os grupos quanto a Traj X e Vel X com olhos fechados. Em relação ao Dmáx, tanto no plano X quanto no Y, em todas as condições sensoriais, só houve diferença significativa na condição OASE no plano sagital, sendo maior nos jovens. Conclusões: Jovens saudáveis oscilam mais que os idosos saudáveis na posição sentada. Além disso, a ferramenta utilizada mostrou ser útil para análise da oscilação postural estática na posição sentada, possibilitando o surgimento de estudos que a associem com o efeito de diversas tarefas motoras.

Palavras-chave: oscilação postural; equilíbrio sentado; idosos; jovens.

Received: 10/11/2008 – Revised: 26/02/2009 – Accepted: 08/05/2009

[1] Department of Ophthalmology, Otorhinolaryngology and Head and Neck Surgery, Faculdade de Medicina de Ribeirão Preto, Universidade de São Paulo (FMRP-USP), Ribeirão Preto (SP), Brazil
[2] Department of Clinical Medicine, FMRP-USP
[3] Physics and Mathematics Department, Faculdade de Filosofia, Ciências e Letras de Ribeirão Preto, USP
Correspondence to: Taiza E. G. Santos-Pontelli, Departamento de Oftalmologia, Otorrinolaringologia e Cirurgia da Cabeça e Pescoço, Faculdade de Medicina de Ribeirão Preto-USP, Av. dos Bandeirantes, 3.900, Monte Alegre, CEP14040-900, Ribeirão Preto (SP), Brazil, e-mail: taiza@fmrp.usp.br
Os resultados parciais deste trabalho foram apresentados em forma de pôster no 16° SIICUSP, 2008.
Partial results of this study were presented in poster form at the 16th SIICUSP, 2008.

Introduction

Postural control is the ability to keep the body center of mass within the base of support during static and dynamic postures. This is a perceptual-motor process that involves the sense of position and motion derived from the visual, somatosensory and vestibular systems. It also involves the processing of sensory information and the selection of motor responses that maintain or recover body balance[1]. The maintenance of this control is important to the performance of the activities of daily living (ADLs) that require the ability to remain stable in several positions, to react automatically to voluntary body and limb movements, and react to external disturbances[2].

The aging process impairs the sensory systems (visual, somatosensory and vestibular systems), the aspects related to the motor task (force, amplitude, biomechanical alignment, flexibility) and the central processing[3], which are essential for the performance of the functional activities[4]. This degenerative process can be noted through changes such as gait deviations, instability, nausea, frequent falls and loss of balance[5], the latter being one of the main factors that currently limit the social life of older adults[6]. More than half of the cases of postural imbalance appear between the ages of 65 and 75, and about 30% of older adults have symptoms at that age[6].

In the older adult population, the deterioration of postural balance is considered a primary cause of falls[7], and as age advances, its incidence increases. This is an alarming fact because 20% of falls require medical attention[8], and in some cases they can lead to fractures that correspond to 70% of accidental deaths in people over 75 years of age[9]. It is estimated that nearly 45% of older adults over 65 will suffer at least one fall each year[10]. In addition to the fractures, the falls result in other consequences such as minor injuries, psychological complications and significant loss of functional independence[11]. In this context, the manifestation of balance disorders has a significant impact on older adults and may lead to reduced functional capacity[12], immobility, fear of recurrent falling and high costs with health treatments[6].

The method that objectively assesses balance and has received the most attention in the literature is posturography and currently the most widely used posturographic measurement is the center of pressure (CP). It is defined as the point of application of the resultant of the vertical forces acting on the surface of support, and it is quantified using a force platform[13]. Another method of posturographic analysis described in the literature is baropodometry using an electronic baropodometer[14]. The use of posturography to assess postural stability in healthy older adults is considered a promising and sensible approach to identify pre-clinical changes in the postural control system[15].

As already shown in the literature[16,17], static sitting balance is essential to the performance of ADLs. Tasks related to feeding, personal hygiene, dressing and toileting require the ability to maintain a sitting posture. Balance in this position is also considered a predictor of functional recovery in people who have suffered a stroke. Tyson et al.[17] assessed this relationship through the application of different questionnaires and found that most patients with sequelae from stroke and deficient sitting balance did not recover from their impairments, and only a few cases recovered independence in the ADLs.

Several studies that compared the postural control of healthy young and older adults focused on the importance of dynamic balance when climbing and descending stairs[18] and during gait[19]. These studies indicated that older adults do not reduce body sway effectively during the stair-to-floor transition and that they are more careful when submitted to a faster gait due to the fear of losing their balance. Other studies have investigated reaction and recovery times after an external disturbance[20] and static balance in the standing position[21] using the force platform to compare the postural sway of young and older adults. It has been already demonstrated that older adults have slower reaction times for both static and dynamic reactions.

One of the few studies that evaluated postural sway in the sitting position used the force platform to assess subjects in the subacute phase of stroke[22]. During the assessment, the subjects remained seated on a chair with a wide seat and with their feet on a footrest[22]. However, no studies in the literature have used an electromagnetic system to objectively and quantitatively analyze postural sway in young and older adults during static sitting.

One of the difficulties faced by researchers and therapists who work with balance is the lack of instruments that quantify postural sway with precision. The 3Space Isotrak electromagnetic sensor system (Polhemus®) is an important instrument in this field of knowledge because of its easy transportation that allows assessments in various settings and because it is more affordable than the force platform.

The present study aims to describe a new methodology for the analysis of static sitting postural sway and to compare the results for healthy young and older adults using the Polhemus® three-dimensional electromagnetic system. This instrument can provide quantitative data on postural control while sitting, and this data is necessary for outlining rehabilitation measures and for monitoring the results of a specific treatment.

Methods

Eighty-seven subjects were submitted to anamnesis to identify possible diseases. Five young and 44 older adults were excluded from this research due to vestibular, neurological, musculoskeletal, cardiovascular, psychiatric disorders or visual impairment without corrective lenses. Thirty-eight healthy non-athletes were included, with body mass index (BMI) between 18.5 and 24.9. The subjects performed physical exercise no more than twice a week, without regularity, and were divided into two distinct groups: young adults (n=17; 13 women and 3 men aged 19 to 28; mean age 23±2.38 yrs) and older adults (n=21; 19 women and 2 men aged 65 to 75; mean age 67±2.42 yrs). All subjects received detailed information about the participation and signed an informed consent form. The study was approved by the Medical Ethics Committee of Hospital das Clínicas of Faculdade de Medicina de Ribeirão Preto, Universidade de São Paulo (Process number 5317/2007).

Postural sway was measured by the Polhemus® 3Space Isotrak electromagnetic sensor system, a device developed to determine position and spatial orientation in three dimensions. It records the relative position (coordinates x, y, z and Euler angles θ, ϕ, ρ) between the system's receiver and transmitter. The subject's relative spatial position (x, y, z), digitized by the device, was transferred to the computer in a rate of 60 Hz. Because it is a digital signal, free from electromagnetic interference, it was not necessary to use digital filters to assess balance. When the sensor is secured to a stable structure, the signal deviation is the digitizing limit itself and represents a relative spatial variation of approximately 0.2 mm per coordinate. The data were obtained and transferred to a notebook computer in real time using a serial/USB interface and software developed in LabView 8.0. An HP Pentium 4 computer was used to automate the measurement and data processing instruments in an interface created in LabView 8.0. The software and interface were developed by a research group called Grupo de Inovação de Instrumentação Médica e Ultrassom (GIIMUS).

The sensor was positioned on the spinous process of the second thoracic vertebra to measure trunk movement. The thoracic region was chosen for sensor positioning because it is the most stable portion of the spine and because it adequately transmits trunk sway. The magnetic coil transmitter was placed on a surface away from the subject at a distance of nearly 40 cm and at the same height as the sensor. The subject sat without foot or back support on a wooden chair with adjustable height and a seat measuring 50 cm in length[23] and 50 cm in width (stable surface). The chair was then covered with a piece of foam (density of 30 kg/m^3), measuring 50 cm in length and 50 cm in width (unstable surface) to support the whole thigh. The subject was asked to remain seated and static ("still") during data collection, with the upper limbs resting on the thighs. Before data collection the subject was given a full explanation of the procedures and practiced with eyes open and closed on the stable surface for a few seconds. They were also allowed to ask any questions about the procedures. Procedure analysis and adjustment for interference was performed during practice.

The measurements were taken under four sensory conditions, in the following order[23]:

- **Condition 01:** subject seated on a stable surface with the eyes opened (EOSS);
- **Condition 02:** subject seated on a stable surface with the eyes closed (ECSS);
- **Condition 03:** subject seated on an unstable surface with the eyes opened (EOUS);
- **Condition 04:** subject seated on an unstable surface with the eyes closed (ECSS).

In the EO conditions, subjects were instructed to keep looking straight ahead at a target at a distance of 1.5 m. Each sensory condition was evaluated for 90 seconds. The variables maximum amplitude, total trajectory and mean velocity in the frontal (Y) and sagittal (X) planes were statistically analyzed using the non-parametric Mann-Whitney test for independent samples (inter-group analyses) and the Wilcoxon test for dependent samples (intra-group analyses) in SPSS (version 11.0) for Windows. The maximum amplitude (Amp) in the anterior-posterior (AP) direction was considered AP Amp and the maximum amplitude in the latero-lateral (LL) direction was considered LL Amp. Total trajectory (Traj) was defined as the total space travelled by the body during data acquisition in the AP and LL direction. The value obtained from the ratio of Traj to time was considered as the mean velocity (Vel).

Results

The data from one of the young subjects on the stable surface with eyes opened were not included in the statistical analysis due to external interference in the electromagnetic receiver sensor. Table 1 shows the mean and standard deviations for all variables analyzed in the present study.

Inter-group analysis (unpaired)

On the stable surface, with eyes opened or closed, there was greater AP (X axis) and LL (Y axis) sway in the Traj and Vel parameters for the older adults (EOSS: X-Traj: p=0.013; Y-Traj: p=0.001; X-Vel: p=0.012; Y-Vel: p=0.001; ECSS: X-Traj: p=0.023; Y-Traj: p=0.002; X-Vel: p=0.025; Y-Vel: p=0.003). On the unstable surface, there was greater Traj and Vel in the frontal plane in the young subjects (EOUS: Y-Traj: p=0.003; Y-Vel: p=0.003; ECUS: Y-Traj: p=0.004; Y-Vel; p=0.004).

In the sagittal plane, in the ECUS condition, there was no significant statistical difference between the young and older subjects regarding Vel (X-Vel: p=0.081) and Traj (X-Traj: p=0.075). Concerning the AP and LL Amp in all four conditions, there was a significant difference only in the EOSS in the sagittal plane, with a greater value for young subjects (X-Amp: p=0.016).

Paired analysis for the young and older adult groups

Analyzing the young and older adult groups separately, there was no statistical difference between the EOSS and ECUS conditions in all the variables. Comparing the responses obtained on the different surfaces for the young subjects, there was greater dislocation only in the frontal plane in the US compared to the EOSS (Y-Amp: p=0.044). In the older adult group, the dislocation both in the X and Y planes was significantly greater in the EOUS condition (Y-Amp: p=0.018; X-Amp: p=0.011). In the EC condition, there was no significant difference between the SS and US in both groups.

Paired analysis for the integrated sample

For the 38 healthy subjects, there was no significant difference between the EO and EC conditions in all the analyzed parameters. Comparing EOUS and EOSS for the whole sample, there was greater LL sway (Y-Amp: p=0.002) and AP sway (X-Amp: p=0.034) in the US. There was no significant difference between the surfaces in the EC condition.

Discussion

The greater postural sway in the older adults compared to the younger adults in the standing position is a common result found in the literature[23,24]. There are references that show the same data in the sitting position[25,26] through observational analysis. The present study is the first to analyze sitting balance objectively and quantitatively using the Polhemus® electromagnetic system. Contrary to the evidence in the literature, we observed that young subjects have greater postural sway in the sitting position than the older adults. These results were found when analyzing the influence of vision by comparing the EO and the EC conditions and when analyzing the influence of the type of surface by comparing the stable (wooden) and unstable (foam) surfaces.

Sensory information is essential for human postural control. In the absence of visual information (EC condition) or in the absence of exact information about the surface's orthogonality (unstable surface condition), there is a greater demand from the neuromotor systems to maintain postural balance. The greater sway in older adults, usually observed through the variability of the CP, is attributed to the decreased efficiency of the sensory systems with age[25]. This could also decrease the redundancy of sensory information commonly exhibited by healthy adults. Combined with the inability to select the relevant sensory information, the reduction in the efficiency of the sensory systems could be responsible for an increase in body sway in the standing posture and for the postural unbalance in older adults[23,27].

Recently, Tucker et al.[20] compared the reaction times and the pattern of temporal coordination of the CP of young and older adults and found a more rigid pattern associated with advanced age during the maintenance of postural control in

Table 1. Results expressed as mean±standard deviation of all variables: maximum amplitude (Amp) in cm, total trajectory (Traj) in cm and velocity (Vel) in cm/s, in all sensory conditions in both planes.

Conditions/	Young adults				Older adults			
Variables	EOSS	ECSS	EOUS	ECUS	EOSS	ECSS	EOUS	ECUS
X-Amp Mean±SD	1.25±0.49	0.9±0.42	1.15±0.56	0.98±0.47	0.85±0.28	0.88±0.69	1.13±0.75	1.1±0.53
Y-Amp Mean±SD	0.66±0.32	0.65±0.38	0.96±0.38	0.96±0.38	0.71±0.31	0.68±0.35	0.96±0.47	0.85±0.39
X-Traj Mean±SD	137.10±46.12	135.14±45.92	144.78±41.35	138.28±41.72	114.57±29.41	114.21±35.53	113.57±32.07	118.13±33.51
Y-Traj Mean±SD	92.08±31.52	89.64±33.11	103.45±32.63	94.9±34.99	45.41±16.27	49.15±21.16	52.98±17.12	50.69±17.79
X-Vel Mean±SD	1.52±0.51	1.5±0.51	1.61±0.45	1.54±0.46	1.28±0.32	1.27±0.39	1.26±0.35	1.32±0.37
Y-Vel Mean±SD	1.02±0.34	1.0±0.36	1.15±0.36	1.05±0.38	0.5±0.18	0.55±0.23	0.59±0.19	0.57±0.19

EOSS=eyes opened stable surface; ECSS=eyes closed stable surface; EOUS=eyes closed unstable surface; ECUS=eyes closed unstable surface.

the standing position. According to the authors, older subjects adopt more rigid movements to maintain body stability in challenging conditions, which may be related to the joints' musculoskeletal and ligament changes or to a strategy of active postural response[20].

Using the Polhemus® system to analyze body sway in the static standing position in Parkinson's patients, Minati[28] also observed a more rigid posture in the EC condition on the SS. However, on the US these patients swayed much more in the EC condition than the EO condition. There may be a threshold that defines the capacity to maintain a better postural balance using the rigid strategy. Once the patient is in a situation where this threshold is passed, he/she becomes unable to use this strategy, which results in greater postural sway and fear of falling. Because there was more stability in the situation analyzed in the present study, this threshold may not have been reached and only the strategy of rigid posture was used. Further studies that assess postural sway objectively in healthy young and older adults are necessary to confirm this hypothesis.

The fact that no difference was found between the sensory conditions in the intra-groups evaluation or the integrated sample may also be due to the stability of the sitting posture. However, statistical differences were observed in some Amp analyses. This parameter analyzes the extreme points of body sway, independent of the moment when they were reached. Despite being one more parameter for the analysis of postural control, Amp does not represent static balance adequately. This parameter could be of great importance for future analyses of functional activities.

According to Gill et al.[29], the measurement of trunk sway is a useful tool for the clinical assessment of postural balance control. The Polhemus® device has been an efficient tool for this purpose and to generate objective parameters other than those analyzed by the force platform. Another advantage of this device use is the ease of transportation, unlike the force platform that requires a specific location. The limitation of the device is related to its data acquisition environment, because it is necessary to avoid places with a metallic structure or with an electrical system that can create a magnetic field and interfere with data collection.

This study has great relevance because it introduces a methodology for the analysis of balance in the sitting position. Thus, it provides basis for studies that associate the effect of several motor tasks with the postural sway measured by the Polhemus® device. Moreover, it provides data from healthy subjects for later comparison with patients with various diseases.

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