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Electromyographic Responses of Postural Variations through Neurosensory Stimuli

Andrade Maria Júlia Marinho de, Silva Débora dos Santos* and Veiga Paulo Henrique Altran

Physiotherapy of the Center of Biological Sciences, Catholic University of Pernambuco, Brazil

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***Corresponding author:** Silva Débora dos Santos, Student of the bachelor's degree in Physiotherapy from the Center of Biological Sciences and Health, Catholic University of Pernambuco. Rua do Príncipe, s / n, Boa Vista, Recife - PE, Brazil

Abstract

Posture can be defined as an interaction of the body segments, which can respond to stimuli and if shape according to these. Postural evaluation is a method used in physical therapy in order to analyze these body segments and your influence on therapy. The aim of this study is identified whether the life experience, through stimulating sensorineural components, has influence on posture. It is a study observational and cross-sectional quantitative character and was composed of a group of 31 individuals. Synergy was observed between the Tibialis anterior and gastrocnemius muscles through surface electromyography and to evaluate postural variation Romberg test was used. An evaluation was performed through positive and sensorineural components other stimuli through negative stimuli. The collected data were statistically analyzed using the Wilcoxon test with significance in 5% ($p < 0.05\%$ *). When analyzed the positive stimulus, it was identified that there was statistical significance ($p = 0.002$) between gastrocnemius, which featured an average of 7.47μV, and the anterior tibial, 4.32μV. When analyzed the negative stimulus, it turns out that there was no statistical significance ($p = 0.834$), in which the introduced an average of 6.72μV gastrocnemius and the anterior tibial, 5.62μV. The results reveal that the posture is influenced by stimuli sensorineural components, making detours to front, in the case of positive stimuli, and possibly perform deviations forth through negative stimuli, but the authors believe have gotten failure in this If, due to some biases.

Keywords: Electromyography; Posture; Human posture; Stimuli sensorineural components; Romberg test

Abbrevations: PTS: Postural Tonic System; CNS: Central Nervous System; PNS: Peripheral Nervous System; EMG: Electromyography; AD: Analogue/Digital

Introduction

Posture can be defined as an interaction of the body segments, which is able to respond to and stimulate the stimuli according to these, seeking good body alignment [1-3]. Postural assessment, which is based on visual analysis, is a method used in physiotherapy for the purpose of analyzing these body segments and their influence on therapy [4,5].

The postural tonic system (PTS) is governed by the central nervous system (CNS) and peripheral (PNS) from the proprioceptive and exteroceptive information generated by the postural receptors, having the tonic and phasic muscles as effectors and responsible for the final response of this system. The foot and the eye are the main receptors of PTS, and act primarily on static and dynamic postural adjustment. They are responsible for associating proprioception and exteroception, at the same time as they are encaptures and exteroceptors. Other receptors also influence this system, such as the mandibular apparatus and upper centers, in addition to the skin, muscles and joints. Posture maintenance encompasses a complex composed of alignment and control of various body segments, and requires a constant ability to remain in balance, trying to overcome internal and external stimuli [6-8].

Body control is a system composed of the joint balance and body posture. This body control system encompasses both the postural orientation, which consists in maintaining the position of the body segments in relation to themselves (proprioception), the environment (expproprioception), and locating one object in relation to another (exteroception), and the postural balance in relation to the forces acting on the body during motor activities [9,10]. Postural control is an adaptation process that requires an interaction between the neural and musculoskeletal systems, including the biomechanical relationships of the body segments, aiming at stability and spatial orientation during the static or dynamic balance, being responsible for the maintenance of the body's center of gravity [5,10-13].

It is now accepted that human posture is maintained through a central postural program, assisted by sensory information of different natures such as vestibular, visual and somatosensory systems, which together contribute to the stabilization of posture, as well as being the systemic base of a body posture representation, adjusting the motor output response. If one of these sensory systems is not functioning properly, it will consequently generate overload from another system to compensate for dysfunction, which characterizes sensory re-weighing. This systemic view demonstrates that postural control results from an interaction between the individual, the activity being performed and the environment, always considering experience and adaptation [7,10,14-19].

The vestibular system responds to several stimuli such as visual and sound and stands out for detecting body oscillations and feelings of balance. Vestibular receptors respond to head movements during static and dynamic postures in relation to gravity. The visual system is extremely important for postural control, since once an individual presents dysfunction of the vestibular system, but maintains the integrity of the visual system, it will present small difficulties in performing the activities of daily life, since in small body displacements oscillations, there is a 35% participation of the visual system against only 15% of the vestibular system. The visual system is responsible for stabilizing the body during its oscillations [9,10,20,21].

The somatosensory system is distinguished by having several receptors distributed throughout the body, and these can respond to stimuli of different natures. When the body changes its position, the muscle stretching excites the muscle spindles that by reflexes come into tension, sending stimuli to the proprioceptive receptors. These receptors have the capacity to inform the position and the displacement of the various body segments, whose maintenance is obtained through small postural adjustments, as well as being able to respond to touches, changes in temperature and pain [10,20,22].

Jean-Pierre Roll et al. [19] demonstrates the relationship between postural proprioceptive receptors, identifying that the stimuli in the anterior region of the feet lead to backward displacements, and the stimuli in the posterior region lead to forward displacements. Busquet [23] determines that these postural movements follow certain patterns of adaptation that are governed by three basic principles, the principle of comfort, energy saving and the absence of pain. These principles make all postural changes that occur, are carried out respecting these basic elements. Busquet [23] still guides that tissues in tension, provoke pains and important alterations in the posture of the individuals. Jean-Pierre Barral [24] advocates that the so-called "auscultation" of the organs can identify dysfunctions, which lead to restrictions or strains that influence posture. Another determining factor for posture is the psychic, which is directly related to the daily life of the human being, arising from the external environment, as well as internal or biological factors.

The identification between the factors that alter the position of the body can be an important diagnostic factor, collaborating in the semiology and in the treatment of the dysfunctions that have in the posture some cause, since disorders of the postural control indicate possible pathologies [25,26]. Thus, the authors doubt whether external stimuli such as positive life experiences activate the gastrocnemius muscle, causing the individual to move forward, or if stimuli such as negative experiences activate the anterior tibial muscle, displacing the individual back. Therefore, the objective of the present study is to identify if the life experience, through sensorineural stimuli, has influence on the posture.

Materials and Methods

The present study is linked to the Catholic University of Pernambuco (UNICAP), the Center for Biological Sciences and Health (CCBS), the Physical Therapy course and was carried out in the Specialized Laboratory of Physiotherapy and Occupational Therapy Corpore Sano, from October 2016 to July of 2017. It is an integral part of the research project entitled "Analysis of the Influence of Visceral Manual Therapy in Conditions of Upper Limbs", approved by the Ethics Committee under CAAE: 56390116.3.0000.5206, Opinion No. 1,871,884 and is linked to the research group "Evidence Based Physiotherapy".

The study is cross-sectional and quantitative in nature, where there is no conflict of interest on the part of the authors, as well as in accordance with resolution nº 466 of December 12, 2012, on the ethical point of view of the guidelines and regulatory norms of research involving human beings.

The sample consisted of a group of 31 healthy individuals, of whom 29.03% (n = 9) were males and 70.97% (n = 22) females, with a mean age of 22.03 years, ranging from 19 to 29 years. As inclusion criteria, healthy individuals of both sexes, who were not submitted to psychological treatments and who agreed to participate in the study through the signing of the free and informed consent form (TCLE), were identified; as exclusion criteria, individuals with some type of postural and/or balance deficit or vestibular disorders such as vertigo or labyrinthitis were identified. The voluntary participant was asked about any of these disorders and was automatically excluded from the study if he/she affirmed positively.

At the first moment, individuals were informed about the procedure and signed the ICF, if they agreed. Subsequently, they were sent to the place destined to carry out the tests, for individual data collection. In order to evaluate the postural variation of the individual, the synergy between the anterior and gastrocnemius muscles was observed through surface electromyography (EMG), which is one of the ways to analyze body oscillations, since it is a simple noninvasive method that causes little discomfort during its execution. The results can provide important data for the evaluation of certain parameters related to the electrical activity of the muscles during the body oscillations and contribute to a better understanding of the postural mechanism [27].

The four-channel Miotec® electromyograph model 440 was used, using Miotool® software (Porto Alegre, Brazil), with internal gain of 1000 times, sampling frequency of 2000Hz, fourth-order Butterworth analog filter order, CMRR 110dB at 60Hz, 1GΩ input impedance, 14-bit analogue/digital (AD) converter with frequency range from 10Hz to 500Hz. The data was acquired at 2000Hz and stored on the use computer the researcher's staff. In the present study surface electrodes were used because they were not invasive and did not cause discomfort.

There may be variation in skin impedance due to moisture, oiliness, density of the corneous layer of the skin, and presence of hairs [28]. To reduce this impedance, a tricotomy was performed, which consists of removal of the hairs and cleaning with 70% ethyl alcohol in the region where the electrodes were applied, in the dominant lower limb of the individual. The placement of the electrodes to register the activity of the anterior tibial and gastrocnemius muscles, took as reference the distance from the lateral condyle of the femur to the belly of both muscles, using a pair of electrodes for each muscle. The reference electrode was applied to the lateral malleolus of the fibula (Figure 1).

Source: personal archive.

Figure 1: Application of the electrodes.

To evaluate the balance several tests are fit to be used, however, the Romberg test is one of the most recommended. The execution of the test reveals body oscillations that can be interpreted in different ways, depending on the way they will be analyzed [22]. In order to perform the test, the volunteer was standing and barefoot, with a distance of 20 cm between the feet, which was already delimited on the floor by a mark that was under the hall of both feet of the individual, with the shoulders 90° with hands outstretched and eyes closed. After having the patient properly positioned to perform the test, two evaluations were carried out, the first one through positive sensorineural stimuli, such as making him think about what would make him happy, and the second, through negative sensorineural stimuli, how to do it think about what would make him sad or angry. Both evaluations had duration of 20 seconds each, with a time interval of 5 seconds between them, being the neurosensorial stimuli given through verbal commands. Two electromyographic records were obtained by stimulus, one of the anterior tibial and one of the gastrocnemius, totalizing four electromyographic registers.

All data were distributed and organized in an Excel spreadsheet, after which a descriptive analysis was carried out to characterize the study sample. The Kolmogorov-Smirnov test was used to test the assumptions of normality and homoscedasticity of the variables involved in the study and identified that the samples did not follow normal distribution. The paired Wilcoxon test was performed to compare if the position measurements of two samples are equal in the case where the samples are dependent. The objective of Wilcoxon's test of signs is to verify if there are significant differences between their results in the two situations. The Wilcoxon test is used when there is no distribution in the samples, i.e. it is a nonparametric test.

Results

The present study had as general objective to identify if the life experience, through sensorineural stimuli, has influence on the posture. The work was performed with surface electromyography and the subjects were submitted to two evaluations through distinct neurosensory stimuli to observe the synergy between the anterior tibial and gastrocnemius muscles. In the first evaluation, the individual was influenced to think of something positive, such as good memories and good experiences, to generate a positive stimulus and the tendency would be that the posture would be diverted forward, predominating the activation of the gastrocnemius. In the second stimulus, the individual was influenced to think of something negative, such as trauma or anger, to generate a negative stimulus and the tendency would be for the posture to be diverted backward, activating the anterior tibial muscle. In this study, the results partially corroborated this concept.

Table 1: Descriptive characteristics of the subjects participating in the study.

	Average (IC 95%)	Standard Deviation	Median	Coef. of Variation (%)	Min	Max
Age	22,03 (21,06-23)	2,64	21	11,98	19	29
Male	29,03% (n=9)					
Women	70,97% (n=22)					

Table 1 shows the characteristics of the subjects participating in the study. As can be observed, the sample consisted of 31 patients, among them, 29.03% (n = 9) are males and 70.97% (n = 22) are females. It is also observed that the mean age of patients is approximately 22 years, ranging from 19 to 29 years.

In Table 2, with regard to the positive sensorineural stimulus, it can be seen that the anterior tibial depolarized an average of 4.32μV, with a high variation in these data, ranging from 0.3 to 17.8, already in the gastrocnemius, it is possible to observe an average depolarization of 7.47μV, also with a high variation,

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ranging from 1.4 to 21.5. From the Wilcoxon test, there was a statistically significant difference in the positive stimulus between the anterior tibial and the gastrocnemius (p = 0.002*), that is, there is evidence to rule out the hypothesis that the electromyographic result between these two muscles are equal and conclude that there is a predominance in the electrical activity of the gastrocnemius muscle.

Table 2: Results of descriptive statistics of the positive and negative stimuli between anterior tibial muscles and gastrocnemius.

	Average (IC 95%)	Standard Deviation	Median	Coef. of Variation (%)	Min	Max	P value
Positive Stimulus							
Tibial Anterior	4,32 (3,22-5,41)	2,99	3,5	69,36	0,3	17,8	
Gastrocnêmio	7,47 (5,5-9,43)	5,36	5,5	71,81	1,4	21,5	0,002*
Negative Stimulus							
Tibial Anterior	5,62 (3,71-7,53)	5,21	4	92,59	1,7	24	
Gastrocnêmio	6,72 (4,73-8,71)	5,43	5	80,71	1,4	21,6	0,834

Statistically significant difference p-value ≤ 0.05%*.

Regarding the negative sensorineural stimulus, we can observe that the anterior tibial depolarized an average of 5.62µV, with a high variation in these data, ranging from 1.7 to 24, in the gastrocnemius, it is possible to observe an average of 6,72µV, with a variation of 1.4 to 21.6. From the Wilcoxon test, it was found that there was no statistically significant difference in the negative stimulus between the anterior tibial and the gastrocnemius (p = 0.834).

The graphs below provide a better insight into the performance of the anterior tibial and gastrocnemius muscles during the evaluation of both stimuli. It was noted that there was statistical relevance in the positive stimulus, with one (p = 0.002*), determined by the marked difference in depolarization between muscles. In the negative stimulus, it was noted that there was no statistical relevance (p = 0.834), and that both muscles remained the same for the level of depolarization (Figure 2).

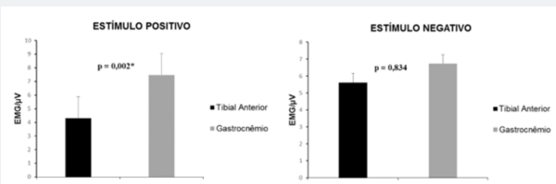

Figure 2: A better insight into the performance of the anterior tibial and gastrocnemius muscles during the evaluation of both stimulus (Positive stimulus & Negative stimulus).

Discussion

As expected, after a positive stimulus, the individual performs a postural shift forward. The greater activation of the gastrocnemius muscle confirmed this expectation from the data of its depolarization, since having the posture deviated forward, the same must be contracted in order to avoid the loss of body balance, preventing the individual from falling forward.

Given a negative stimulus, it was expected that the individual would have his posture deviated back and it was expected that the depolarization of the anterior tibial muscle would be greater than the depolarization of the gastrocnemius muscle so that the body maintained the state of equilibrium, but was seen that the results did not meet the expectations, possibly due to some biases.

The authors believe that the small-time interval between one electromyographic evaluation and another may have been responsible for the failure of the evaluation in the negative stimulus. The first evaluation was performed through a 20-second positive neurosensory stimulus, followed by the evaluation through the negative sensorineural stimulus, also with duration of 20 seconds, with a time interval of 5 seconds between the evaluations. In this way, the individual could still be under the influence of some positive stimulus, becoming unable to have their posture deviated backward when given a negative stimulus, resulting in a lower mean depolarization of the anterior tibial.

The authors also attribute the failure of these results to the difference between the types of fibers that make up the anterior tibial and gastrocnemius muscles, reflecting directly on their metabolisms. The anterior tibial muscle has a predominance of type II phasic muscle fibers, therefore, of rapid contraction and are activated by only 5% of the time, since they are responsible for the production of muscle strength. On the other hand, the gastrocnemius muscle has a predominance of type I muscle fibers, therefore, of slow contraction, because its functional demand requires that its fibers remain active during 90% of the time due to postural stimuli, since they are responsible for the maintenance of the body against gravity. According to Bricot [6], tonic fibers are dependent on the extrapyramidal system, characterizing their involuntary activity. That is, although during the negative stimulus the anterior tibial must contract more than the gastrocnemius to maintain the balance of the body when the individual goes backward, involuntarily the gastrocnemius will be as contracted as the anterior tibial by keeping its fibers activated for longer, besides the fact that the gastrocnemius has a greater number of transverse fibers [29,30].

According to Doumas et al. [12], threatening situations cause a decrease in body oscillation, which further evidence the

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contraction of the gastrocnemius during the evaluation of the negative sensorineural stimulus, since it remains in contraction during 90% of the time. Doumas et al. [12] also points out that with negative feedback, an increase of cortisol occurs, which also leads to a considerable increase in stress levels.

The results obtained in the present study were determined by the Romberg test, which was chosen because of its easy clinical applicability and versatility regarding the objectives [22]. It is observed that this test is used to evaluate the scales of the body when standing and these deviations can be evaluated both forward and backward, which can be used for these results by adding the sides. Another fact that led the authors to choose the test was to be performed with eyes closed, being a way to inhibit the influence of the visual system, which according to Passetto [20] and Peterka [21], is one of the factors that participates most in an active form in small oscillations of body movements, which could further enhance the influence of neurosensory stimuli in this study.

Godelieve Denys Struyf [31], who developed the GDS method, describes his concept of muscular chains as "The individual structures over his life history. The muscular chains will shape the individual according to his needs of corporal expression", being able to affirm that the experience of life has total influence on the posture. The muscle chains are composed of muscles responsible for the postural changes in each person. According to Vieira [32], based on the GDS method, all external or environmental stimuli, such as thoughts, memories, life experiences, traumas and conquests, can also influence posture.

According to Massara [33], posture involves more complex characteristics, such as personality and psycho-emotional factor. Postural adaptations should not be attributed solely to anatomical and biomechanical aspects, since environmental factors, such as social and cultural factors, are increasingly being considered as postural features [34]. The authors of the present study draw attention to the fact that, when given positive sensorineural stimuli, most volunteers performed postural deviations forward, but when negative sensorineural stimuli were not statistically different, it could be due to some biases.

Conclusion

In the present study it was verified that posture is influenced by sensorineural stimuli, performing forward shifts in the case of positive stimuli, and possibly performing backward shifts through negative stimuli, but the authors believe that they have failed, in this case, due to some biases. It is clear that these results are silent and give us only the impression that these postural changes occur in this pattern, but it is an important signal, which should not be neglected when performing a postural evaluation, in addition to the suspicion that the posture may be related with some other alteration in several aspects of the individual. The authors advocate further research on this subject, with a larger number of volunteers.

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