

ELECTROENCEPHALOGRAPHIC ANALYSIS OF BRAIN WAVE BEHAVIOR DURING STATIC AND DYNAMIC POSTURAL CONTROL IN INDIVIDUALS WITH CONGENITAL BLINDNESS

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ABSTRACT

Postural control is characterized by neuromuscular corrections and/or monitoring of stability limits, involving increased processing of sensory information due to postural demands. The lack of vision disrupts postural control and, consequently, affects body balance. However, data on brain waves to monitor the maintenance of static and dynamic postural stability in individuals with total blindness are scarce. This study describes a protocol that compares the differences in brain wave behavior during the maintenance of static and dynamic postural control between individuals with total blindness and individuals with vision. We will evaluate delta (1-4 Hz), theta (4-8 Hz), alpha (8-12 Hz), beta (12-30 Hz), and gamma (> 50 Hz) waves during postural stability assessments, functional mobility (i.e., Timed Up and Go test), and 3D gait. Through this study, we will seek to better understand the patterns of brain activity when postural control is challenged by sensory systems (i.e., somatosensory and visual) and explore possible changes in brain waves induced by assistive devices, such as a cane, during functional mobility and gait. In practice, this study is fundamental for the development of rehabilitation strategies to promote better functional independence, improving movement quality and attenuating the risks associated with joint degeneration and falls.

Keywords: electroencephalography; brain waves; postural control; visual impairment.

INTRODUCTION

Maintaining postural stability is a continuous task, necessary due to constant movement in human daily life. This stability is maintained by postural adjustments, which involve a dynamic integration between internal (neuromuscular) forces and external environmental factors, such as wind, ground friction, etc. These postural adjustments are fundamental for rapidly processing sensory information to, for example, avoid falls. The mechanism responsible for this maintenance is known as postural control (PC), which allows the body to move quickly and precisely to keep the center of pressure (CoP) within the base of support (Bruijin et al., 2013; Winter, 1995).

The central nervous system plays an essential role in PC, using reactive (feedback) and predictive (feedforward) strategies to regulate muscular responses in

situations of disturbances, whether anticipated or unexpected (Álvares Barbosa et al., 2016; Winter, 1995). These strategies help the body preserve or recover balance, activating sequences of muscular response that anticipate future movements. At cortical levels, brain activity prepares the body for these corrections even before a disturbance occurs (Boebinger et al., 2024; Sherman et al., 2022).

Cortical involvement becomes even more relevant as the complexity of postural tasks increases. Electroencephalographic (EEG) studies show that different patterns of cerebral oscillation (alpha, beta, delta, gamma, and theta waves) are evident during both static and dynamic postural tasks (Boebinger et al., 2024; Oliveira et al., 2017). In static tasks, there is a correlation between loss of balance and a decrease in brain waves. In dynamic tasks, such as gait, increased cortical excitability reflects the sensorimotor and cognitive demands to maintain balance.

Congenital blindness significantly alters this dynamic of postural control. Blind individuals depend heavily on somatosensory information, compensating for the absence of visual information (Parreira et al., 2023). This compensation is possible thanks to cross-modal plasticity, a phenomenon that increases the capacity to use the remaining senses. The increased neural activity in specific brain areas during tasks involving somatosensory perception, for example, suggests that blind individuals use unique strategies to maintain balance. The main objective of this protocol study is to analyze, through EEG, the behavior of cortical activity during static and dynamic postural control in individuals with total congenital blindness and compare them with sighted individuals.

METHODOLOGY

This will be a comparative study that will use a portable EEG to record brain activity during static postural control, functional mobility, and gait among blind and sighted individuals. The study follows the ethical and methodological standards established by the Brazilian National Health Council and is registered under ethical approval.

Participants and Eligibility Criteria

Adults between 18 and 55 years old, right-handed and of both sexes will be recruited. Blind individuals will be diagnosed based on the WHO classification for visual impairment, being characterized as blind those with visual acuity worse than 6/60; and the cause will be any ocular disease that resulted in congenital blindness. To ensure data validity, individuals with recent injuries that may have affected balance or who use medications that alter the central nervous system will be excluded.

Assessment Procedures

Stabilometry: Postural control will be assessed using force platforms where participants will stand for 45 seconds. Four conditions will be tested: eyes open/closed on a rigid surface and on foam. The analysis will include CoP variables (velocity and length).

Functional Mobility Test (Timed Up and Go -- TUG): The TUG test corresponds to the moment when participants get up from a chair, walk three meters, go around a cone, and return to the chair. The analysis will be done using an inertial sensor positioned in the lumbar region to measure temporal and angular variables. Blind individuals will perform the test with and without the aid of a cane.

3D Gait Analysis: Gait will be analyzed on a nine-meter-long walkway, using 8 infrared cameras synchronized with force platforms. Reflective markers will be placed on the participants to record variables such as speed, step length, and joint angles.

Cortical Activity Analysis: Cortical activity will be recorded using a 32-channel portable EEG, with electrodes distributed according to the international 10/20 system. The analysis of brain waves will be performed during the assessments, focusing on delta, theta, alpha, and beta waves.

Statistical Analysis

Descriptive analysis will be used to show the anthropometric characteristics of the participants and the results of the measured variables. The normality of the data will be verified with the Shapiro-Wilk test, and repeated measures analysis of variance will be applied to compare EEG signals in different conditions. For non-parametric data, the Friedman test will be used. When a statistical difference is found, the Wilcoxon test with Bonferroni correction will be used to analyze the differences within the group. A significance level of $p \leq 0.05$ will be considered significant, and the SPSS software will be used to perform the analyses.

EXPECTED RESULTS

Due to its potential as an innovative study, this research has significant implications for intellectual property related to innovation. To date, there is no model in the literature that analyzes brain activity through brain waves in blind individuals during functional activities, such as maintaining static and dynamic balance and walking. Thus, through this project, our objectives are to achieve the following results:

A. Characterize the brain activity pattern of individuals with congenital blindness using EEG in the maintenance of postural control, to serve as a reference for future work;

B. Better understand the patterns of brain activity when postural control is challenged by the disturbance of sensory systems (somatosensory and visual) in individuals with total blindness, as well as whether assistive devices, such as a cane, promote any change in brain waves;

C. In practical terms, this project is particularly important for the development of rehabilitation strategies aimed at increasing functional independence, improving movement quality, and thus reducing the risk of degenerative joint progression and trauma, mainly caused by falls.

CONCLUSION

This pioneering study intends to characterize the behavior of brain waves in individuals with congenital blindness during static and dynamic postural control. By analyzing the role of brain waves in different cortical regions, the study will provide valuable information for the creation of rehabilitation strategies that can improve the functional independence and quality of life of these individuals. The brain plasticity observed in blind people will be a crucial area for future investigations, contributing to the development of more effective therapies.

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