PLANTAR BIOPHOTONIC STIMULATION IMPROVES OCULAR-MOTOR AND POSTURAL CONTROL IN MOTOR VEHICLE ACCIDENT PATIENTS

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INTRODUCTION

Victims of Motor Vehicle Accidents (MVA) may be subjected to multiple head traumas including, but not limited to, concussion, whiplash, and mild traumatic brain injury. These types of head injuries primarily affect central sensory-motor and cognitive controls (CSMCC) which include ocular-visual, ocular-motor, vestibular, and cerebellar systems. Generally, CSMCC allow and govern one`s perceptuality and subsequent adaptive capability to adjust in changing environment. In other words, CSMCC substantiates how we internally sense, perceive, gather and use details and cues in our immediate surroundings to optimally perform according to our needs. Dysfunction of any or all of these systems creates internal conflict (mismatch) at the CSMCC level, that may reflect through simultaneous changes in one`s emotional, physiological, cognitive, or intellectual state, commonly observed as symptoms and disabilities in victims significantly impacted during an MVA.

These conditions may also develop into a postural deficiency syndrome (PDS), an umbrella term for a series of posture related CSMCC dysfunction disorders. While these categories of symptoms usually tend to be dealt with separately, a neurophysiological assessment methodology has been developed to identify why and how these may be linked in order to better understand their respective origin. Consequently, integrated ways to treat such persistent post trauma multivariate symptomatology were developed. The specific methodology was developed from , the Fine Postural System (Gagey, 1987) biomedical model and its correlate the Postural Deficiency Syndrome (Da Cunha, 1987) to assess potential reversibility of dysfunctional central sensory-motor and sensory-cognitive controls involved in spatial perceptuality.

Visual-ocular convergence (VOC) and postural balance (PB) tests are commonly used by some specialized clinicians to assess the severity of head injury and monitor progression through the healing process, while determining the integrity of the CSMCC. However the quantification of results from PB tests and the use of passive biophotonic stimulation (PBS) may provide a novel and effective assessment method. (Souvestre and Landrock, 2004a, b)

Passive biophotonic stimulation is obtained by using a dermal optical device based on the concepts of both dermal optical perception (DOP) and dermal optical sensitivity (DOS). DOP defines the perceptual awareness and capability which relate to the sensory-cognitive processing of external and internal information from stimuli received through dermal sensors embedded in the skin. These sensors are connected through central neural sensory-motor and sensory-cognitive synergistic systems. DOS reflects the physical sensory part of the perception and rather characterizes the physical mechanisms. (Duplessis, 1985)

The skin is known to be sensitive to a broad portion of the electromagnetic spectrum of light which can be easily observed when simultaneously experiencing sun tan caused by ultraviolet rays as well as heat essentially due to infrared rays. Biophotonic technology depends on the spectrum composition of colored surfaces which define the 'spectrance' (Geslin 1984) and the resulting interaction with the skin.

With neurophysiological stimulation CNS afferents can elicit both a physical and cognitive response at the same time (Paillard, 1986, 1985). An appropriate dermal optical device can exert neurophysiological stimulation at high level sensory-motor controls in the CNS, and be capable of correcting a vast array of motor, sensorial, perceptive, and cognitive disturbances which can be clinically identified and measured.

The use of PBS on bilateral plantar sensory afferents has been shown to stimulate the CSMCC. A comparison may be made between the outcomes of the PB and VOC tests when an individual is tested both with and without PBS, thereby, allowing the quantification of the degree of dysfunction. Furthermore, stimulation of the plantar sensory afferents via PBS may also prove a useful treatment modality for restoring dysfunctional CSMCC pathways (Souvestre PA and Landrock CK, 2006).

This study was performed to review and analyze assessment data of MVA patients identified in a Trauma and Concussion Clinic with significant dysfunctional postural balance and ocular-motor control.

This study aims to determine the extent of improvement in VOC and PB assessment scores by short term biophotonic stimulation.

METHOD AND ANALYSIS

Participant pool

Patients' clinical files were reviewed for individuals who sustained head trauma in association with an MVA. The patient pool was limited by two notable criteria (1) the use of a force plate stabilometric analysis as a means of PB assessment and (2) a direct link between the MVA-related injury and present symptoms.

As part of an integrated neurophysiological assessment, all patients underwent a thorough review of medical history including physical, emotional, cognitive, and intellectual trauma. All patients meeting the above mentioned criteria (n=20) were included in the present study. One patient was excluded due to a diagnosis of Parkinson’s disease. The remaining 19 patients (8 males, 11 females, mean age 56 ± 11 years, age range of 30-75 years) were identified as having been involved in an at least one MVA and suffered from associated head trauma. The average time from the date of MVA to the first appointment was 21 ± 19 years.

Assessment Method

The neurophysiological assessment comprised of multiple protocols to evaluate the function of CSMCC includes VOC and PB tests. All patients underwent the PB assessment while only 12 of the 19 patients underwent the VOC test involving the measurement of the objective Punctum Proximum of Convergence (oPPC). All tested patients were asked to attain quiet stance with different pre-marked feet placement respectively for VOC and BP tests..

For the VOC test, patients were asked to attain quiet stance with pre-marked parallel feet placement. The 0 cm edge of a 30cm ruler was placed at the nasion. A target placed at the 30 cm mark of the ruler was steadily moved toward the patient. The examiner recorded the distance at which the eyes ceased to converge or returned to forward gaze. If the eyes exhibited asymmetrical convergence, the distance was recorded for the eye with the greatest capacity for convergence. A lower value indicated greater convergence.

For the PB test, the dominant foot was placed 45º ahead and aside of the non-dominant foot (Winter DA et al, 1996). Patients were instructed to close their eyes with imaginary visual focus at a static point straight ahead in the frontal plane and remain in quiet stance for one minute on a force platform (Accusway, Bertec Corp., OH, USA) with arms on their sides. The center of pressure (COP) trajectory was recorded at 50 Hz during the test. Data collection began as soon as the patient’s eyes closed and stopped immediately if the patient opened his/her eyes, made contact with any supportive structure, or requested cessation for any reason.

Immediately following this initial series of tests, all patients were re-assessed in the same conditions while passive biophotonic stimulation was applied to the bilateral plantar postural sensory afferents. Under stimulation, the same order of testing was replicated to avoid any potential conflict or bias due to change in sequence when interpreting all test data.

Stabilogram Diffusion Analysis

The 50 Hz COP data collected in the PB test was analysed using the stabilogram diffusion analysis (SDA) method. This method models COP data as a correlated random-walk, and the short-term and long-term processes are calculated via a set of six parameters. These parameters are expressed as the critical point coordinates (separating the dynamics into short- and long-term regions), and for each region a diffusion coefficient is calculated. This is derived from Einstein’s classical law for Brownian motion and defined further for COP by Collins and De Luca (1993). Analysis of a COP time series in this manner defines higher and lower levels of stochastic activity which can be interpreted as strategies of open loop and closed loop control respectively (Collins and De Luca, 1993).

SDA of force plate data was used to assess differences in motor control strategies. The use of a fractal analysis such as SDA provided an important tool in the assessment of neural mechanisms associated with loss of balance control in the patients reviewed.

<u>Statistical Analysis</u>

The parameters in the VOC and PB test were compared with and without stimulation.

<u>For the VOC test parameters</u>, a two tailed t-test was performed with a level of significance at 0.05.

<u>For the PB test parameters</u>, the level of significance was kept at 0.1 as we had prior knowledge about the decreasing nature of the values of the parameters. JMP 7 (SAS Inc. NC, USA) was used to conduct the statistical analysis of the data.

RESULTS

Outcomes of the SDA of the COP trajectory from the PB test showed a trend towards a significant reduction in the short term diffusion coefficient (0.2±.03 to 0.15±.03; p=.084) and a trend towards an increase in the long term diffusion coefficient (0.003±.001 to 0.006±.001; p=.079) with stimulation. The Hurst exponent did not show a significant change in the two conditions. Figure 1 below shows a COP trajectory plot for one patient under the two conditions along with respective 95% confidence interval ellipses.

A two sided t-test performed on oPPC parameters for both conditions revealed convergence to be significantly closer ($p<0.001$) with stimulation (5.3 ±1.0 cm) versus no stimulation (11±1.0 cm) condition.

DISCUSSION

The current investigative study evaluates the effectiveness of passive Biophotonic stimulation of the plantar sensory afferents on sensory-motor performance enhancement with respect to both Visual-Ocular Convergence and Postural Balance tests.

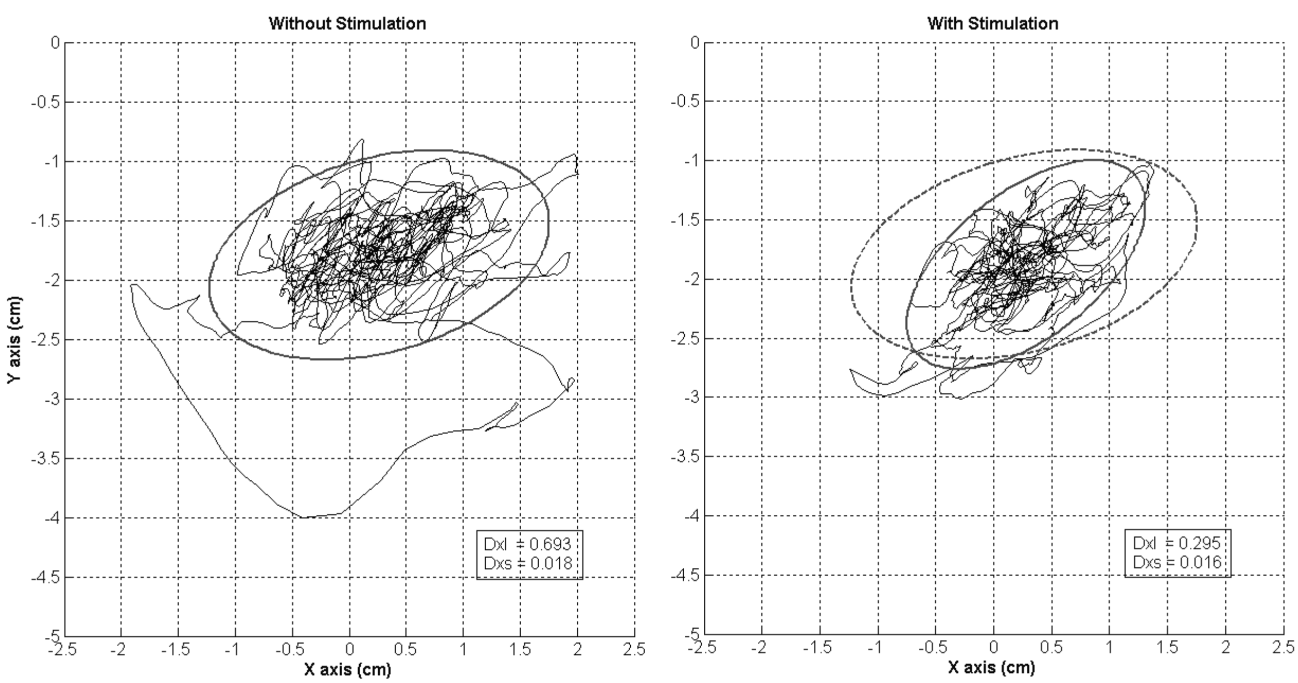

Figure1: COP trajectories for the two conditions with respective 95% confidence interval ellipses. The anterior-posterior diffusion coefficients of the patient data show a reduction with stimulation. The superimposed dotted ellipse from the no stimulation condition highlights the COP variation in the two conditions. Dxs: short term medio-lateral diffusion coefficient. Dxl: long term medio-lateral diffusion coefficient

Without any stimulation – All test data consistently showed a significant loss of central sensory-motor control leading to abnormal ineffective patterns of ocular-motor function and postural balance control along with patients' difficulty to maintain focus and follow directions.

Under PBS with respect to the PB test – The reduction in the short term and consequent increase in the long term diffusion coefficient implies that there was a reduction in the randomness on short term basis but increased for the long term. This indicates that the patients were able to suppress the immediate perturbations to attain stance and relied more on a particular strategy, different from the one presented prior to being under PBS, to attain long term stability in their standing posture. The COP trajectory plot (Figure 1) shows a tighter control over the sway under stimulation and is re-emphasized by a smaller 95% confidence ellipse.

Under PBS with respect to the VOC test – The considerable reduction consistently observed in the oPPC distance suggests that such stimulation enhances both the sensory-motor and sensory-cognitive controls governing visual perception, cognitive decision and ocular motor tasks.

It is noteworthy to mention that effective space and balance controls and visual-postural performance appear to be adversely influenced by traumatic alteration in cognitive transfer of visual, perceptual and spatial references. This results in decreased VOC and PB scores which can be positively influenced by passive plantar biophotonic stimulation. (Souvestre et al, 2010)

CONCLUSIONS

This retrospective analysis of MVA patient data has provided evidence of the efficacy of noninvasive passive biophotonic stimulation in improving central sensory-motor and related cognitive controls. Under biophotonic stimulation, all tested patients demonstrated a significant increase in ocular-visual performance as well as a notably faster corrective postural response with reliance on a long-term postural strategy to effectively maintain better balance. These data suggest that passive biophotonic stimulation may prove useful in treating symptoms associated with MVA-related central sensory-motor and cognitive controls dysfunction.

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