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The effects of stroboscopic balance training on cortical activities in athletes with chronic ankle instability

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Abstract

Objectives

To investigate the effect of a 6-week stroboscopic balance training program on cortical activities in athletes with chronic ankle instability.

Design: Randomized controlled trial.

Setting: Single-center.

Participants: Thirty-nine participants were assigned to the strobe group (SG, n = 13), non-strobe group (NSG, n = 13), and control group (CG, n = 13).

Main outcome measures

Cortical activity and balance velocity were evaluated while the athletes were on the HUBER balance device. Electroencephalographic measurements of cortical activity were made at the transition from bipedal stance to single-leg stance.

Results

The SG showed significant increases in Cz theta and alpha values and COP-v (center of pressure velocity) between pretest and posttest ($p < 0.001$, $p = 0.003$, $p < 0.001$). Posttest Cz theta was significantly higher in the SG compared to the CG ($p = 0.009$) and posttest Cz alpha was significantly higher in the SG compared to the NSG ($p = 0.039$) and CG ($p = 0.001$). Posttest COP-v was significantly higher in the SG than in the CG ($p = 0.031$) and NSG ($p = 0.03$).

Conclusions

Stroboscopic training may be clinically beneficial to improve balance parameters in athletes with CAI, and may have utility in sport-specific activity phases of rehabilitation to reduce visual input and increase motor control.

Introduction

Chronic ankle instability (CAI) is characterized by repetitive episodes or perceptions of the ankle giving way; ongoing symptoms such as pain, weakness, or reduced ankle range of motion (ROM); diminished self-reported function; and recurrent ankle sprains for more than 1 year after the initial injury (Hertel & Corbett, 2019). Following the injury, the central nervous system (CNS) experiences compensatory overutilization of visual feedback to achieve neuromuscular control (Grooms et al., 2015). While uninjured individuals can compensate for the elimination or alteration of somatosensory input around the foot/ankle complex by dynamically re-evaluating other sensory inputs, this ability is reduced in individuals with CAI (McKeon et al., 2012; Riemann et al., 2004). Furthermore, altered motor planning, execution, and sensory processing may represent the mechanisms underlying one of the most commonly described disorders in people with CAI: impaired balance (Wikstrom et al., 2009).

Current treatments for CAI include balance training, which is associated with various biometric improvements as well as changes in electroencephalography (EEG). Taube et al. hypothesized that the cerebral cortex had a decreased role and that greater focus was placed on activity in the subcortical structures after balance training (Taube et al., 2008). Theta waves (4–7 Hz) are associated with memory tasks, including working memory (Sauseng et al., 2010), whereas low (8–10 Hz) and high (11–13 Hz) alpha waves are associated with cortical deactivation and inhibition consistent with sensorimotor function (Borich et al., 2015; Lopes Da Silva & Storm Van Leeuwen, 1977). Furthermore, alpha waves (8–13 Hz) and beta waves (14–25 Hz) are accepted as sensorimotor rhythms representing movement preparation and motor planning (Pfurtscheller & Berghold, 1989; Pfurtscheller & Lopes da Silva, 1999). EEG studies in healthy adults have shown that theta waves may be associated with changes in balance performance (Hulsdunker et al., 2015; Slobounov et al., 2009, 2013). Moreover, it has been reported that beta waves in parietal and central cortical regions decreased following sudden changes in gait patterns (Wagner et al., 2016). In response to manipulations that challenge standing balance, frontoparietal alpha and theta EEG power increases, indicating an increase in cortical activity (Goh et al., 2017; Slobounov et al., 2009). Despite the positive gains from balance training, it is a long process that requires considerable effort. Understanding the mechanisms between balance training and cortical activity is important in order to identify ways to improve this treatment.

Balance training has been shown to improve functional outcomes of individuals with CAI (McKeon & Care, 2012; Wikstrom et al., 2009). Gradually increasing the difficulty level of balance training by including jumping exercises allows the sensorimotor system to adapt to more challenging tasks (McKeon & Care, 2012). However, it was reported that individuals with CAI were more dependent on visual information compared to those in the uninjured control group during single-leg balance assessments (Song et al., 2016).

Stroboscopic training reduces the amount of visual input by repeatedly switching the visual input on and off instead of eliminating it. The flickering effect of the stroboscopic eyewear creates a visual perturbation for the subject that challenges visual cognition (Dale et al., 2017). It can provide visual feedback for postural control in individuals with somatosensory deficits and may be useful in rehabilitation programs for motor control (Bennett et al., 2003, 2004; Kim et al., 2017). Stroboscopic training has also been proposed as a technique to facilitate anterior cruciate ligament rehabilitation and reinjury prevention (Grooms et al., 2015).

Stroboscopic training reduces visual feedback to the CNS, which is believed to stimulate an adaptive strategy in which the weights of the remaining proprioceptive inputs are increased, as opposed to continuing to compensate with visual feedback. Considering the evidence of visual overdependence in CAI, stroboscopic training may have a favorable effect on cortical measures and increase the effectiveness of balance training in athletes with CAI.

This present study aimed to evaluate the effect of a 6-week stroboscopic balance training program on athletes diagnosed as having CAI. We hypothesized that athletes who performed stroboscopic balance training would show greater increases in cortical activities and center of pressure velocity than athletes who received the same balance training without stroboscopic vision and the control group who received no training.

Study design

This report is part of a larger investigation of cortical activity and treatment responses among athletes with CAI. The study was conducted as a randomized controlled trial with double-blind allocation and a pretest–posttest repeated measures design. Athletes with CAI were randomly divided into 3 different groups and comparisons were made within and between these groups. After all CAI athletes performed the pretest, those in the strobe group (SG) received 6 weeks of balance training with

Balance training program (BTP)

All participants in the SG and NSG participated in a BTP 3 days per week for a total of 6 weeks (McKeon et al., 2008). The CG did not participate in the BTP. The NSG performed the exercises without glasses, whereas the athletes in the SG performed the exercises using stroboscopic glasses (SENAPTEC, Beaverton, Oregon) at a duty cycle of 100 ms clear/150 ms opaque (Fig. 3). The Senaptec stroboscopic glasses have liquid crystal lenses that alternate between transparent and (nearly) opaque with the

Electroencephalography

The mean theta, alpha, and beta (LF/HF) values from the central (Cz) and occipital EEG recordings of the groups are compared in Table 3, Table 4. There were significant increases in Cz theta and alpha values between pretest and posttest in the SG ($p < 0.001$, $\eta_p^2 = 0.43$; $p = 0.003$, $\eta_p^2 = 0.22$). The mean posttest Cz theta value was significantly higher in the SG compared to the CG ($p = 0.009$, $\eta_p^2 = 0.24$). Mean posttest Cz alpha value was significantly higher in the SG when compared with the NSG

Discussion

This study compared the effects of a 6-week balance training intervention performed with and without stroboscopic vision on cortical activity and balance velocity in athletes with CAI. Our results revealed changes in Cz theta, Cz alpha, and COP-v after performing the balance training with stroboscopic eyewear but not after completing the program with normal visual input. These results support our a priori hypothesis. Furthermore, we believe that our CAI sample is representative of the larger

Conclusions

The results of this study suggest that a 6-week balance training program with stroboscopic vision may be able to modify the level of visual dependency in athletes with CAI. After training, athletes in the stroboscopic training group demonstrated significant changes in central theta and alpha waves and COP-v. These results suggest that stroboscopic training may be clinically beneficial not just to improve balance parameters in athletes with CAI, but also in sport-specific activity phases of

Ethical approval

Ethical approval was obtained from the Ethics Committee of Nevşehir Haci Bektaş Veli University (ID: 2018.14.163) and informed consent was obtained from all participants.

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Declaration of competing interest

None declared.

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