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The Impact of Altered Visual Input and Auditory Stimulations on Balance and Postural Stability

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Abstract

Balance and posture are two critical components that affect an individual's safety and daily life. Vestibular, proprioceptive, and visual input all contribute to maintaining postural stability. Therefore, the purpose of this study was to determine the effects of visual and auditory inputs on balance and postural stability. To test this, the excursions (sway) of 30 participants in four different visual conditions were measured by using a Wii Balance Board. The four visual conditions consisted of eyes open, eyes closed, a moving dot with no sound, and a moving dot with sound. During the two moving dot conditions, the participants wore a pair of IKKOS goggles that displayed the dot and emitted an auditory clicking sound. Mediolateral, anterior-posterior, and total excursions were measured during testing. A one-way ANOVA was used to determine differences in excursion between the four conditions. There were significant differences between groups for the mean anterior-posterior ($p < .001$) and mean total excursions ($p < .001$), but not for mean mediolateral excursions ($p = .469$). The smallest excursions occurred during the eyes open condition ($p < .05$); therefore this was the most stable condition. The largest excursions were measured during the eyes closed condition. The IKKOS goggles conditions, in which vision was reduced, resulted in smaller excursions than the eyes closed condition. Based on the results, we believe that training programs that use the IKKOS goggles could be developed in which the goal would be for the individuals to rely more on auditory stimulation and proprioception to maintain balance and posture.

Keywords: Altered, Stimulations, Stability

1. Introduction

Balance and posture are two critical components that affect an individual's safety and daily life. Numerous studies have shown that vision affects the balance and posture in healthy young to middle aged populations. Palm et al. conducted a study on young, physically active adults by using a Biodex balance machine to test the subjects' balance with and without visual input.[16] The results showed that increased sight improves balance. These results were attributed to the biofeedback mechanisms in which the body could better correct its posture when it was visually aware of changes.[1,7,17] Balance decreased because postural control is a combination of vestibular, visual, and proprioceptor sensory inputs.[4,10,20] When vision was taken away, participants relied on vestibular and proprioceptor inputs to control their balance which increased sway patterns.[5, 11]. Therefore, walking patterns were negatively altered due to compensating for the lack of visual input.[19]

Vestibular, proprioceptive, and visual input all contribute to maintaining postural control.[14] In addition, studies have been conducted on young to middle aged individuals that show the ability of the postural control system to reassess itself depending on sensory inputs.[2, 15] One instance in which the ability of the postural control system to reassess itself is portrayed is during sport training programs that rely on sensory input other than vision.[8] A study by Hammami et al. compared static balance in rugby players, sprinters, and jumpers. The researchers explained that due to vision often being obscured during the sport of rugby, these players rely heavily on proprioception to maintain balance and posture. Therefore, learning to rely on sensory inputs other than vision could improve a person's balance and posture when vision is limited. Research by Palm et al. also concluded that when vision is limited, balance is able to be maintained the most when there is some type of auditory stimulation.[16] This finding further supports how balance and posture are influenced by vestibular, proprioceptive, and visual inputs.

In conclusion, vision has a strong influence on a person's balance and posture. When vision is impaired, proprioception and vestibular senses are the only means working to maintain balance and posture. Some studies have found that it is possible for the postural control system to rely more on other sensory inputs to maintain balance and posture when vision is reduced. Determining if the postural control system can reassess itself to depend on other sensory inputs may show if certain training programs can be developed to help people maintain balance and posture if visual or auditory inputs ever become altered. The purpose of the current study is to determine the effects that visual and auditory inputs have on balance and postural stability. The researchers hypothesize that when vision is limited or impaired, an individual's postural sway will increase and the ability to maintain balance will decrease.

2. Methodology

All of the data collection for this study took place within the Advanced Interdisciplinary Movement Science Laboratory (AIMS Lab) at Campbell University. The study was approved by Campbell University's IRB prior to data collection. There was a total of thirty subjects (male = n, females = n) ages 18-40 (Mean = 21.4 years S.D = 3.1 years) years old participating in the study. Recruitment of participants consisted of expressing the need for participants to various classes on campus and by direct contact between the researchers and individuals. Written voluntary informed consent was obtained from all participants before participating in the study. Height, mass, and age of all participants were recorded prior to testing. Participants were considered low risk using the American College of Sports Medicine (ACSM) guidelines and could not have any significant visual or hearing impairments. Participants could have corrective lenses, but could not be considered blind. Anyone that needed assistance for hearing was also excluded from the study.

Participants performed three 30-second trials of standing in four different conditions, resulting in a total of twelve trials. While participants did not undergo a familiarization session, the four conditions were presented in random order to prevent any potential learning effect that might occur with subsequent trials. Participants completed all three trials for each condition before moving on to the next condition. The four conditions included: 1) eyes open, 2) eyes closed, 3) dot moving in a side-to-side pattern while wearing a pair of IKKOS (Ponte Vedra Beach, FL) goggles (dot), and 4) dot moving in a side-to-side pattern with an auditory clicking sound (dot with sound). For the two conditions with the IKKOS goggles, the dot was moving in a side-to-side pattern at 0.100 Hz and the patient perceived the view in the goggles as a 139.7 cm television. For the auditory clicking sound condition, a clicking sound was heard each time the dot reached the side of the screen and continued traveling in the opposite direction.

During each trial, the participants did not wear shoes or socks, stood with feet shoulder width apart, toes pointed forward, and arms by their sides on a Wii Balance Board (Nintendo, Redmond, WA) that measured the excursion from the neutral position. The Wii Balance Board has been found to be a valid tool when accessing standing balance.[6] When testing center of pressure (COP) path length assessments, the Wii Balance Board has been shown to give reliable results when compared to a laboratory-grade force platform. Matlab (MathWorks, Natick, Massachusetts) was used to assess excursions from the Wii Balance Board. Mediolateral, anterior-posterior, and total excursions were measured during testing. The mean of the three trials in each condition was determined at 100 Hz and utilized for statistical analysis.

A one-way analysis of variance (ANOVA) was used to determine differences between the mediolateral, anterior-posterior, and total excursions for the four visual conditions. A Bonferroni post-hoc test was used to determine which visual conditions differed from each other. Alpha level was set at 0.05 to determine significance. All data were analyzed using SPSS Statistics 19 software package (IBM, Armonk, NY).

3. Data

The one-way ANOVA showed that significant differences did occur between the total excursion ($p < .001$) and anterior-posterior excursion ($p <.001$), but not for mediolateral excursion ($p = .469$). Post-hoc analyses revealed that the eyes open condition had significantly less total excursion than the eyes closed condition ($p < .001$), the dot condition ($p = .015$), and the dot with sound condition ($p = .047$). Figure 1 shows the mean and standard deviation of total excursion for each condition. The eyes open condition also had significantly less anterior-posterior excursion than the eyes closed condition ($p < .001$), the dot condition ($p = .003$), and the dot with sound condition ($p = .006$). The means and standard deviations for anterior-posterior excursion for each condition is shown in Figure 2. Figure 3 indicates the mean mediolateral excursions, with no statistical difference between the four conditions.

The results showed that there was less anterior-posterior and total excursion in the eyes open condition than the other three visual conditions. Therefore, participants were more stable when standing in the eyes open condition because they were able to receive visual feedback from their surroundings.[1, 7, 10] The dot with sound condition had slightly smaller excursion values than the dot no sound condition. Subjects tended to have the greatest amount of anterior-posterior, mediolateral, and total excursion in the eyes closed condition.

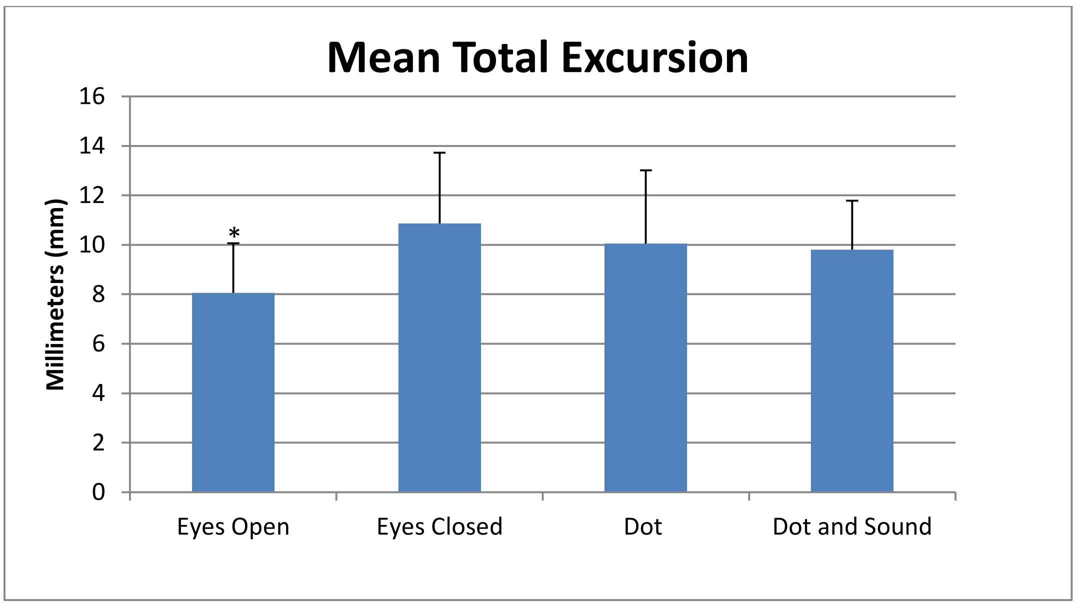

Figure 1 shows the mean total excursions for all four conditions. The * indicates a significant difference from the other three conditions, $p < .05$.

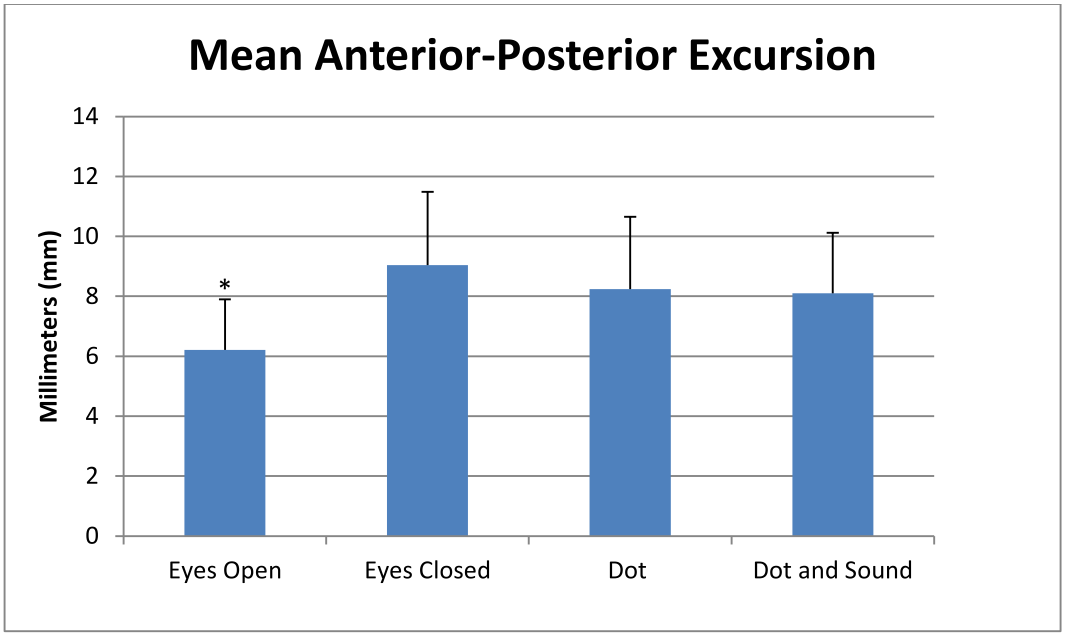

Figure 2 shows the mean anterior-posterior excursions for all four conditions. The * indicates a significant difference from the other conditions, $p < .05$.

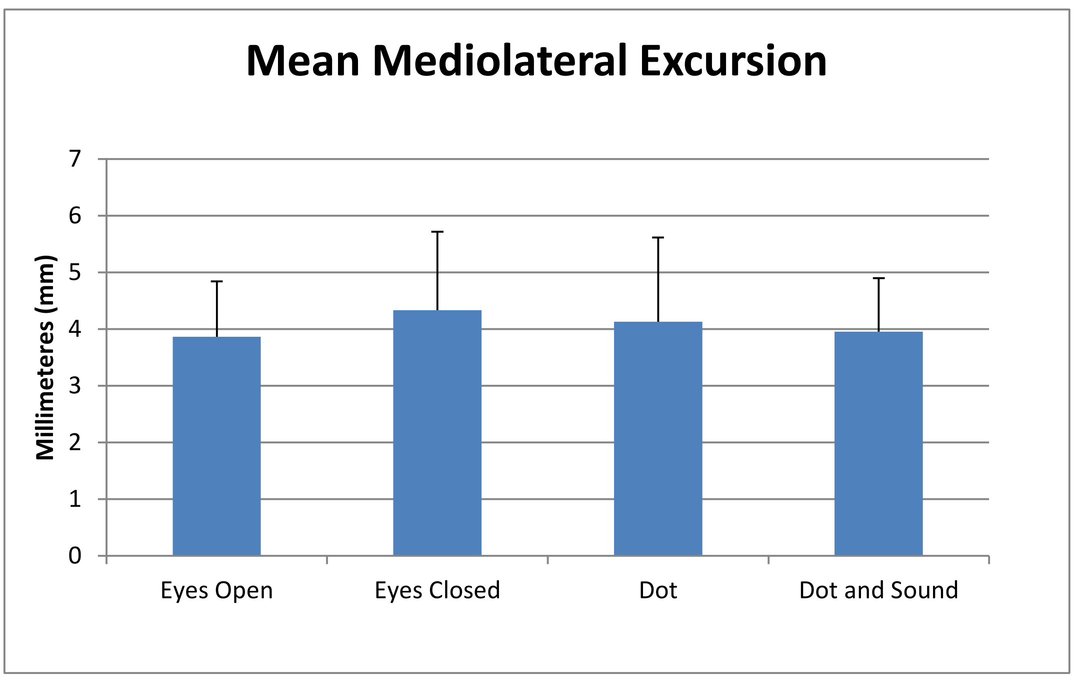

Figure 3 shows the mean mediolateral excursions for all four conditions.

4. Discussion

The purpose of the current study was to determine the effects that visual and auditory inputs have on balance and postural stability. The results show significantly less anterior-posterior and total excursions for the eyes open condition when compared to the other three conditions. The subjects were most stable during the eyes open condition because the body was able to better detect and correct its posture when it was visually aware of any sway and changes in posture.[1, 7, 10] Although no other condition offered significant differences, the dot with sound condition consistently resulted in being the second most stable, while the dot no sound condition consistently resulted in being the third most stable among all visual conditions. Subjects were consistently least stable during the eyes closed condition. Thus, the results suggest that vision plays the leading role in maintaining balance and posture. When subjects did not receive visual feedback from their surroundings regarding balance and posture, they were more likely to have increased sway patterns. Our results agree with previous studies in that when vision is reduced or taken away, a person's balance is negatively altered hence contributing to increase sway patterns.[3, 12, 13] Our results also agree with Adamo et al. that when visual feedback is available, a person is able to correct and maintain postural stability more efficiently.[1] Vision allows the body to detect and adapt to changes to prevent loss of balance and falls.

The increased sway in the anterior-posterior direction rather than mediolateral direction can be attributed to the increased stability in stance and joint mobility in the mediolateral direction.[5] The body can better resist sway or force in the mediolateral direction because the base of support is larger than in the anterior-posterior direction. During static balance when a person's legs are directly side by side, the magnitude of the base of support in the anterior-posterior direction is the length of the individual's feet (Figure 4). The magnitude of the base of support in the mediolateral direction is the distance from the outside of one foot to the outside of the other foot. The magnitude of the base of support in the mediolateral direction does include the distance between the person's feet.

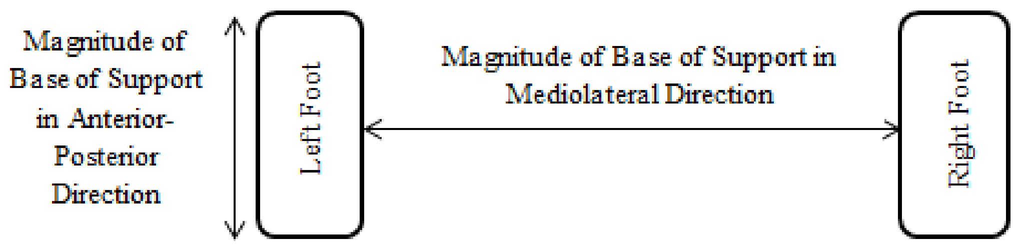

Figure 4 depicts how the base of support is determined in both the mediolateral and anterior-posterior directions.

Therefore, the larger base of support in the mediolateral direction results in having smaller excursions. Participants in the present study were instructed to stand with feet shoulder width apart which provided the participants with a larger base of support in the mediolateral direction. The results of this study agree with previous literature that smaller excursions occur in the mediolateral direction than the anterior-posterior direction during static standing.[4] Therefore, an increased base of support leads to smaller mediolateral excursions and decreased instability.

The IKKOS goggles, used in the present study, provided altered visual and auditory inputs that successfully affected balance and sway. IKKOS claims that training with these goggles can enable a person to adapt to new situations and stimuli better.[21] Our results show that, other than the eyes open condition, wearing the IKKOS goggles resulted in the least amount of sway which indicates that the subjects did benefit from the goggles.

Based on our results, we believe that training sensory inputs other than vision is possible which would increase balance and posture. In a study by Rougier and Farenc, the ability to maintain balance and posture were examined in blind and healthy individuals.[18] Results showed that the blind individuals had decreased sway amplitudes because they relied on proprioceptive abilities to maintain balance. Golomer et al. states that the training of professional dancers strengthens proprioceptive inputs which cause sensorimotor dominance to switch from vision to proprioception.[6,9] A study by Hutt and Redding examined the effects that an elite pre-professional dancing program can have on maintaining balance and posture when vision is denied. [9] The results showed an increase in dynamic balance maintenance in the eyes closed condition. The researchers concluded by explaining that if training with certain proprioceptive strategies can increase dynamic balance in athletes, then these same changes could possibly occur in non-athletes as well.

Training programs that use the IKKOS goggles could be developed in which the goal would be for the individuals to rely more on auditory stimulation and proprioception to maintain balance and posture. Programs could possibly be produced in which vision and auditory stimulations would be manipulated in an attempt to cause the postural control system to reassess itself to rely more on auditory stimulation and proprioception. This type of training would be very beneficial is populations with decreased vision, such as the elderly. Therefore, by using the IKKOS goggles over time, individuals may be able maintain or increase balance and posture by relying more on auditory stimulation and proprioception.

In conclusion, this study supported previous findings in that balance decreases as sight is reduced. Our results showed that vision plays the leading role in maintaining balance and posture. Although the results were not significant, the dot with sound condition resulted in smaller excursions than the dot no sound and eyes closed conditions which had no auditory stimulation.

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