ORIGINAL

Postural stability against full-field dynamic visual disturbance in archery players

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Abstract : Objectives : The effects of full-field dynamic visual disturbance on body sway were examined in archery players (n = 24), ball game players (n = 35), and untrained subjects (n = 34). Methods : Participants were asked to stand on a platform surrounded a box, the inside of which was randomly dotted. After the box suddenly began to swing and continued to swing back and forth at a frequency of 0.42 Hz for 60 seconds in a damped sinusoidal waveform, the body center sway was recorded using a stabilometer. Results : Standard deviation (SD) of body center sway in the anterior-posterior direction suddenly increased just after the box began to swing, and gradually decreased as the box swung in a damped sinusoidal waveform. After a sudden initial increase in SD of body center sway, it significantly decreased in archery players, compared with that of ball game players 20 seconds or untrained subjects 15 and 20 seconds after the onset of the box motion. Conclusion : Archery players showed higher stability against visual disturbance, compared with ball game players and untrained subjects, suggesting that they rely on proprioceptive inputs to maintain balance, and that their training re-weights sensorimotor dominance from vision to proprioception for posture regulation to increase shooting accuracy. J. Med. Invest. 67 : 67-69, February, 2020

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INTRODUCTION

The central nervous system selects and integrates sensory information from the visual, vestibular, and somatosensory systems to control posture (1). The central integration of sensory information dynamically regulates the adaptation to changing environmental conditions by selecting the available sensory information. This process is referred to as sensory re-weighting (2).

Training in sports effectively develops a specific strategy of posture control (3, 4). Therefore, we proposed the hypothesis that specialized training allows sportsmen to select and re-weight a particular sensory input in response to sports-specific performance of motor skills. In the present study, in order to prove this hypothesis, an attempt was made to examine if training in sports modifies the visual dependency of posture control. For this purpose, we examined the effects of full-field dynamic visual disturbance on body sway in archery players, ball game players and untrained subjects.

PARTICIPANTS AND METHODS

Twenty-four archery players (10 male and 14 female, average age : 21.1 years), thirty-five ball game players (21 male and 14 female, average age : 21.3 years), including tennis players, baseball players, football players and rugby players, and thirty-four untrained subjects (17 male and 17 female, average age : 22.9 years) were enrolled in the present study.

This study was performed in accordance with the Declaration of Helsinki and was completed before the date of enforcement of the Japanese Ethical Guideline for Medical Research (2003/7/29). An abstract of the study has been published in Equilibrium Research 63 : 470, 2004. An informed consent was obtained from each subject prior to the beginning of the study.

In order to measure their body center, i.e. the center of pressure, we asked participants to stand on a platform, wearing socks with eyes open, and to look at the inside of a randomly dotted box (150 cm x 120 cm x 70 cm) (Fig. 1). Foot position was

Figure 1 Experimental design. A participant stands in a box, the inside of which was randomly dotted and is instructed to look at the randomly dotted pattern. The box suddenly begins to swing, approaching the participant, and continues to swing back and forth in a damped sinusoidal waveform. Body center sway was recorded using a stabilometer.

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standardized using drawn footprints. After pre-session, during which participants were instructed to keep their eyes closed, they were asked to look at the randomly dotted pattern, and then the box would suddenly begin a swing motion, approaching the participants and would continue to swing back and forth at a frequency of 0.42 Hz for 60 seconds in a damped sinusoidal waveform (Fig. 2A). The session was performed three consecutive times after the pre-session.

The sway of body center was recorded using a customized stabilometer (Sanei-sokki, Japan) in a right-left (Fig. 2B) and a back-forth movement (Fig. 2C) independently. Analog signals were low-pass filtered (10 Hz) and sampled at 100 samples/second (PowerLab/8SP, AD Instruments, Inc, USA). We calculated the standard deviation (SD) of signals of the body center per 5 seconds; from 10 seconds before the onset of the box motion, to 25 seconds after the onset of the box motion.

Statistical analysis was carried out using Wilcoxon rank-sum test. $p < 0.05$ was considered statistically significant.

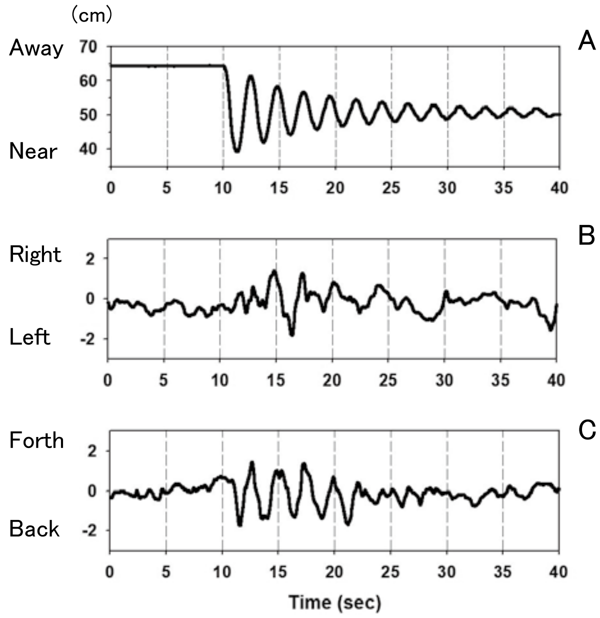

Figure 2 Representative records of the damped-sinusoidal swing of the box in the back-forth direction (A), of the body center sway in the right-left direction (B) and the back-forth direction (C).

RESULTS

SD of body center sway in the anterior-posterior direction did not change during the pre-session, when participants were instructed to keep their eyes closed (Fig. 3A). In the subsequent sessions, when participants were instructed to look at the randomly dotted pattern, SD of body center sway in the anterior-posterior direction suddenly increased just after the box, the inside of which was randomly dotted (Fig. 1), began to swing, approaching the participants, and then gradually decreased (Fig. 2C) as the box swung back and forth in a damped sinusoidal waveform (Fig. 2A). In the first session (Fig. 3B), after a sudden initial increase in SD of body center sway in the anterior-posterior direction, it was significantly decreased in archery players, compared with that of ball game players, 20 seconds after the onset of the box motion. SD of body center sway in archery players was also significantly decreased, compared with that of untrained subjects 15 and 20 seconds after the onset of the box motion. In the second session (Fig. 3C), after a sudden initial increase of SD of body center sway in the anterior-posterior direction, it was significantly decreased in archery players, compared with that of untrained subjects 15 and 20 seconds after the onset of the box motion. In the third session (Fig. 3D), the decrease in SD of body center sway in the anterior-posterior direction was not different among archery players, ball game players, and untrained subjects.

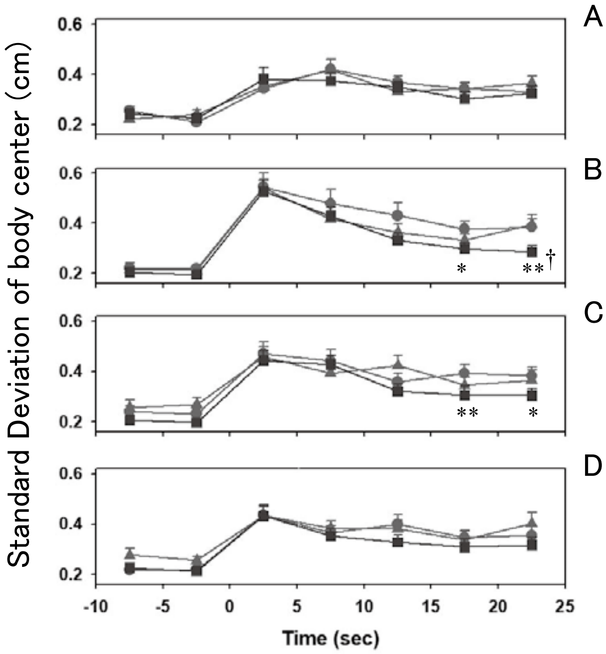

Figure 3 Effects of full-field visual disturbance on standard deviation of body center sway in the anterior-posterior direction in pre- (A), first (B), second (C) and third (D) sessions. Data represent the mean ± standard error. Square : archery players (n = 24). Triangle : ball game players (n = 35). Circle : untrained subjects (n = 34). $^*p < 0.05$, $^{**}p < 0.01$ vs. untrained subjects. $^\dagger p < 0.01$ vs. ball game players

DISCUSSION

In the present study, the body sway was increased just after a sudden and unexpected full-field dynamic visual disturbance in archery players, ball game players including tennis players, and untrained subjects. However, archery players recovered posture control faster than ball game players and untrained subjects. These findings suggest that archery players are significantly more stable against visual disturbances and are less dependent on visual inputs for posture control, compared with ball game players and untrained subjects. It is further suggested that archery players rely on proprioceptive inputs to maintain balance and that their training re-weights sensorimotor dominance from vision to proprioception for the regulation of posture, in order to increase shooting accuracy. It has been reported that judoists also rely on proprioceptive inputs for posture control (5). Further studies are required to examine whether long training period or young age is more likely to induce sensory re-weighting for posture control.

Conversely, there is evidence that tennis players rely on visual inputs for posture control, because they swayed significantly less during stance, when they relied more on visual input to maintain their balance (6). Tennis training appears to change the strategy of postural control into relying on visual input for detecting the motion of both the opponent and the ball. Vision can actually be divided into peripheral vision and foveal vision. It has been reported that peripheral vision plays a major role in the maintenance of balance, whereas foveal vision only plays a supplementary role in balance (7). Therefore, probably because tennis players have better balance control when relying on peripheral visual inputs, their balance recovery was delayed after they became unstable in response to disturbance of peripheral visual input, which was presented by a full-field randomly-doted pattern in the present study.

Nevertheless, in the present study, the recovery of body sway was not different among archery players, ball game players, and untrained subjects in the third session. A possible explanation is the fact that anticipation is another mechanism for posture control. When the brain recognizes imminent disturbances, it commands the anticipatory muscle responses to minimize their effects on body posture (8,9). Therefore, it is suggested that the participants predicted the movement of the box and the anticipatory muscular responses controlled their posture adjustments in the third session.

CONCLUSION

The present study suggests that archery players rely on proprioceptive inputs to maintain balance and that their training re-weights sensorimotor dominance from vision to proprioception for the regulation of posture to increase shooting accuracy. Tennis training appears to change the strategy of postural control to rely on visual inputs for detecting the motion of both the opponent and the ball. Consequently, specific sport training may induce sensory re-weighting and the development of specific balance control.

CONFLICT OF INTEREST

The authors declare no conflicts of interest.

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