THE ANALYSIS OF OCULAR MOVEMENT FOR THE DYNAMIC POSTURAL CONTROL OF TURN MOTION ON THE BALANCE BEAM

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This study demonstrated the importance of dynamic postural balancing and ocular movement in a turn motion on the balance beam using a manufactured wireless EOG measuring system with three female gymnasts. This study found that among the dynamic postural control variables, angular displacement and ocular movement were closely related. During a turn motion, the ocular movement was in opposite direction of the angular displacement of head and trunk along the medio-lateral axis. This resulted from the gymnast's effort to stare at the end of the balance beam or the front in order to keep balance. The change of angular displacement of head around the medio-lateral axis and vertical axis was in opposite direction of the ocular movement. When the motion was successful, the gymnasts performed a spotting motion.

KEY WORDS: E.O.G, Ocular Movement, Balance Beam, Turn, Dynamic Postural Control

INTRODUCTION:

Stable posture is essential for gymnasts to maintain static and dynamic postural control on the balance beam. Prior studies on postural control mechanisms (Kim & Han, 2002; Lee, 2005) and body balancing abilities (Lee et al., 2004) reported that the most important factor that affects body balancing was visual information, and this is related to the position of the performer's eyes in a three-dimensional space which is determined by the movements of head and eyes (Schmid & Zambarbieri, 1991), and they provide not only information about the environment but also the sense of direction to the body in the environment. A study measured ocular movements compare between experts and novices in figure skating and diving (Guillemant, et al., 1995). In gymnastics, measurements of visual information abilities have been used for various purposes such as investigation of technical elements (Davlin et al., 2001; Asseman & Gahery, 2004) and balancing and control (Danion et al., 2000). They emphasized the importance of the head position during the gymnastic motions and insisted that gymnasts must control their sight which varies by the positions of eyes and head during the performance of a motion. However, most prior studies used visual blocking techniques and scientific bases regarding accurate ocular movements were insufficient. Accordingly, this study intended to investigate the effects of ocular movement during female apparatus gymnasts' performance on the balance beam on the visual control types and dynamic postural control abilities according to the success and failure of turn motion on the balance beam, and their relationships with kinematic variables.

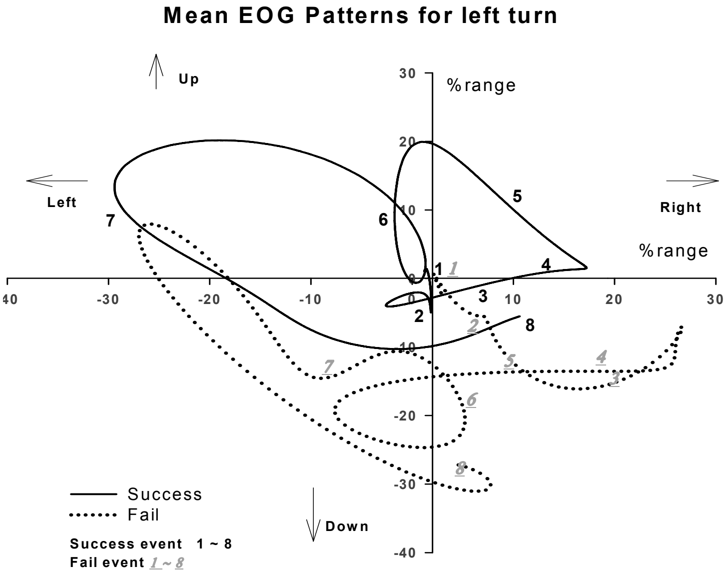
METHOD:

Data Collection: We selected three female collegiate gymnasts. The mean age of the subjects was 20.7±1.2 years, their mean height was 158.7±4.7 cm, their mean weight was 51.7±2.9 kg, and their mean career was 11.7±2.1 years. For video analysis of motion, we used four JVC video cameras. We set the frame rate to 60 frames/sec and exposure time to 1/500 s. To set three-dimensional spatial coordinates, we installed a control object of 1m×2m×2m at the top middle point of the balance beam. For measurement of ocular movement, we manufactured a small EOG.(Electrooculogram) using a wireless telemetry system to measure the forms of nystagmus and ocular movements during a turn movement on the balance beam without giving burden to the gymnasts. To examine the ocular movement according to events during a turn motion on the balance beam, we installed a signal tuner in such a way that the electric signals generated when the LED of the tuner turned on would be sent to the LabView program. For the EOG, a Ag/AgCI electrode (3M Co.) was attached to the epicanthus lateralis of each eye of the subjects, a left and right monitoring electrode to the right epicanthus lateralis, an indifferent electrode to the left epicanthus lateralis, and a grounding electrode to the procerus at the center of forehead (Park, 2006).

Data Analysis: For coordinates of the central point of body joints, we used the body segment parameters by Plagenhoef (1983) and digitized the data. For motion analysis data, we used the motion analysis package Kwon 3D XP (Visol, Korea) to obtain the three-dimensional coordinates of each body joint point to which control points and markers were attached. To remove noise of raw data which is generated in the digitizing stage, we smoothed the data using the secondary low-pass filer from Butterworth with the cut-off frequency set to 6Hz. The EOG signals were transmitted by radio wave with a wireless transmitter and received with a receiver connected to a computer. The waveform size was observed in real time using the Lab VLEW 7.1 (National Instrument, USA), and we created a software to store data for post-processing. The voltage values were saved as a MS Office Excel file at the sampling rate of 500 Hz per second. To remove noise from the raw data of EOG, we used an electronic low-pass filter (Matlab Elliptic filter, 8th, 50 Hz band pass).

RESULTS:

The ocular movement results of EOG were expressed as % range by normalization of the differences between maximum and minimum values and classification into left-right and top-down movement types. Movement of the waveform to the positive (+) value indicates that the eyeball moves to top right direction whilst movement of the waveform to the negative (-) value indicates that the eyeball moves to the bottom left direction. Figure 1 show the event results of average ocular movement when the turn motion succeeded and failed. When we compare the left and right ocular movement, at T90 event which had the largest difference, the movement was 5.31% when the motion succeeded while the movement was 26.44% when it failed. At T180 event as well, the movement was 25.95% when the motion failed, showing a greater range to the right than the case when the motion succeeded. Moreover, at FD event, the movement was -28.48% when the motion succeeded whilst it was -14.40% when the motion failed, showing a difference in left movement. All the up-down ocular movements were negative when the motion failed which showed more downward movements than the case when the motion succeeded. Figure 2 shows the angular displacements of head and trunk around medio-lateral axis when the motion succeeded and failed. Compared to the mean E.O.G. pattern, downward ocular movement appeared in the section where angular displacement was extended whilst upward ocular movement appeared in the section where angular displacement was flexed. In particular, the events that exhibited the highest difference between success and failure were LD and FD which were the landing section of the angular displacement of head and trunk. The extended pattern appeared and the downward ocular movement was conspicuous when the motion failed. Figure 3 shows the angular displacements of head and trunk around the anterior-posterior axis when the motion succeeded and failed. Greater lateral and medial flexion patterns appeared when the motion failed than when it succeeded. The ocular movement patterns also showed greater left and right movements when the motion failed than when it succeeded. The head almost did not moved until TTO event and showed an lateral flexion pattern at T90 and T180 events when the turn began. Ocular movement exhibited the same pattern as that of the angular displacement of head. However, movement in the top right direction appeared at T90 and T180 when the angular displacements of head and trunk were great. Therefore, ocular movement was in the opposite of the turning direction. At FD event, ocular movement suddenly changed from top left to bottom right direction. The reason for this seems to be that at the landing position, the angular displacement of the head rotates 360° and moves in the opposite of the turning direction for dynamic postural control.



(1) STM: Start Motion
(2) TTO: Foot Take Off
(3) T90: Turn 90°
(4) T180: Turn 180 °
(5) T270: Turn 270 °
(6) T360: Turn 360 °
(7) FD: Foot down
(8) LD: Landing

Figure 1: Mean EOG patterns of left turn

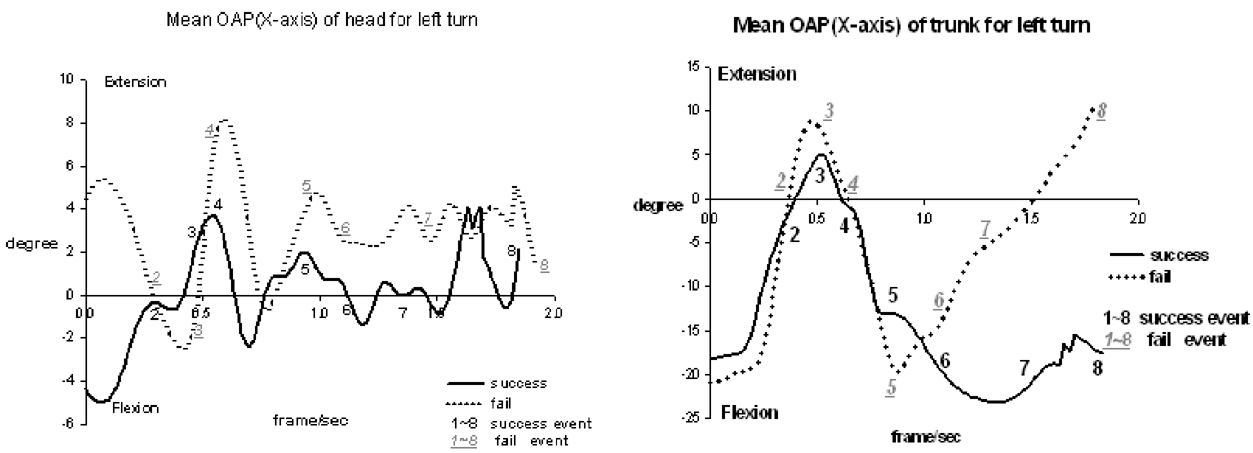


Figure 2: Mean angular displacement of head and trunk around medio-lateral axis

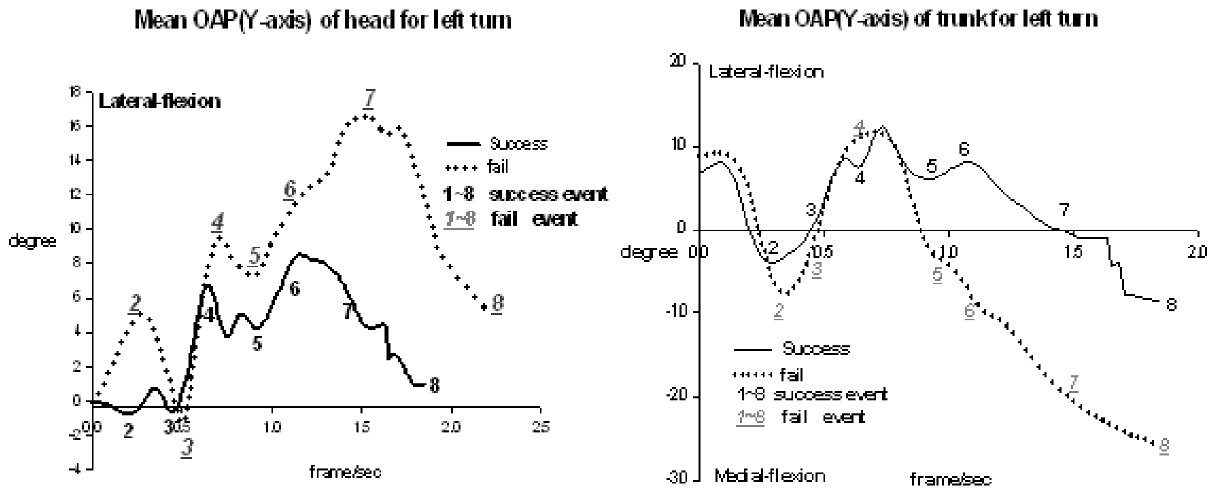


Figure 3: Mean angular displacement of head and trunk around the anterior-posterior axis

DISCUSSION:

Davin et al. (2001) studied a visual system of back somersault, and found that angular displacement, angular speed, and visual position influenced the landing motion and kinematic postures of gymnasts. We comparatively analyzed the angular displacements and angular speeds of body against ocular movement on the basis of the findings from prior studies. We found that the angular displacement around medio-lateral axis of head had closer relationship with the up-down ocular movement than that of trunk. When the angular displacement of head showed extended pattern, the ocular movement was downward whilst when the angular displacement of head showed flexed pattern, the ocular movement was upward. This result was more conspicuous when the motion failed, indicating that ocular movement plays a key role in gymnast's dynamic postural control to keep balance. The angular displacement of head around the antero-posterior axis had closer relationship with left and right ocular movements that that of trunk. In general, ocular movement was in opposite of the turning direction at the start of the turning and in the same direction as the turning direction from 180°. This finding was identical to the finding of Park et al. (1994) that eyeballs move in the opposite of the body's turning direction and after the climax, the eyeballs move in the same direction as the body's turning direction from 180°. Consequently, we can see that when the angular displacement of head around the antero-posterior axis which greatly affects the left-right ocular movement when the motion succeeds or fails is high, the change of ocular movement is also high. Because the left-right ocular movement is in the opposite of the turning direction in the landing section, ocular movement has a positive correlation with the antero-posterior angular displacement of head which affects dynamic postural control. The subjects tried to stare at the balance beam even when they lost balance.

CONCLUSION:

The findings of this study indicated that among the dynamic postural control variables, angular displacement and ocular movement are closely related. During a turn motion, the ocular movement is in opposite direction of the angular displacement of body around the medio-lateral axis. The reason for this seems to be that gymnasts try to stare at the balance beam or the front to keep balance on the balance beam. This is called spotting in a fast head-turning motion which is an essential element of the rotation movement. It also has close relations with the speed and quantity of rotation (Park, 2006).

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