P02-7 ID130

QUANTITATIVE ANALYSIS OF THE DYNAMIC BALANCE ABILITY BETWEEN THE COLLEGE STUDENTS AND HANDBALL PLAYERS

Han-Nien HUANG[1], Ming-Yao Su[2], Show-Hwa Chen[3], Cheng-Lung Tang[4], Tsorng-Lin Chia[5]

[1]Physical Education Office, Ming Chuan University, Taoyuan, Taiwan
[2]Physical Education Section, Tung Fang Design University, Kaohsiung, Taiwan
[3]Department of Sports Management, Chia Nan University of Pharmacy & Science, Tainan, Taiwan
[4] School of Design, Ming Chuan University, Taoyuan, Taiwan
[5]School of Information Technology, Ming Chuan University, Taoyuan, Taiwan

The purpose of this study was to investigate the differences of dynamic standing ability (Balance keeping time; BKT) and the change of the angular velocity (deg. / s) of a platform between healthy non-athelete female students and handball players using an unstable platform-like seesaw. Methods: The seesaw is capable of rotating side to side in both directions of right and left; it was set horizontally at an angle of zero degrees as a base, with the maximum degree of the seesaw inclination set at 25 degrees. In addition, a high-speed digital video camera (SONY-HDR-CX520V) was set to record the BKT and the changes of motion in the frontal plane from both sides of the plate. Results: There is a significant difference observed in both BKT and the change of angular velocity between non-athletes and handball players. Conclusion: The findings suggest the data gained from the experiments may establish a dynamic balance fitness norm and can be used as an assessment method of the lower extremity coordination ability.

KEY WORDS: bilateral, standing balance, angular velocity, unstable, seesaw.

INTRODUCTION: When subjects stand balanced on an unstable platform with an inclined surface, bilateral regulation of the lower extremities and changes in angular velocity are required to moderately coordinate the bodyis balance. In recent years, balancing ability has been regarded as an important indicator of muscular and skeletal health from the aspect of clinical issues, especially in older adult populations. Therefore, many researchers have discussed techniques to promote balancing ability in both static and dynamic equilibriums. In previous studies, the center of foot pressure (CoP) to evaluate the anterior-posterior displacement and the center of mass (CoM) to evaluate the position of body sway within the base of support (Peterka 2002; Ko et al. 2003; Roth et al. 2006) have been most frequently utilized to measure postural stability. Additionally, the neural mechanisms of bipedal standing balance on horizontal or rotational perturbations of the support surface were demonstrated by Nashner (1976, 1977). Thereafter, many more studies have evidenced that the visual, vestibular and proprioceptor systems contribute to posture control (Dietz et al. 1993; Schieppati et al. 1995; Wardman et al. 2003). Besides, the characteristics of the body movements during ankle, trunk and head oscillations, that is to say, the measurement of the position and displacement of the CoP using a moving platform, have been explored (Corna et al. 1999; Almeida et al. 2006; Paloski et al. 2006). However, very few studies, to our knowledge, have been reported the effects in the incessant transformation of angular velocity while standing upright on an unstable platform (Mezzarane and Kohn 2007); especially, the bilateral dynamic standing balance on a moving platform-like seesaw is not as clearly defined. A testing method for lower extremities dynamic balance applying convenient, reliable, and effectual equipment for the evaluation is necessary. The major motivation of this study, therefore, is to study the causes of different balance abilities in the lower extremities, comparing healthy non-athletes and students athletes through the stimulation of instability balance on a seesaw.

METHODS: All the subjects who participated in the present study were female students in the third or fourth year of study in the same college at Ming Chaun University in Taiwan. They were healthy and free from any balance disorders or injuries during the process of the study. See Table 1 for more details.

Table 1
Subject characteristics of each group (SD).

Subjects	Age (yrs)	Height (cm)	Weight (kg)	BMI (kg/m^2)
College students	20.43±1.26	161.45± 6.36	52.64±6.42	19.12~25.36
Handball players	20.81±0.63	165.72± 6.55	59.27±3.24	20.43~26.62

Procedures and Analysis System

The participants had to stand barefoot on a custom-built platform-like seesaw for 10 trials of balance testing (See Figure 1-A). This seesaw is capable of rotating side to side in both directions of right and left; it was set horizontally at an angle of zero degrees as a base, with the maximum degree of inclination set at 25 degrees. First, each student held a support frame with her right hand and simultaneously kept standing balance. Following the investigator's instruction of "**ready-go**", the subject let go of the support and maintained a standing posture on the unstable platform as long as possible. In order to investigate the balance keeping time (BKT), we recorded start-end time by high-speed digital video camera (SONY-HDR-CX520V) and calculated 60 frames per second as BKT (BKT = (end frame value − start frame value) ÷ 60 frames/second) (See Figure 2). This camera was set three meters in front of the platform and also recorded the changes motion of in degrees from both sides of plate. Additionally, in order to analyze the angular velocity, we placed a mark on both sides of plate edge (See Figure 1-B) to read the changes of degrees at the start and end times. Then through a simple equation (See Figure 3), we analyzed the change in horizontal degrees between the right and left sides of the frontal plane.

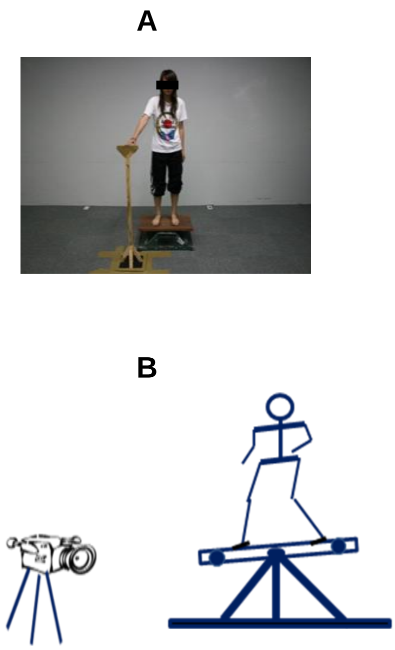

Figure 1: Illustrations of experimental setup

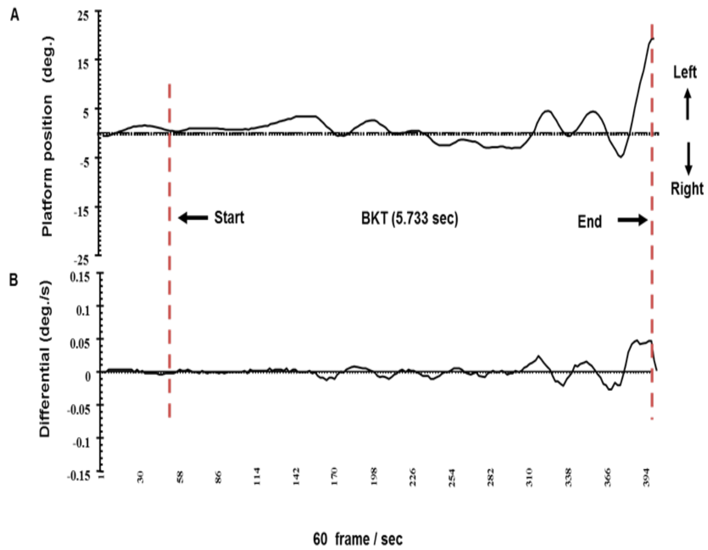

Figure 2: Representative example of the angular change in plateform position (A) and its velocity curve by the derivative technique (B). The balance keeping time in this example is 5.733 sec.

$$V_A(t) = \begin{bmatrix} x_{t+1} - x_t \\ y_{t+1} - y_t \end{bmatrix} = \begin{bmatrix} vx_t \\ vy_t \end{bmatrix}, 1 \le t \le M\text{-}1, t \in N \quad (1)$$

$$\cos\theta = \frac{A(t) \cdot V_A(t)}{|A(t)||V_A(t)|} \quad (2)$$

$$\omega_A(t) = \frac{\|V_A(t)\| \sin\theta}{\|A(t)\|} \quad (3)$$

$$\Omega_A = \sqrt{\frac{\sum_{t=1}^{M-1}[\omega_A(t)]^2}{M-1}} \quad (4)$$

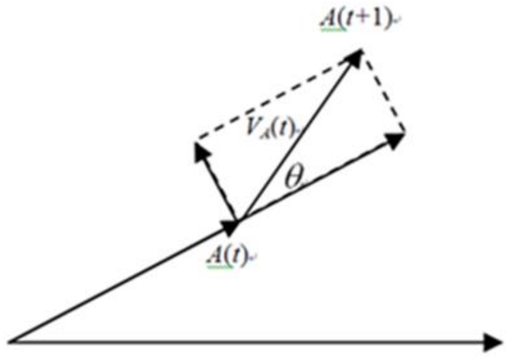

Figure 3: Equation used to analyze the change in horizontal degrees between the right and left sides of the frontal plane, and calculate Root Mean Square of angular velocity.

Statistical Analyses

Statistical analysis of significant differences between the healthy non-athletes and athletes was performed by the independent sample *t*-test. Pearson's correlation coefficient analysis was also used to assess the relationship between the BKT and the Root Mean Square (RMS) of angular velocity. An alpha level of significance was set at $P < 0.05$ in the test.

RESULTS: In this study, statistically significant results of BKT between the healthy non-athletes and handball players wereobserved in both BKT and the change of angular. Handball players had significantly higher BKT (2.733 ± 0.51 sec) than healthy non-athletes (1.206 ± 0.449 sec), and their angular velocity (RMS) is also higher (33.313 ± 4.389 deg. / s) than that of the non-athletes (27.063 ± 1.534 deg. / s). In addition, a high correlation coefficient between BKT and the change of angular velocity in handball players was observed (r = 0.677).

DISCUSSION: This research investigated effective and functional aspects of balance control is a dynamic balancing task as well as the variances between healthy non-athletes and handball players on an unstable platform. According to previous studies, the functional stretch response related to postural muscles in the lower extremities during quiet standing posture during horizontal movements of a platform (Nashner 1976, 1977). To move further ahead on a movable platform, two basic strategies of ankle and hip movement in the standing postural flexibility were clearly demonstrated by Horak and Nashner (1986). It is true in general that human lower limb joints are constructed to move more easily from sagittal (anterior/posterior, A/P) rather than from frontal (medial/lateral, M/L) planes. To our knowledge, however, there are no study has dealt with the complex task of keeping bilateral dynamic standing balance using a platform-like seesaw. In our present results, the average value of BKT at baseline measurement ranged from 1.695 to 3.313 s among handball players. Those values were very small when compared with the results of other literature. Almeida, Carvalho and Talis (2006), having measured the time of keeping balance using movable seesaws with changing the 'index of difficulty' for balancing, reported that all subjects could keep balance for 10 s even on the more unstable seesaws. On the other hand, maximum inclination of our platform was set at ± 25 degrees in the horizontal plane, which was enough to cause falling when the subjects demonstrated imbalance. Therefore, the 'index of difficulty' of our apparatus was considered to be higher, which might have resulted in the lower BKT. There were, however, some methodological differences between the above-mentioned Almedia et al's (2006) and our platforms. The platform in our present study rotates around a single roll-axis during balancing, while the pitch-axis of Almedia et al's (2006) platform moves back and forth a little. Hence, this may also influence the BKT.

Up to now, many studies have discussed the role of both the sagittal and frontal planes on upright standing with the center of pressure or the center of mass (Horak, & Nashner, 1986; Winter, et al., 1998). From Nashner's studies (1977), maintaining the postural activation patterns is determined by the central programs of the ankle strategy and the hip strategy. However, balance control demands not only unilateral adjustment such as between the agonist and antagonist groups on the center of pressure, but also the cooperation between the muscular functions and the higher central nervous system, especially with a bilateral balancing task like standing on a moving seesaw.

CONCLUSIONS: In this study, one of the major strategies was to utilize an instability stimulation to investigate the difference of BKT and changes in angular velocity between healthy non-athletes and handball players. Our findings suggest that the bilateral dynamic standing balance of lower extremities is increased with the change of angular velocity on an unstable platform-like seesaw. Moreover, these results show that it is feasible to assess the bilateral dynamic coordination ability of lower extremity like-BKTs using this method.

REFERENCES:

Almeida, G.L., Carvalho R.L. & Talis, V.L. (2006). Postural strategy to keep balance on the seesaw. *Gait & Posture,* 23, 17-21.

Corna, S., Tarantola, J., Nardone, A., Giordano, A. & Schieppati, M. (1999). Standing on a continuously moving platform: is body inertia counteracted or exploited? Experimental Brain Research, 124, 331-341.

Dietz, V., Trippel, M., Ibrahim, I.K. & Berger, W. (1993). Human stance on sinusoidally translating platform: balance control by feedforward and feedback and mechanisms. Experimental Brain Research, 93, 352-362.

Horak, F.B. & Nashner, L.M. (1986). Central programming of postural movements: Adaptation to altered support-surface configurations. *Journal of neurophysiology,* 55 (6), 1369-1381.

Ko, Y.G., Challis, J.H., Newell, K.M. (2003). Learning to coordinate redundant degrees of freedom in a dynamic balance task. Human Movement Science. 22, 47-66.

Mezzarane, R.A. & Kohn, A.F. (2007). Control of upright stance over inclined surfaces. Experimental Brain Research, 180, 377-388.

Nashner, L.M. (1976). Adapting reflexes controlling the human posture. Experimental Brain Research, 26, 59-72.

Paloski, W.H., Wood, S.J., Feiveson, A.H., Black, F.O., Hwang, E.Y. & Reschke, M.F. (2006). Destabilization of human balance control by static and dynamic head tilts. *Gait & Posture,* 23, 315-323.

Peterka, R.T. (2002). Sensorimotor integration in human postural control. Journal of Neurophysiology. 88, 1097-1118.

Roth, A.E., Miller, M.G., Ricard, M., Ritenour, D. & Chapman, B.L. (2006). Comparisons of static and dynamic balance following training in aquatic and land environments. *Journal of Sport Rehabilitation*, 15, 299-311.

Schieppati, M., Nardone, A., Siliotto, R. & Grasso, M. (1995). Early and late stretch responses of human foot muscles induced by perturbation of stance. Experimental Brain Research,105, 411-422.

Wardman, D.L., Taylor, J.L. & Fitzpatrick, R.C. (2003). Effects of galvanic vestibular stimulation on human posture and perception while standing. *The Journal of Physiology,* 551(3), 1033-1042.

Winter, D.A., Patla, A.E., Prince, F., Ishac M, Gielo-Perczak K. (1998). Stiffness control of balance in quiet standing. Journal of Neurophysiology, 80, 1211-1221.

Acknowledgement

We thank all participants for their assistance in the present study and Dr. Tsorng-Lin Chia for technical and analytical support.