POSTURAL STABILITY DURING DROP LANDING IN MODERN DANCERS AND BALLET DANCERS

Harumi Sawahara[1] and Mayumi Kuno-Mizumura[1]

Graduate School of Humanities and Sciences, Ochanomizu University, Bunkyo-ku, Tokyo[1]

The purpose of this study was to investigate postural stability of landing in modern and ballet dancers (n=18) during three different drop landings. Two-way mixed ANOVA were used to compare the differences of kinematic and ground reaction force (GRF) between the groups and the landing tasks. Modern dancers showed significant shorter center of pressure (COP) sway than that of ballet dancers ($p<0.05$). Maximum trunk forward flexion ($p<0.05$) and knee flexion ($p<0.05$) occurred earlier in modern dancers than in ballet dancers. There were no significant differences in peak vertical GRF between two groups. These data suggest that greater trunk forward angle and shorter time between initial contact of the drop landing and the occurrence of the maximum trunk forward flexion and knee flexion would relate to higher postural stability during landing in modern dancers.

KEY WORDS: dance, ground reaction force, center of pressure sway, lower extremity kinematics.

INTRODUCTION: Dancers perform many types of jumping in their performance for artistic purpose. From the aesthetic point of view, dancers are instructed to land on the floor as quietly as they can during their training and practice. In addition, it is speculated that quiet landing can retain some potentials to prevent dance injury. In ballet training, dancers are trained to keep their upper body in upright position during movements. It is supposed that ballet dancers keep their upper body in the same ways even during jumping or landing. On the other hand, in modern dance, there are various unique dance movements, which are different from ballet. It is reported that “ground work”, “work with the center of gravity”, and “motion in space” are specific styles to modern dance (Gorwa et al., 2014). These differences of performance in two dances might influence the biomechanical process of landing. However, there are few previous reports investigated landing biomechanics in dance, especially in modern dance. Therefore, the purpose of this study was to examine the difference in biomechanical characteristics during drop landing tasks between modern dance and ballet.

METHODS: Eighteen healthy dancers volunteered to participate in this study (8 modern dancers: age 21.0 ± 1.7 years, mass 54.1 ± 6.3 kg, height 161.4 ± 4.1 cm, dance training experience 14.8 ± 3.2 years; 10 ballet dancers: age 20.3 ± 1.1 years, mass 48.7 ± 4.7 kg, height 159.9 ± 5.8 cm, dance training experience 15.1 ± 2.3 years). All participants were physically active and none of them suffered pain in their lower back or lower extremity within the 12 months before data collection. Before data collection, all participants read and signed an informed consent document. Video images were recorded by using a digital video camera at a sampling rate of 60 Hz (iVIS HF R42; CANON Inc., Tokyo, Japan) from the right side of the subject. Reflective markers were placed over the following anatomical landmarks: right acromion, right greater trochanter of femur, right lateral fibula epicondyle, right lateral malleoli, right fifth metatarsal heads. Kinematic variables such as joint angle of the hip, knee, and ankle was calculated by two-dimensional motion system (Frame-Dias 4, Tokyo, Japan). Ground reaction force (GRF) were recorded at 1000Hz by the force platform (type 9287B, Kistler Instrument Corp, Switzerland). Center of pressure (COP) was calculated from the vertical component of GRF.
Participants performed three types of single-legged drop landings from a 30-cm platform onto a force platform. The order of the three different landing tasks was randomized. We asked subjects to perform three different landing tasks such as (1) counter landing (CL) task: land on a force platform in natural manners. (2) deep landing (DL) task: perform deep landing with their eyes kept at the height which was the same as the three quarters of the subject’s height.

(3) hand touched landing (HL) task: performed with their hands attached forward to the floor at the end of the landing. Each participant remained barefoot during testing, and subjects begun all tasks in a single-limb stance on the left leg and landed on the force platform on the right leg. They were also asked to keep the landing posture for at least three seconds. The effect of the arms was minimized by asking the subjects to keep their arms on their waist.

All statistical comparisons were performed of the drop landing phases for three seconds since the initial contact of the toe on the force platform. Peak vertical GRF and COP sway were analyzed as kinetic dependent variables. Joint angles were assessed at the maximal angle of sagittal trunk forward flexion, knee flexion, and ankle dorsiflexion and at the time from initial contact with the force platform to the occurence of maximum kinematic measures. The SPSS software version 22 (SPSS Inc., Chicago, IL, USA) was used for statistical analysis. For each dependent variable, two-way ANOVA was used to analyze the data. An alpha level of 0.05 was used for all statistical tests with a Bonferonni adjustment.

RESULTS: There was no significant difference in normalized peak vertical GRF by subject's body weight (N/BW) between modern and ballet dancers in each drop landing tasks. However, significant difference between modern and ballet dancers appeared in COP sway in 1-2 sec ($p = 0.02$) and 2-3 sec ($p = 0.018$) after the toe contacted the floor (Figure 1).

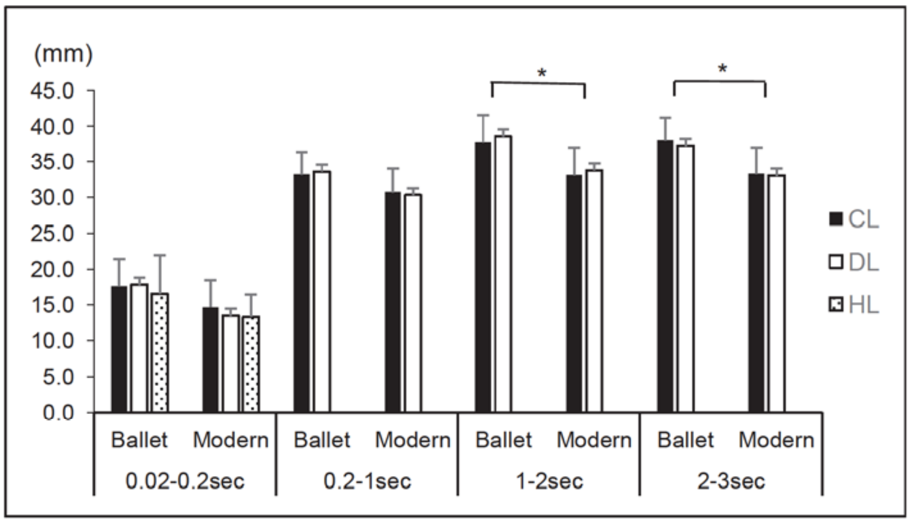


Figure 1. Total distance of COP sway during different phases after initial contact of each landing tasks (* : p < 0.05)

Significant main effects of the peak angle of sagittal trunk forward flexion were not obtained ($p < 0.05$)(Figure 2), neither in the peak angle of sagittal knee flexion nor in the peak angle of sagittal ankle dorsiflexion between modern and ballet dancers. Significant greater trunk forward flexion was found in modern dancers during both CL and DL task compared to ballet dancers. However, in both modern and ballet dancers, the peak angle of trunk forward flexion ($p < 0.01$) were significantly greater in DL task compared with CL task. As for the peak angle of knee flexion ($p < 0.01$) and ankle dorsiflexion ($p < 0.05$), both group showed significant greater joint angle during DL task than those of CL task.

There were significant differences between two dance groups for temporal characteristic evaluated from the time between initial contact on the force platform and the occurence of the peak measured angles during the different drop landing tasks ($p < 0.05$)(figure 3). The peak angle of trunk forward flexion and knee flexion in modern dancers appeared significantly earlier than those in ballet dancers. The timing related to the peak angle of ankle dorsiflexion was not significant between two dance groups except in HL task that the peak angle of ankle dorsiflexion appeared significantly earlier in ballet dancers ($p < 0.01$).

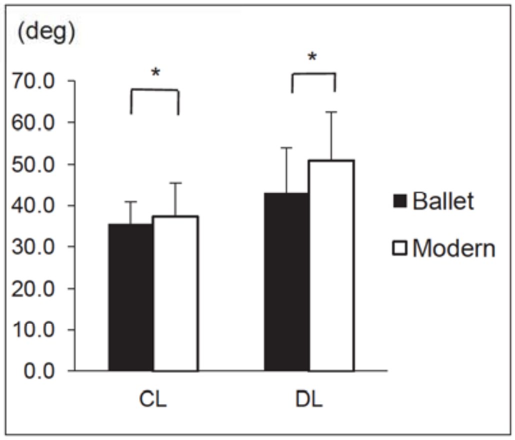
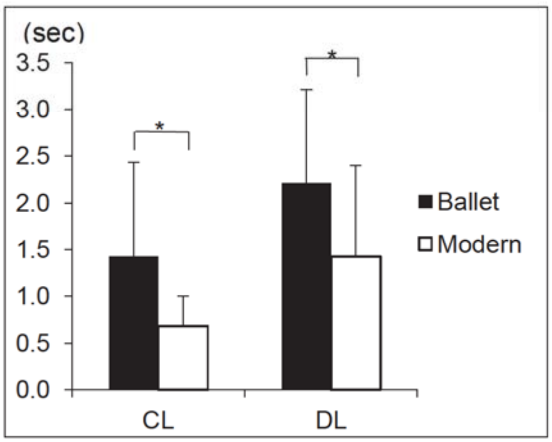


Figure2. The peak angle of sagittal trunk forward flexion (*: $p < 0.05$)



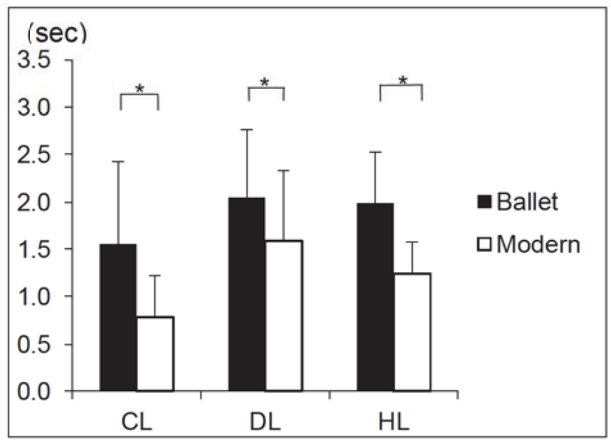


Figure 3. The timing of the peak angle occurrence for trunk forward flexion (left) and for knee flexion (right) (*: $p < 0.05$)

DISCUSSION: There were no significant differences in the peak vertical GRF both between two dance groups and among the trails. From this result, it is indicated that the ability to attenuate the force induced by landing could not be different among modern dancers and ballet dancers. However, modern dancers were significantly smaller in COP sway after drop landing. This result suggests the possibility that modern dancers have higher ability to maintain their balance of their landing posture than ballet dancers. It has been reported that for a correct execution of complex movements, the coordination, strength, and balance of agonist and antagonist muscles are very important in modern dance (Agopyan et al., 2013). Therefore, higher postural stability examined from COP sway in this study could be the effect of training from modern dance.

In this study, there was a significant difference only in the peak angle of trunk forward flexion among two dance groups. Therefore, it could be suggested that both modern and ballet dancers have similar kinematic characteristics in their lower limbs. In the previous research, greater knee flexion and ankle dorsiflexion angle demonstrates smaller GRF (Fong et al., 2011; Rowley & Richards, 2015). From these previous reports, modern and ballet dancers might have similar kinematic characteristics of the knee and the ankle joint which might cause no difference in the shock attenuation during landing between two groups. It could also be considered that modern dancers showed greater trunk flexion during landing since modern dancers have not been trained to keep their upper body in the upright position like ballet.

For postural stability after landing, modern dancers showed smaller COP sway compared to ballet dancers. It is indicated that the time from initial contact with the force platform until the occurrence of maximum angle of trunk forward flexion, knee flexion and ankle dorsiflexion in the sagittal plane, modern dancers could reach their landing posture earlier to provide higher stabilty after landing.

CONCLUSION: From the results of this study, it is indicated that shock attenuating ability has no difference in dance specific influences such as modern dance or ballet. However, modern dancers show higher stability after landing because of their temporal characterisitcs of the lower extremity movements. Futher study should be needed to compare our results in dancers to the age-matched non-dancers.

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