ANTERIOR CRUCIATE LIGAMENT INJURY RISK FACTORS DIFFERENCES BETWEEN FEMALE DANCERS AND FEMALE SOCCER PLAYERS DURING SINGLE-LEGGED AND DOUBLE LEGGED LANDING TASKS

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The purpose of this study was to compare ACL injury risk factors between female dancers and female soccer players during single-legged drop landing and double legged drop landing vertical jump tasks. Fifteen elite female soccer players and 45 professional female dancers (15 ballet, 15 modern, and 15 Korean dancers) were recruited to participate in this study. Two-way repeated measure of ANOVAs (participant groups & landing tasks, 4x2) were used. Female dancers landed with a significantly lower trunk flexion, trunk external rotation, knee external rotation, and knee valgus moment than those of female soccer players. Also, single-legged drop landing task demonstrated a higher trunk external rotation and knee valgus moment than those of double legged drop landing vertical jump task.

KEY WORDS: anterior cruciate ligament, injury risk factors, female dancers, landing.

INTRODUCTION: Female athletes have a 4 to 6 times higher risk of ACL injury than their male counterparts who play the same sports at similar levels (Hewett, Myer & Ford, 2006; Lim et al., 2009). Research suggests that female athletes have increased trunk instability, increased knee extensor and valgus moments, increased knee internal or external rotation, lesser total hip and knee flexion angles than do male athletes during activity and these variables are also known as ACL injury risk factors (Kim & Lim, 2014; Orishimo et al., 2014). Interestingly, female dancers have lower ACL injury rates (0.009 ACL injuries per 1,000 exposures) than other female team sports athletes (0.07-0.31 ACL injuries per 1,000 exposures) (Orishimo et al., 2014), and no clear disparity between female dancers and soccer players during single-legged drop landing and double legged drop landing vertical jump tasks. Landing is commonly associated with ACL injury. The drop landing tasks with single-legged and double legged landings are often used as a research model to investigate landing neuromechanics (Ambegaonkar et al., 2011). Although numerous studies have observed differences in landing biomechanics of the lower extremity between single-legged and double legged landing tasks across separate studies, there is currently little research comparison in two types (single-legged vs double legged landing tasks) of the landing biomechanics in the same study and none comparing athletes to dancers including Korean dancers. The purpose of this study was to compare ACL injury risk factors between female dancers and female soccer players during single-legged drop landing and double-legged drop landing vertical jump tasks. Our primary hypothesis was that female dancers would have lower ACL injury risk factors than female soccer players during landing tasks. The secondary hypothesis was that single-legged drop landing task would have different results in ACL injury risk factors compared to double legged drop landing vertical jump task in all groups.

METHODS: Fifteen elite female soccer players and 45 professional female dancers (15 ballet, 15 modern, and 15 Korean dancers) were recruited to participate in this study. Eight eagle cameras (Motion Analysis Corp, Santa Rosa, California, USA) and one force plates (AMTI, Watertown, Massachusetts, USA) were used for collecting motion and ground reaction force data.

Two landing tasks were conducted to calculate the ACL injury risk factors. One was single-legged drop landing task from 45 cm height (Orishimo et al., 2014; Liederbach et al., 2014), the other one was double legged drop landing vertical jump task from 45cm height (Ambegaonkar et al., 2011). Single legged landing performed on dominant leg. Landings were defined as the period of time from initial contact with the force plate to the point in time at which the maximum amount of knee flexion was achieved during each trial. Joint angles were calculated for the ankle, knee, and hip using the motion capture data. Net joint moments were calculated for each joint by standard inverse dynamic techniques using specialized computer software (Visual 3D, C-Motion Inc, Rockville, Maryland, USA). Joint moments were reported as external moments and normalized to body mass.
Two-way repeated measure of ANOVAs (participant groups & landing tasks, 4x2) were used with the participant groups and landing tasks as the between and within factors, respectively. Post-hoc tests with the Tukey correction were performed when significant factor effects and/or interactions were observed. *p* values of < .05 were considered statistically significant.
RESULTS: Female soccer players demonstrated a higher trunk flexion than those of ballet (*p* <.001) and Korean dancers (*p* = .035) (Figure 1), and double-legged drop landing jump task demonstrated a higher trunk flexion than those of single-legged drop landing task (*p* <.001) (Figure 1). Female soccer players demonstrated a higher trunk external rotation than those of modern (*p* = .009) and Korean dancers (*p* = .018) (Figure 2), and single-legged drop landing task demonstrated a higher trunk right rotation than those of double-legged drop landing jump task (*p* <.001) (Figure 2). Female soccer players demonstrated a higher knee external rotation than those of ballet (*p* = .005), modern (*p* = .033) and Korean dancers (*p* = .014) (Figure 3). Female soccer players demonstrated a higher knee valgus moment than those of ballet (*p* = .007), modern (*p* = .019) and Korean dancers (*p* = .043) (Figure 4), and single-legged drop landing task demonstrated a higher knee varus moment than those of double-legged drop landing jump task (*p* <.001) (Figure 4).

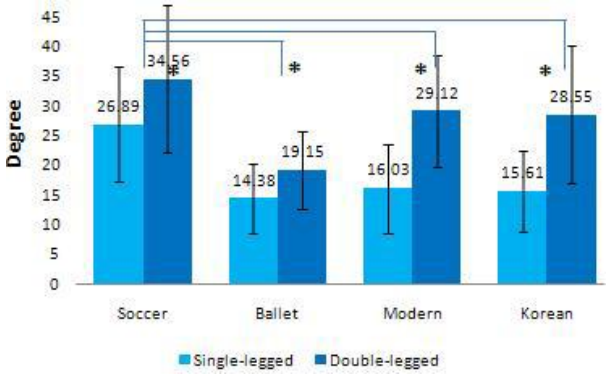

Figure 1: Trunk flexion angle.

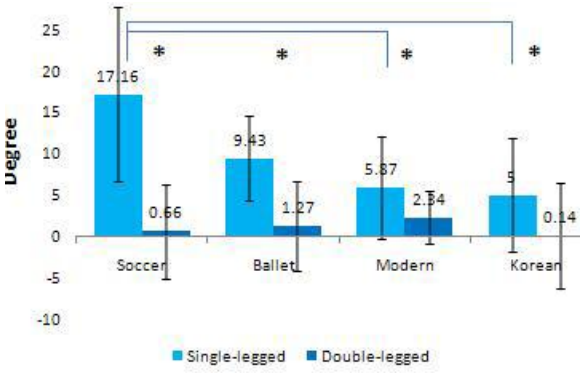

Figure 2: Trunk rotation angle.

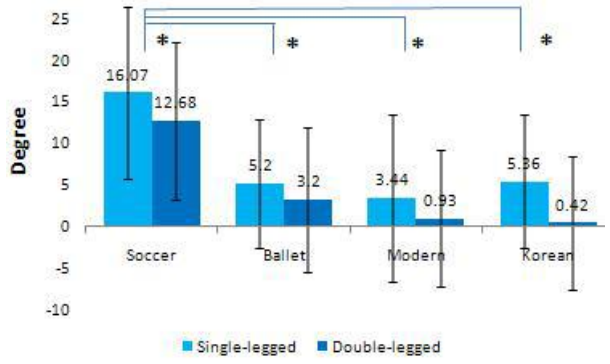

Figure 3: Knee rotation angle.

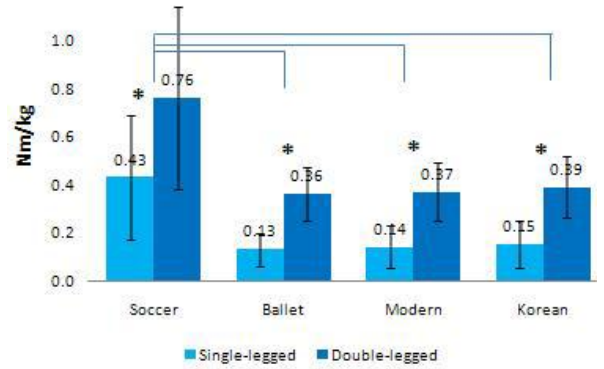

Figure 4: Knee valgus moment.

DISCUSSION: The purpose of this study was to compare the effects of group (female dancers vs female soccer players) and task (single-legged drop landing vs double legged drop landing vertical jump) on the ACL injury risk factors. This study found that female dancers landed with a significantly lower trunk flexion, trunk external rotation, knee external rotation, and knee valgus moment than those of female soccer players. Also, single-legged drop landing task demonstrated a higher trunk external rotation and knee valgus moment than those of double legged drop landing vertical jump task. This may partially explain the low ACL injury rate among female dancers in double legged drop landing vertical jump task.
Orishimo et al., (2014) reported that dancers exhibited a lower trunk side flexion and lower trunk forward flexion compared with team sport athletes and our study showed same result. Previous study have shown that a lack of trunk control is linked to ACL injuries in female team sport athletes (Hewett, Myer & Ford, 2006). Dancers train specifically for many years to maintain an upright and square torso during all of their jumping activities and dancers performed the unique way in which they train jumps with respect to intentional trunk stability and precision of the upper extremity position (Liederbach, Dilgen & Rose, 2008). Accomplishment of aesthetically precise balance and jumping skills is indistinguishably necessary for both men and women in dance to advance to the professional ranks(Orishimo et al., 2014). Unlike many sports, where jumping is practiced as a means toward a specific point-scoring task, jumping in dance is utilized in and of itself solely for the purpose of helping to convey a story and/or for displaying technical virtuosity (Liederbach, Dilgen & Rose, 2008).
Previous study reported that female team sport athletes landed with a significantly greater peak knee valgus than those of female dancers (Orishimo et al., 2014). Our study showed no significant differences in peak knee valgus between female soccer players and female dancers. This may be due to items of team sports (Orishimo et al., 2014; mixed basketball, volleyball, soccer, lacrosse and rugby vs our study; only soccer) and landing height difference (Orishimo et al., 2014; 30cm vs our study; 45cm).
Previous study reported that female dancers were found to have a lower hip adduction torque than those of the other 3 groups (Orishimo et al., 2014). Our study showed same result. This finding in female dancers may help explain the lower incidence of ACL injuries compared with that of female athletes (Orishimo et al., 2014). However, it is unclear why female dancers have a lower hip adduction moment than male dancers when the ACL injury risk is equal for these groups. It may be that controlling hip adduction moments is a different mechanical task for female dancers, necessitating the increased control of hip and knee motion to improve lower extremity alignment as required by dance performance (Orishimo et al., 2014).
Single-legged drop landing task had differences results in ACL injury risk factors compared to double legged drop landing vertical jump task in all groups. This is due to higher ankle and hip joint stiffness and greater use of ankle muscles (Ambegaonkar et al., 2011). Yeow, Lee & Goh (2011) reported that the hip and knee showed major contributions to energy dissipation during double-leg landing, while the hip and ankle were the dominant energy dissipaters during single-leg landing in the sagittal plane. Also, the hip acted as the key energy dissipater during double-leg landing, while the knee contributed the most energy dissipation during single-leg landing in the frontal plane. The knee also exhibited greater frontal plane joint ROM, moment and energy dissipation during single-leg landing than double-leg landing. Their findings indicated that different energy dissipation strategies were adopted for double-leg and single-leg landing in sagittal and frontal planes. Considering the prominent frontal plane biomechanics exhibited by the knee during single-leg landing, this maneuver may have greater likelihood of leading to traumatic knee injuries, particularly non-contact ACL injuries, compared to the double-leg landing maneuver (Yeow, Lee & Goh, 2011).
Several implications can be derived from these findings. It is likely that the extensive training in landing technique that professional dancers undergo from a young age is partially responsible for the protective biomechanics that they exhibit during landing. This is

particularly encouraging for the potential of injury prevention programs to effect changes in movement patterns and ultimately decrease ACL injury rates among female team sport athletes. A variety of different programs have been developed, and many of them have been shown to be effective in reducing ACL injury rates (Yoo et al., 2010). Those programs that are most effective include correction of biomechanical faults as one of their elements but almost universally focus on sports-specific exercises (Yoo et al., 2010; Orishimo et al., 2014). It may be worth investigating dance training and the possibility of incorporating some of its elements into injury prevention programs for team sport athletes.

The present study has several limitations that should be considered. First, all participants performed the drop jump tasks barefoot. Whereas soccer players always use footwear, dancers may or may not use footwear, depending on the type of dance. This factor potentially changed the way that soccer players and some dancers performed the landing. Second, biomechanical differences are not the only reason that may account for the difference in ACL injury rates between female team sport athletes and dancers. Female soccer players have the element of the unpredictability of ball and player motion, which may account for a large part of the high ACL injury rates.

CONCLUSION: Female dancers had lower ACL injury risk factors than those of female soccer players during landing tasks. Single-legged drop landing had differences results in ACL injury risk factors compared to double-legged drop landing in all groups.

These biomechanical findings may provide insight into the cause of the epidemiological differences in ACL injuries between dancers and athletes and the lack of a landing disparity. If dancers use ACL-protective strategies during activity, then their training routines should be further investigated to improve ACL injury prevention programs.

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