# LOWER EXTREMITY STIFFNESS DURING SEPAKTAKRAW SPIKE LANDINGS

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Sepaktakraw spike landing is the aggressive skill that leads to many injury of lower extremity. Leg and knee joint stiffness is the important factor of sepaktakraw spike injury particularly when landing. The purpose of this study was to investigate lower extremity stiffness of sepaktakraw spike landings. Results showed that leg stiffness and knee joint stiffness of roll spike (RS) during landing was significant higher than half roll spike (HRS). These indicate that RS can cause a high risk of injury due to greater lower extremity stiffness than HRS. Thus sepaktakraw players need to have a good strength and flexibility of muscle to prevent potential risk of lower extremity injury during sepaktakraw spike landings.

**KEY WORDS:** injury, leg stiffness, knee joint stiffness

**INTRODUCTION:** Sepaktakraw currently gains its popularity around the world. According to the International Sepaktakraw Federation (ISTAF), over 25 national association around the world are the members of ISTAF. Sepaktakraw spike is an offensive skill which players kick a takraw ball with acrobatic movement. Two spike techniques, Roll spike (RS) and half-roll spike (HRS), are commonly used. Nevertheless, injuries are commonly found during these spikes (Neraphong, Jalayondeja, & Vatchalathiti, 2000). Additionally, RS was also found to have the highest impact force and loading rate during landing of sepaktakarw spike (3.97 BW and 158.8 BW/s) (Kerdsomnuek, Limroongreungrat, & Chaunchaiyakul, 2015).
Lower extremity stiffness is one of biomechanics factors that can help to understand mechanics of lower extremity injury. Leg and joint stiffness are commonly used to investigate lower extremity stiffness. The stiffness of the overall musculoskeletal system during landing phase was represented by the stiffness of leg spring or the leg stiffness (Farley & Morgenroth, 1999). The joint stiffness is the stiffness of each joint which effect on the stiffness of the leg which is determined by response to the joint moment of its joint angle (Farley, Houdijk, Van Strien, & Louie, 1998). Thus, the joint stiffness indicates to the mechanism of the joint in response to a high reaction force at those joint during landing. The leg stiffness level is needed to adjust the mechanics of movement in order to maintain or increase performance in some circumstances. However, high leg stiffness may lead to bony injury such as knee osteoarthritis, or less of stiffness may cause an injury with tissue such as non-contact ACL injury (Butler, Crowell, & Davis, 2003).
Previous study investigated leg and knee joint stiffness during landing from volleyball block jumps and revealed that males landing with leg and knee joint stiffness greater than females (Hughes & Watkins, 2008). This result showed that less stiffness in females related to reduce dynamic stability of the leg may lead to ACL injury. Sepaktakraw spike landing is the aggressive activity that causes a high risk of injury; however, no previous study have yet reported the lower extremity stiffness. Therefore, the purpose of this study was to investigate difference of leg and knee joint stiffness during sepaktakraw spike landings.

**METHODS:** Ten healthy male sepaktakraw players (mean age: 19.6 ± 2.8 years, mean weight: 61.4 ± 7.2 kg, and mean height: 1.72 ± 0.04 m.) were participated in this study. All subjects read and signed informed consent which approved by Mahidol University Institutional Review Board (MU-IRB). Ten-camera optoelectronics system (BTS SMART DX 5000, Bioengineering

Inc., Italy) synchronized with a force platform (Kistler Type 9286BA, Kistler Group, Winterthur, Switzerland) were used to collect data at the sampling rates of 200 Hz and 1,600 Hz, respectively. Forty-four markers were attached on the subjects according to LJMU Lower Limb and Trunk Model (Robinson & Vanrenterghem, 2012; Vanrenterghem, Gormley, Robinson, & Lees, 2010).
A 10-mimute warm up and practice spike before collection to familiarize with the protocol. Subject was instructed to spike the ball that was suspended in the air according to individuals' preference and landed on the force platform. Each subject performed two different spikes; roll spike (RS) and half-roll spike (HRS). Five successful trials were averaged and analyzed. Visual3D software (C-motion, Germantown, MD, USA) was used for data reduction and analysis. Cardan angle sequence is XYZ was performed. The X-axis was defined as flexion-extension movement of segment. The landing phase was defined as the event from initial contact on the floor to maximum knee joint flexion. Initial contact was defined as the event when the vertical ground reaction force (vGRF) increased more than 20 N. Leg stiffness ($K_{leg}$) and knee joint stiffness ($K_{joint}$) were obtained. $K_{leg}$ is the ratio of the change in vGRF to the change in vertical displacement of center of mass (CoM) at whereas $K_{joint}$ was calculated by the ratio of the change in knee joint moment to the change in knee joint angle in sagittal plane movement (Farley & Morgenroth, 1999). The SPSS program (version 17.0, Chicago, IL, USA) was used for all statistical analysis. Pair sample t-test was used to compare the leg stiffness, and knee joint stiffness of two sepaktakraw spike landings. The significant test was set at $p<0.05$.

**RESULTS:** The means and standards deviation of leg stiffness and knee joint stiffness during sepaktakraw spike landings are shown in Table 1. The results revealed that the leg stiffness and knee joint stiffness for RS were significantly greater than HRS ($p<0.05$).

**Table 1**
**Mean ± SD of the leg and knee joint stiffness.**

| | RS | HRS |
|---|---|---|
| Leg stiffness (kN/m) | 23.18 ± 8.18 | 10.12 ± 3.70* |
| Knee joint stiffness (Nm/kg·m/deg) | 0.042 ± 0.019 | 0.022 ± 0.015* |

* significant difference from RS ($p < 0.01$)

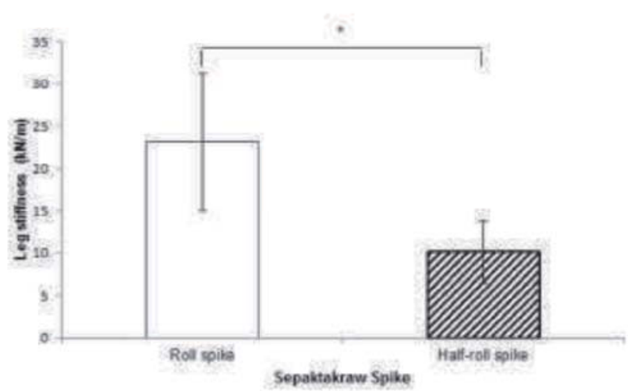


**Figure 1: The leg stiffness of sepaktakraw spike landings.**

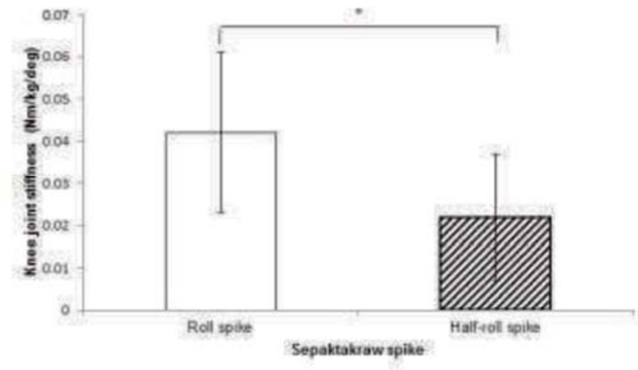


**Figure 2: The knee joint stiffness of sepaktakraw spike landings.**

**DISCUSSION:** The objective of this study was to examine sepaktakraw spike differences in leg and knee joint stiffness of lower extremity during landing. Although stiffness during landing has been reported, it has focused in different tasks including hopping, drop jump landing and volleyball blocking (Ambegaonkar et al., 2011; Farley et al., 1998; Hughes & Watkins, 2008). The results showed that the leg and knee joint stiffness for RS was significantly greater than HRS.

Leg stiffness had been investigated during hopping task on different surfaces. It was found that the leg stiffness ranged from 13.9 kN/m to 28.1kN/m which was adjusted to perform the same performance on different surface stiffness (Farley et al., 1998). Hughes and Watkins (2008) studied leg stiffness during volleyball block landing and found that leg stiffness in male and female were 15.02 kN/m and 10.29 kN/m, respectively. The current study found that the leg stiffness of sepaktakraw spike landings was in similar to hopping (10.12 kN/m - 23.18 kN/m). However, the plane of movement is different since hopping strictly occurs in the sagittal plane but sepaktakraw spike occurs in multidirectional planes. The leg stiffness of sepaktakraw spike landings was higher than volleyball block landing may be due to sepaktakraw spike is the single-leg landing but volleyball block is double-leg landing. In addition, this study found that leg stiffness for RS was significant higher than HRS (Figure 1) due to high vertical ground reaction force and decrease CoM displacement during landing.

Knee joint stiffness of volleyball block landing was reported to be 0.0035 Nm/kg·m/deg and 0.0019 Nm/kg·m/deg in males and females, respectively (Hughes & Watkins, 2008). While knee joint stiffness of dancers and basketball players during drop jump landing were 0.016 and 0.018 Nm/kg/deg, respectively (Ambegaonkar et al., 2011). The knee joint stiffness in this study are greater than both volleyball block landing and drop jump landings. Thus, landing of sepaktakraw spike may prone to lower extremity injury greater than volleyball block and drop jump landing because of high lower extremity stiffness. In addition, this study showed that the results of knee joint stiffness of RS were significant higher than HRS (Figure 2). This also supported leg stiffness that RS has a high risk of injury more than HRS. These factors are providing RS has a high risk of bony injury more than HRS during landing because of too much of leg stiffness (Butler, Crowell, & Davis, 2003). These also supported by the previous study which found RS had greater vertical ground reaction force and loading rate than HRS (Kerdsomnuek, Limroongreungrat & Chaunchaiyakul, 2015).

**CONCLUSION:** In summary, roll spike may have higher injury risk than half-roll spike particularly bony injury due to high leg stiffness, high vertical ground reaction force and loading rate. Therefore, players should be a high performance to perform roll spike to prevent potential risk of injury.

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