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# RELATIONSHIP OF LEG STIFFNESS MEASURES DURING BASIC AND SPORTS SPECIFIC MOVEMENT TASKS IN HIGH LEVEL NETBALLERS


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The purpose of this study was to investigate the relationship between lower extremity leg stiffness measures during basic jumping and sports specific movement tasks. Twelve high level female netballers preformed five trials of a maximal countermovement jump (basic), 50 m sprint and change of direction cutting task (sports specific). Data was obtained using a 10 camera Vicon system and AMTI force plate. A one-way repeated measures (ANOVA) indicated significant differences in leg stiffness during basic and sports specific tasks. Pearson correlations revealed no relationships between basic and sports specific tasks. The results suggest that relevant sports specific movements may be more appropriate to assess leg stiffness when screening athletes.



**KEYWORDS:** leg stiffness, netball, jumping, sprinting, agility


**INTRODUCTION:** Netball is a high intensity, intermittent sport, requiring maximal jumping efforts, repeated sprints and optimal agility. Exposure to high impact forces during these activities results in an elevated incidence of injury. Studies have shown that Netball players are approximately 3.3 times more at risk of sustaining a lower limb injury (ankle, knee, calf and shin) when compared to other court based sports such as basketball (McKay, Payne, Goldie, Oakes, & Stanley, 1996). There are few studies examining the risk factors for injuries in netball, however, age, prior injury incidence, playing position, or the strength and stiffness properties of the muscle may be related to such incidences.

Stiffness describes the deformation of the body under a given force and it enables the muscle to increase its resistance to change under an applied load (Brughelli & Cronin, 2008; Butler & Crowell, 2003). Stiffness is task dependent and can be augmented through training to improve performance and minimize injury risk (Komi, 2000; Kuitunen, Kyröläinen, Avela, & Komi, 2007). Stiffness assessment provides information on ways to optimize performance, loading rates and potential injury risk in athletic populations (Butler & Crowell, 2003). To date, research has focused on profiling various athletic groups and potential associated injury risk during basic countermovement tasks (Hobara et al., 2008; Hobara, Kimura, et al., 2010). However questions remain as to whether basic movement tasks are good predictors of an athlete’s stiffness patterns during functional tasks, when stiffness may vary due to the demands of sport-specific tasks.

Athlete screening and monitoring is important to optimize performance and manage potential injury risk. Lower extremity leg stiffness has known links to both injury risk and optimal performance (Brughelli & Cronin, 2008; Butler & Crowell, 2003). Specifically, relatively higher levels of stiffness have been linked to high impact injuries such as stress fractures, whereas lower levels of stiffness have been associated with soft tissue injuries (Butler & Crowell, 2003; Hobara, Kimura, et al., 2010; Watsford et al., 2010).

The purpose of this study was to ascertain lower extremity leg stiffness differences between a conventional basic jumping task and sports specific movement tasks. Based on previous research it was hypothesized that there would be no relationship between stiffness in basic tasks and sports specific tasks, whereby athletes who display higher levels of stiffness during jumping tasks would not necessarily display higher stiffness during sports specific tasks.

**METHODS:** Twelve national to international level adult female netballers were recruited (See Table 1) and provided informed consent prior to participation in the study. This population was targeted as the training and competition demands regularly involve basic and sports specific functional movements such as jumping, sprint/power movements and change of direction tasks. The study was approved by University ethics prior to the commencement of data collection. Following a self directed warm up, participants were instructed to complete five trials of three training and competition relevant tasks at a self-selected, competition pace, rest periods were allowed between trials. Tasks included a maximal effort unilateral countermovement jump, 50 m sprinting and an anticipated change of direction cutting task. All tasks were performed on the participant's dominant leg and captured at 500 Hz using a 10 camera Vicon system (Vicon MX; Oxford Metrics Ltd., Oxford, United Kingdom) and AMTI force plate (Advanced Mechanical Technology Inc., Watertown, U.S.A.) sampling at 1000 Hz. The standard Vicon Plug-in-gait full body model (35 reflective marker set) was used to determine center of mass (COM) displacement. Leg dominance was defined using a modified protocol where participants performed three drop jumps self-selecting the jumping leg (Padua et al., 2006).

Following analysis of the frequency content and residuals of the power spectra (Winter, 2005) a cut off frequency of 16 Hz for the jumping tasks and 23 Hz for the running and change of direction cutting tasks was implemented in a low pass Butterworth dual-pass fourth order filter.

Leg stiffness was determined using the formula outlined in McMahon and Cheng (1990). Leg stiffness measures were normalized to body weight and standardized to touchdown velocities of 6.17 m/s (Sprint) and 4.81 m/s (Cutting) using residual calculations derived from linear regression analysis.

Tests for normality were undertaken prior to statistical analysis. The difference in stiffness measures and mechanical parameters were assessed using a one-way repeated measures analysis of variance with a Bonferroni post-hoc. Pearson correlations were undertaken to assess the relationships between lower extremity leg stiffness from the three tasks. All statistical analyses were calculated using the Statistical Package for Social Sciences (SPSS, v21.0, Inc., Chicago, IL, USA).

**Table 1: Descriptives of participants (mean ± SD)**

| n | Age (y) | Height (cm) | Weight (kg) | Training Years | Training Hours/wk |
|---|---|---|---|---|---|
| 12 | 17.58 ± 1.62 | 176.66 ± 4.89 | 66.80 ± 5.43 | 9.64 ± 1.86 | 9.82 ± 3.84 |

**RESULTS:** The results displayed a mean jump height of 14.71 cm and average contact time of 0.75 s during the countermovement jump. Participants had an average contact time of 0.16 s during the sprint and 0.21 s for the change of direction cutting tasks respectively. There were significant differences in contact time and peak forces between all three tasks. It was also evident that there were significant differences in COM displacement between the countermovement jump and both the sprint and change of direction cutting tasks (Table 2).

Leg stiffness measures were normalized to body weight and standardized for impact velocity (Table 3). A repeated measures ANOVA indicated a significant difference between stiffness measures from the three tasks, $F(1,145) = 195.84$, $p < 0.01$. Bonferroni post hoc comparisons indicated leg stiffness in the countermovement jump was significantly lower than the sprint task ($p < 0.01$), and the change of direction cutting task ($p < 0.02$).

Pearson correlations revealed that the stiffness from the sprint and change of direction cutting tasks were significantly related ($r(12) = 0.70$, $p < 0.02$) while sprint and countermovement jump ($r(12) = 0.261$, $p > 0.41$), and change of direction cutting and countermovement jump ($r(12) = -0.094$, $p > 0.78$) were not related.

**Table 2- Summary of mechanical parameters**

| Countermovement Jump | | | Sprint | | | Change of Direction Cutting | | |
|---|---|---|---|---|---|---|---|---|
| CT (s) | Peak Vert F (N) | COM (m) | CT (s) | Peak Vert F (N) | COM (m) | CT (s) | Peak Vert F (N) | COM (m) |
| 0.745 ± 0.126 * | 592.2 ± 156.0 * | 0.20 ± 0.07 * | 0.164 ± 0.012 * | 1157.3 ± 178.9 * | 0.04 ± 0.01 | 0.208 ± 0.025 * | 889.8 ± 162.9 * | 0.04 ± 0.01 |

*- Significant difference *p* <0.05. CT: contact time; VertF: vertical force; COM: centre of mass.

**Table 3- Summary of leg stiffness scores**

| Test | Countermovement Jump | | Sprint | | Change of Direction Cutting | |
|---|---|---|---|---|---|---|
| | Kleg (kN/m/kg) | Jump Height (cm) | Kleg (kN/m/kg) | Impact Velocity (m/s) | Kleg (kN/m/kg) | Impact Velocity (m/s) |
| Mean ± SD | 53.96 ± 34.39 * | 14.71 ± 3.32 | 130.41 ± 29.13 | 6.17 ± 0.36 | 107.33 ± 41.36 | 4.81 ± 0.34 |
| Standarised Score | - | - | 131.13 | 6.17 | 109.92 | 4.81 |

*- Significant difference *p* <0.05. Kleg: leg stiffness.

**DISCUSSION:** The results of this study supported the main hypotheses that lower extremity leg stiffness measures obtained during conventional jump tasks and sports specific tasks would be significantly different. These results suggest that an athlete displaying a higher or lower stiffness measure relative to the group during basic jumping movements will not necessarily record a similar stiffness measure during more sports specific tasks.

Previous research and the findings of this study suggest that these differences may be attributed to the varying kinematic and kinetic mechanisms (COM, contact time, peak forces) necessary to manage higher impact loads and meet the required task demands. The absence of any significant correlations between basic and sports specific task stiffness measures also suggests that assessing lower extremity leg stiffness of netballers during basic jumping tasks may not be the most appropriate means of identifying high risk athletes or the attenuation strategies to employ during training and competition. As a result these measures may not translate to competition and training when optimal performance is desired and injury is most likely to occur.

Although not significantly different, it would appear that leg stiffness measures still reveal the tendency for some differences between task demands for different activities. This supports the assumption that sports specific tasks may be a superior screening tool when compared to basic jumping tasks for the assessment of lower extremity leg stiffness in athletes. However the benefit of utilizing stiffness measures obtained during more sports specific tasks requires further investigation with multiple athletic groups and a larger range of sports specific based tasks.

Although the present study was limited to one specific sporting population, it has demonstrated that it may be preferable to assess lower extremity leg stiffness during more sports-specific functional tasks to identify and monitor athletes for potential injury risk and injury prevention strategy implementation. Further research should aim to establish similar stiffness relationships in other athletic populations and the subsequent stiffness attenuation strategies that can be employed to offset task demands leading to injury risk.

**CONCLUSION:** The present study established clear differences in leg stiffness measures obtained during basic and sports specific movement tasks in a cohort of high level netballers. The results also indicated that there were no relationships in stiffness measures between basic and sports specific movement tasks. Even though, research has previously investigated the relationships between potential injury risk and stiffness measures obtained during basic jumping movements in athletes, the current results suggest that it may be more beneficial to screen athletes using sports specific movements. These measures may better reflect lower extremity leg stiffness strategies employed during training and competition when injury is more likely to occur.

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