RELIABILITY OF ACUTE STATIC STRETCH IMPACT ON VERTICAL JUMP HEIGHT

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The purpose of this study was to examine the reliability of the acute effect of stretch on vertical jump performance. Twenty-four subjects completed eight trials. In each trial warm-up, three pre-stretch jumps, stretching, and three post-stretch jumps were completed. Intraclass correlation coefficients (ICC) were used to evaluate the reliability of the stretch impact on vertical jumping across trials. While pre-stretch and post-stretch jumps were highly reliable (ICC=0.99), the difference from pre-stretch to post-stretch was not (ICC=0.07). The stretch impact on vertical jump may not be reliable for subjects across trials.

KEY WORDS: intraclass correlation coefficient, consistency

INTRODUCTION: Many investigations examining the acute impact of static or proprioceptive neuromuscular facilitation (PNF) stretching on vertical jumping have been conducted. Many have found acute stretching to decrease vertical jump performance (Behm et al., 2006; Bradley et al., 2007; Church et al., 2001; Hough et al., 2009; Walter & Bird, 2009), while others found stretching to have no significant impact on subsequent vertical jump performance (Knudson et al., 2001; Unick et al., 2005; Young & Elliott, 2001). Even with such varied findings, many have concluded that stretching immediately prior to performance has little benefit and potential significant reductions in performance and should be avoided.

While movement outcomes often have declined after stretching, investigations of other related biomechanical variables have not produced consistent results. Previously some researchers have attributed changes in performance after stretch to musculotendon stiffness (Guissard et al., 2001; Toft et al., 1989). Yet others have not supported the idea of musculotendon stiffness (Goodwin et al., 2009; Knudson et al., 2001; Nelson et al., 1996). Investigations of related kinematics (Knudson et al., 2001), flexibility (Behm et al., 2006), muscle activity (Hough et al., 2009), and ground reaction forces (Walter & Bird, 2009) failed to find variables associated with reduced vertical jump height immediately after stretching.

The acute impact of static and PNF stretching on vertical jump height and its associated variables has eluded researchers for some time. Investigators have reported a strong reliability ($r = 0.86$ to 0.99) of individual measures such as jump height, power, and ROM (Behm et al., 2006; Bradley et al., 2007; Walter & Bird, 2009), yet no one has reported the reliability of the stretch impact on vertical jump performance. Knudson et al. (2001) did not find a significant impact on vertical jump performance but did report the stretch impact lacked uniformity across subjects when 55% of the participants decreased in jump height, 10% had no change, and 35% of subjects increased after stretch. Walter and Bird (2009) found a significant impact of stretch on vertical jump, but unlike Knudson et al. (2001), 73% of subjects decreased in jump height, 15% had no change, and 12% increased in jump height. While the characteristics of the subjects in each study may have influenced who was impacted and who was not, there is no evidence to support the reliability of the acute impact of stretching on vertical jump height. The purpose of this study was to examine the reliability of the acute effect of static stretching on vertical jump performance.

METHODS: Prior to participation 13 female and 11 male recreational and varsity athletes (age: 19.6±0.9 yrs, height: 1.75±0.12 m, and weight: 76.0±15.6 kg) from the university population provided informed consent in accordance with testing procedures approved by the university Institutional Review Board. Each of the 24 subjects completed eight sessions, separated by a minimum of 24 hours. Each data session required the subject to warm-up on a Monark cycle ergometer at 120 W for five minutes, execute 2-4 warm-up vertical jumps, then complete three jumps, stretch, and immediately complete three more jumps. Jumps were performed with both hands on hips to isolate the lower extremities and to eliminate potential confounding arm coordination; subjects were instructed to jump as high as possible for all jumps. A Kistler force plate (model 9286AA) was used to measure the ground reaction force data (1000 Hz sampling rate).

After the initial set of three jumps, subjects completed four static stretches for the gluteal, hamstring, quadriceps, and calf muscle groups. Each stretch was performed once unilaterally and held for a timed thirty seconds, as described in the National Strength and Conditioning Association guidelines (Baechle & Earle, 2000). Each stretch was completed on both sides of the body. Adequate stretch was defined as committing to full range of motion at each joint until slight discomfort, but not pain, was achieved. Stretching techniques were demonstrated to the subjects prior to data collection to ensure subject understanding of proper technique, and monitored during the experimental stretching routine.

For the unilateral gluteus stretch subjects sat with knees flexed and their feet flat against the floor. After crossing one leg over the thigh of the other leg, they grasped the back of that same thigh with both hands. Subjects pulled their legs towards their torso to stretch. For the unilateral seated hamstring stretch subjects sat with an anterior tilt of the pelvis. The leg being stretched remained outstretched while the uninvolved leg was flexed in a figure-four position. Subjects then were instructed to lean forward, flexing at the hip, and reach with their hands towards their toes. For the unilateral standing quadriceps stretch subjects stood on one leg with a posterior pelvic tilt and one hand against a wall for balance. Subjects grasped non-weight bearing foot, bringing the knee into flexion as far as possible while keeping the knee perpendicular to the floor. For the unilateral standing calf stretch subjects stood with both hands placed against a wall in front of them. While keeping left knee slightly flexed, subjects were to move right foot back about half a meter and place right heel and foot flat on the floor.

Vertical jump height was calculated from the time off the force plate. Reliability for the pre-stretch jumps, post-stretch jumps, and stretch impact were evaluated using Intraclass Correlation Coefficients (ICC) across the eight trials. Based on jump reliability for consecutive jumps (ICC = 0.97), only the second pre-stretch and post-stretch jump heights were used to determine the effect of stretching on vertical jump. Sit and reach measures completed after the first and eighth sessions were compared with a paired-samples t-test. A repeated measures ANOVA was used to compare stretch impacts across trials and to evaluate gender differences.

RESULTS: The changes in jump height did not significantly ($p>0.05$) affect women differently than men. Subsequent analyses collapsed data across gender. Sit and reach significantly ($p<0.05$) increased over the time period of data collection (from 13.8±6.0 cm to 14.5±5.9 cm, $p<0.05$). The effect size was 0.175, reflecting a small change over time. The ICC for all pre-stretch jumps was 0.99 and the ICC for all post-stretch jumps was also 0.99. The ICC for all differences from pre-stretch to post-stretch, an indication of the impact of the stretch, was 0.07. No significant differences were found when comparing the stretch impact on vertical jump heights across trials ($p>0.05$). See Figure 1.

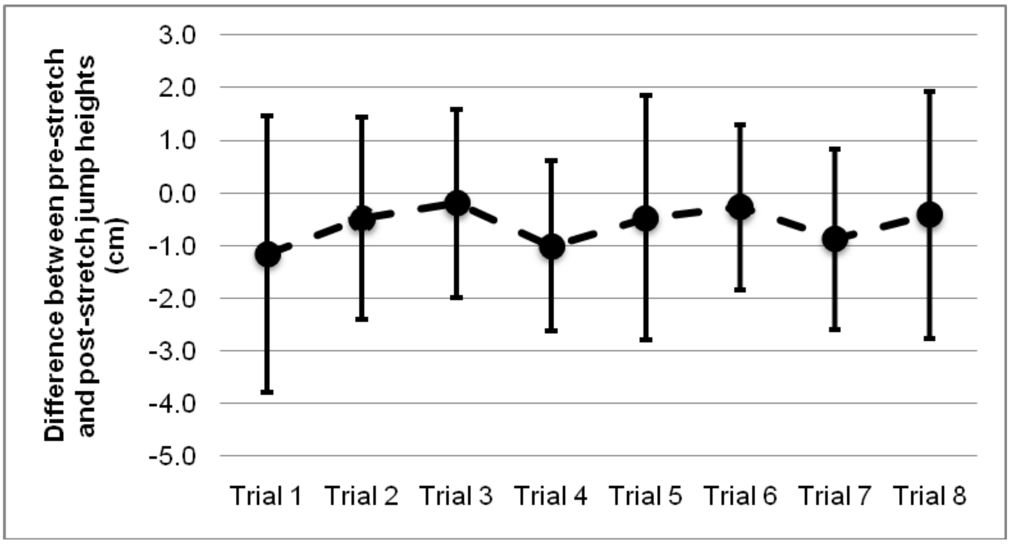

Figure 1: Mean (±SD) differences between pre-stretch and post-stretch jumps for all trials. No differences were found between means. The ICC was 0.07.

DISCUSSION: The purpose of this investigation was to evaluate the reliability of the stretch impact on vertical jump performance. Changes in flexibility over the eight trials were not unexpected but, with an effect size of 0.175, the change was small and potentially inconsequential. Behm et al. (2006) examined flexibility and changes in flexibility on the stretch impact in vertical jump height, but did not find any relationship between flexibility and changes in flexibility and stretch influences of vertical jump performance. The changes were, however, a good reflection of the subject’s adherence and effort in the stretching routine.

The pre-stretch and post-stretch ICC values were strong; subjects were highly consistent performers from trial to trial, both before and after stretching. These values were consistent with jump reliability values found in previous research (Behm et al., 2006; Bradley et al., 2007; Walter & Bird, 2009). In contrast to the pre-stretch and post-stretch reliability, the ICC for the changes in jump height attributed to stretch reflected poor reliability. Stretching did not consistently affect subjects across trials. So little consistency of stretch impact meant subjects could not be grouped according to who was “responsive” to the stretch and who was “unresponsive” to the stretch. Further, the trial-to-trial variation may mean any possible negative influence on vertical jump performance would also vary from day to day.

No subject decreased in jump height for all eight trials. For one or more trials each subject improved in jump height after stretching. Though the average change decreased by 0.61±2.01 cm across all eight trials, the impact of stretching on performance varied, but not consistently in a negative or positive manner. The average relative reductions for each trial were between 0.9% and 3.7%; no trial had an average increase in jump height. On average, some trials were more affected by stretch than others. There was a tendency to decrease jump height after stretching, but not always, and not for the same people each time.

The influence of stretch on vertical jump performance did not differ from trial to trial. However, if only the first trial was considered, the stretch would have been evaluated as having a significant ($p<0.05$) effect on jump height, the mean decreased by 3.7%, typical of other studies of stretch impact on jump height (Behm et al., 2006; Bradley et al., 2007; Hough et al., 2009; Walter & Bird, 2009). The inconsistency of stretch impact on vertical jump across trials in these results may explain the lack of consistent impact of stretching in other studies, where significant decreases in jump height were sometimes found (Behm et al., 2006; Bradley et al., 2007; Church et al., 2001; Hough et al., 2009; Walter & Bird, 2009), but not all of the time (Knudson et al., 2001; Unick et al., 2005; Young & Elliott, 2001). When the stretch influence was significant in previous research, it was often attributed to various biomechanical and physiological phenomena (Goodwin et al., 2009; Guissard et al., 2001; Knudson et al., 2001; Nelson et al., 1996; Toft et al., 1989). It seems unlikely that a biomechanical or physiological change would be unreliable; perhaps some other factor is changing the performance of those who stretch.

CONCLUSIONS: If the impact of stretching is not reliable, it is also not valid. If the impact of pre-activity stretching is not reliable, more research is needed to understand what is influencing the athletes' performance after stretching.

REFERENCES:

Baechle, T. & Earle, R. (2000). *Essentials of Strength Training and Conditioning* (2nd ed). Human Kinetics, Champaign, Illinois.

Behm, D., Bradbury, E., Haynes, A., Hodder, J., Leonard, A., & Paddock, N. (2006). Flexibility is not related to stretch-induced deficits in force or power. *Journal of Sport Science and Medicine, 5,* 33-42.

Bradley, P., Olsen, P., & Portas, M. (2007). The effect of static, ballistic, and proprioceptive neuromuscular facilitation stretching on vertical jump performance. *Journal of Strength and Conditioning Research, 26*, 223-226.

Church, J., Wiggins, M., Moode, F., & Crist, R. (2001). Effect of warm-up and flexibility treatments on vertical jump performance. *Journal of Stretch and Conditioning Research, 15*, 332-336.

Goodwin, J., Glaister, M., Lockey, R., & Payne, E. (2009). Spring-mass leg stiffness is not affected by brief static or dynamic stretching [abstract]. *Medicine & Science in Sports & Exercise, 41,* 267.

Guissard, Duchateau, and Hainaut (2001). Mechanisms of decreased motoneurone excitation during passive muscle stretching. *Experimental Brain Research, 137,* 163-169.

Hough, P., Ross, E., Howatson, G. (2009). Effects of dynamic and static stretching on vertical jump performance and electromyographic activity. *Journal of Stretch and Conditioning Research, 23*, 507-512.

Knudson, D., Bennett, K., Corn, R., Leick, D., & Smith, C. (2001). Acute effects of stretching are not evident in the kinematics of the vertical jump. *Journal of Stretch and Conditioning Research, 15*, 98-101.

Nelson, A., Kokkonen, J., & Arnall, D. (2005). Acute muscle stretching inhibits muscle strength endurance performance. *Journal of Strength and Conditioning Research, 19*, 338-343.

Toft, Espersen, Kålund, Sinkjær, and Hornemann (1989). Passive tension of the ankle before and after stretching. *The American Journal of Sports Medicine, 17,* 489-494

Unick, J., Kieffer, H., Cheesman, W., & Feeney, A. (2005). The acute effects of static and ballistic stretching on vertical jump performance in trained women. *Journal of Strength and Conditioning Research, 19*, 206-212.

Walter, C., & Bird, M. (2009). Acute static stretch effects on multiple bouts of vertical jump. In A. Harrison, R. Anderson, & I. Kenny (Eds.), *Proceedings of the 27th International conference on Biomechanics in Sports* (pp. 752-755). Limerick, Ireland.

Young, W., & Elliott, S. (2001). Acute effects of static stretching, proprioceptive neuromuscular facilitation stretching and maximum voluntary contractions on explosive force production and jumping performance. *Research Quarterly for Exercise and Sport, 72,* 273-279.

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