ACUTE STATIC STRETCH EFFECTS ON MULTIPLE BOUTS OF VERTICAL JUMP

Chelsea C. Walter & Michael Bird

Truman State University, Health & Exercise Sciences, Kirksville, Missouri, USA

The purpose of this study was to evaluate the acute effects of static stretching on vertical jumping and the ground reaction force kinetics when stretching was implemented between multiple performance bouts. Fifty-two young adults were randomly assigned to a control or stretch condition, each group performing four sets of three jumps. After the initial jump series, subjects in the stretch condition performed a set of four unilateral lower extremity stretches, holding each stretch for 30 s on each leg. Vertical jump height and time had a significant interaction effect ($p<0.05$), the stretch group had a significant decrease in jump height only after the first jump. Vertical jump kinetics was not significantly affected from one series to another or between the two conditions. Stretching between exercise bouts had a small, significant effect on the product of the jump, but no effect on the ground reaction force kinetics. No cumulative effects were found across jumps after subsequent stretching.

KEYWORDS: jump height, ground reaction force, rate of force development, impulse force

INTRODUCTION: Deciphering the best way to incorporate a stretch protocol with respect to performance has become increasingly important for athletes. Stretching has long been part of exercise routines, often performed before the exercise bout. Many coaches, athletes, and researchers have advocated the use of stretching for potential benefits in performance and decreased injury risk. While stretching has been hypothetically thought to enhance performance, there is little scientific evidence to back this claim. Moreover, recently researchers have found pre-performance stretching to have a detrimental influence on movement outcomes in various measures including power production (Manoel et al., 2008; Samuel et al., 2008), vertical jump performance (Knudson et al., 2001; Unick et al., 2005), force production (Brandenburg, 2006; Knudson & Noffal, 2004), rate of force development, and ground reaction forces (Young & Elliot, 2001). As stated by Nelson et al. (2008), “this paradox between accepted dogma and current research raises the dilemma over prioritizing performance and safety for athletes” (p. 338).

Some researchers have found small, yet significant, negative effects of pre-performance stretching on movement (Bradley et al., 2007; Brandenburg, 2006; Knudson & Noffal, 2005; Young & Elliot, 2001; Nelson et al., 2005). Others have found pre-performance stretching to have no impact on performance (Knudson et al., 2001; Manoel et al., 2008; Samuel et al., 2008; Unick et al., 2005). The dilemma of pre-performance stretching will continue to be relevant as researchers continue to strive toward best preparing the athlete for success. For example, little research has been conducted to assess the effect of stretch when it is executed within a series of performance bouts (Brandenburg, 2006; Samuel et al., 2008; Unick et al., 2005).

The timing of stretching with respect to performance could play an important role in competitions where athletes perform multiple bouts with time lapse between events such as sprinting, field events in track, and Olympic lifting. Knowledge of how stretching may impact performance, and whether the effects are cumulative may be valuable to both coaches and athletes as they plan the time between competition bouts. The purpose of this study was to evaluate the acute effects of static stretching on vertical jumping and the ground reaction force kinetics when stretching was implemented between multiple performance bouts.

METHODS: Data Collection: Fifty-two recreational and varsity athletes from the university population provided informed consent to participate in this study. Subjects consisted of 19 males and 33 females with ages ranging from 19-23 years. The height and mass of the subjects were 1.71±0.09 m and 74.6±16.0 kg, respectively. Subjects were randomly assigned to either a stretch (n=26) or no-stretch (control, n=26) condition and placed in testing groups of five to six individuals. All participants followed a standardized warm-up protocol consisting of sub-maximal cycling for five minutes, using Monark cycle ergometers at 120 W. This was immediately followed by four series of three vertical jumps with a six minute time lapse between each series. 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 (200 Hz sampling rate).

After the initial jump series, the stretch condition subjects completed four static stretches that targeted the gluteal, hamstring, quadriceps, and calf muscle groups. The same protocol was used after subsequent jump series (based on Knudson et al., 2001; Samuel et al., 2008; and Unick et al., 2005) and the no stretch condition subjects were allowed to rest. Each stretch was performed once unilaterally and held for a timed thirty seconds, as described in the National Strength and Conditioning Association guidelines. Adequate stretch was defined as committing to full range of motion at each desired joint until a 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 also monitored during experimental stretching routine. Each unilateral stretch was completed on both sides of the body.

Stretch protocol

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.

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.

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.

Unilateral standing calf stretch: Subjects stood with both hands placed against a wall in front of them (arms outstretched, elbows straight). While keeping left knee slightly bent, the toes of right foot slightly turned inward, subjects were to move right foot back one or two feet and place right heel and foot flat on the floor.

Data Analysis:

Variables and Statistics: Vertical jump height was calculated from the time off the force plate. Peak vertical force was the maximum vertical value prior to take off. Rate of force development was the difference between the first peak vertical force and body weight divided by the time between those two events. Total impulse force was calculated as the total area under the force curve during the eccentric and concentric phases. Each kinetic variable was normalized to body weight. Based on intraclass correlations of jump heights within each series ranging between 0.97 and 0.99, the first jump of each series was used for analysis. All variables were statistically evaluated using a 2X4 (group by jump trial) repeated measures ANOVA. Post-hoc tests for significant main effects were completed with a Bonferroni correction. The alpha level for significance was 0.05.

RESULTS: Mauchly's test of sphericity was significant ($p<0.05$), so Greenhouse-Geisser adjustments were used. There was no significant relationship between gender and time or three-way interaction (trials x gender x group), allowing for consequent analyses to collapsed data across gender. Vertical jump height had a significant main effect for trials ($p < 0.05$) and a significant interaction effect ($p < 0.05$) for trials and group (see Figure 1). The first jump was significantly greater than the second and third jumps, but not greater than the fourth jump. Peak vertical force had a main effect across jump trials, but no interaction effect between trial and group. Neither rate of force development nor impulse force produced any significant results.

Table 2. Kinetic variable results (Mean ±SD) are all relative to body weight. No significant differences or interactions were found. NS and S indicate no stretch and stretch conditions.

	Variable					
	Peak Vertical Force (BW)		Rate of Force Dev. (BW/s)		Total Impulse Force (BW•s)	
Group	NS	S	NS	S	NS	S
Jump 1	2.40 ±0.34	2.37 ±0.29	6.10 ±3.56	5.34 ±2.94	0.28 ±0.07	0.35 ±0.10
Jump 2	2.29 ±0.27	2.37 ±0.36	5.74 ±2.70	5.75 ±3.10	0.29 ±0.08	0.35 ±0.10
Jump 3	2.23 ±0.21	2.32 ±0.34	5.39 ±2.11	5.28 ±2.61	0.29 ±0.08	0.35 ±0.10
Jump 4	2.24 ±0.22	2.29 ±0.34	5.81 ±2.62	5.50 ±2.87	0.29 ±0.08	0.35 ±0.09

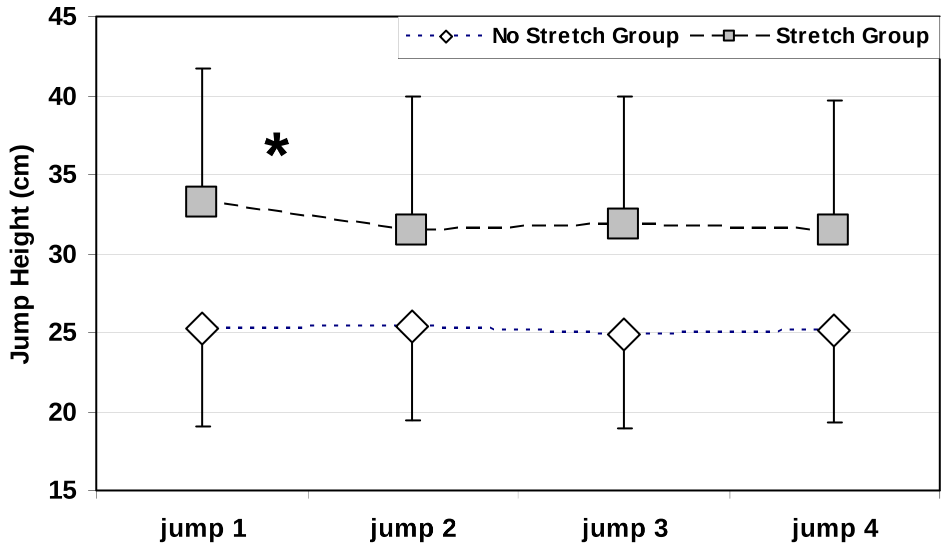

Figure 1. Jump height with SD (cm) across all four trials for each group. The * indicates the significant interaction effect and is evident as the stretch group values fall between jumps one and two. There was also a main effect between jumps as the total mean for the first jump was significantly greater than jumps two and three.

DISCUSSION: The purpose of this study was to determine how acute static stretching would affect vertical jump performance and ground reaction force kinetics when a stretch protocol was implemented between multiple jump bouts. The stretch group jump height significantly decreased ($p<0.05$) between the first and second jump, while the control group did not change. This small, 5.5% decrease was consistent with previous literature, where decreases in performance after stretching ranged from 3% to 24% (Bradley et al., 2007; Brandenburg, 2006; Rubini et al., 2007; Knudson & Noffal, 2005; Young & Elliot, 2001; Nelson et al., 2005). As the vertical jump is often used to reflect somatic power, these results differed from Manoel et al. (2008), who found no muscle power decrement after stretching. The significant interaction between jump and group (see Figure 1) had an effect size of 0.063, which reflects a very small effect. Indeed, the significant impact of stretch between the first and second jumps was not experienced by every subject, as 19 (73%) decreased in jump height, 4 (15%) changed by less than 2%, and 3 (12%) increased in jump height. In the control group, 14 (54%) decreased in jump height, 3 (12%) had little change, and 9 (35%) increased between the first and second jumps. Subsequent jump heights were not different and no cumulative effect of stretch was evident, this differed from Knudson & Noffal (2005), who found somewhat cumulative affects of stretch on strength.

No significant differences were found in the ground reaction force kinetics of the jumps. Normalized values for peak vertical force, rate of force development, and total impulse force were not significantly different across jump bouts or groups. Other studies have found strength or force differences after stretch (Brandenburg, 2008; Nelson et al., 2005; Knudson & Noffal, 2005). However, other studies have not (Young & Elliott, 2001; Samuel et al., 2008). Interestingly, Knudson et al. (2001) found no kinematic differences as a result of stretch. Within the limitations of this heterogeneous subject population and use of primarily ground reaction force data, the impact of pre-performance stretching remains tenuous and elusive, clearly the overall influence on the kinetics and kinematics requires more investigation.

CONCLUSION: Previous recommendations to remove stretch from pre-exercise routines (Brandenburg, 2008) may be considered for between performance stretching in multiple bout events. If stretching is desired, it may be best to complete it immediately after the performance to minimize any potential impacts on performance, especially if the time between bouts is more than a few minutes (Bradley et al., 2007). Stretching as part of the post-performance routine may offer the best benefits for flexibility and performance improvement for some athletes. No cumulative effect of stretch was found for vertical jump heights or ground reaction force kinetics.

REFERENCES:

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.

Brandenburg, J. (2008). Duration of stretch does not influence the degree of force loss following static stretching. *Journal of Sports Medicine and Physical Fitness, 46*, 526-534.

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.

Knudson, D., & Noffal, G. (2005). Time course of stretch-induced isometric strength deficits. *European Journal of Applied Physiology, 94*, 348-351.

Manoel, M., Harris-Love, M., Danoff, J., & Miller, T. (2008). Acute effects of static, dynamic, and proprioceptive neuromuscular facilitation stretching on muscle power in women. *Journal of Strength and Conditioning Research, 22*, 1528-1534.

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

Rubini, E., Costa, A., & Gomes, P. (2007). The effects of stretching on strength performance. *Journal of Sports Medicine, 37*, 213-224.

Samuel, M., Holcomb, W., Guadagnoli, M., Rubley, M., & Wallmann, H. (2008). Acute effects of static and ballistic stretching on measures of strength and power. *Journal of Strength and Conditioning Research, 22*, 1422-1428.

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.

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.

Acknowledgements

The authors would like to recognize the significant efforts of Rebecca Pollock, Anna Mattlage, Ally Eberle, and Benjamin Riebl toward the data collection and processing of this study.