Millersville University

Effects of Flexibility Training on Power

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Abstract

The purpose of this study was to compare static and dynamic stretching techniques to determine their effects on explosive power. In order to investigate the effect of these stretches on an individual's power, a vertical jump test was administered. Prior research has primarily focused on male subjects, so this study included 18 female participants to address this gap in the literature. Each participant completed two jump trials under each condition, with the order of the conditions randomized across participants to control for order effects. Jump height was recorded using a Vertec device, and the highest of the two trials was used as the dependent variable in statistical analysis.

Statistical analysis revealed a significant difference in the jump trial averages between the three conditions (no stretching, static stretching, and dynamic stretching) ($p < 0.05$). Specifically, subjects who performed dynamic stretches showed the highest levels of power output compared to those who did not stretch or performed only static stretches. These findings suggest that incorporating dynamic stretching into pre-exercise routines may lead to improved athletic performance, particularly in activities requiring explosive power. Further research is needed to explore the generalizability of these findings to other populations and forms of exercise.

Introduction

Stretching before exercise is a common routine amongst most athletes. A common component of a warmup routine can include dynamic or static stretching. Stretching is crucial before athletic performance in order to increase body temperature and blood flow, prevent injury, increase range of motion, and decrease muscle stiffness (Park et al., 2018). A typical warmup routine consists of 5 – 10 minutes of aerobic activity like jogging or biking followed by static stretching. Static stretching involves stretching a muscle to its furthest point and holding that position for about 30 seconds (standing calf and quad stretch, butterfly stretch, piriformis stretch). Because static stretching involves little movement of the body and it is completed following warmup aerobic activity, an athlete begins to lose the benefits of the warmup due to a decrease in body temperature.

Studies have begun to shift away from static stretching as a component of an athlete's warm-up routine and highlight dynamic stretching as more beneficial (Baechle et al., 2008). Dynamic stretching consists of taking a muscle through its full range of motion (walking lunges, squats, leg swings). This form of stretching allows an athlete to maintain an elevated body temperature and keep the beneficial effects they gained from aerobic activity during their warm-up. Due to this, it is expected that dynamic stretching does not negatively impact an athlete’s power. Static stretching has been found to lessen an athlete’s power when performing a vertical jump (Church et al., 2001). Previous research has investigated the effects of dynamic vs. static stretching and the effects they have on power, although these studies have primarily looked exclusively at male subjects. A similar study from 2011 conducted exclusively on males found that subjects who completed dynamic stretching as a part of their warm-up had higher vertical jump heights than those who performed static stretching or no stretching (Perrier et al., 2011). This study aims to determine whether static and dynamic stretching after warm-up results in similar findings regarding a vertical jump test in female subjects.

Methodology

Subjects and Procedures

Participants included 18 female NCAA division II university-level track and field athletes (mean ± *SD*; age 20.6 ± 1.42 yr; height 163.12 ± 6.67 cm; mass 56.74 ± 4.92 kg). Prior to participating, all subjects were required to sign an informed consent form and were informed of any potential risks. The subjects reported to the laboratory on four non-consecutive days for a familiarization session and to perform three different trials. The subjects were advised to refrain from exercising 24 hours prior to completing the test. The three trials included non-stretching, static stretching, and dynamic stretching warmup protocols. The order in which subjects completed the three trials and came into the laboratory was randomized for each subject. The general warm-up consisted of 5 minutes of treadmill jogging, starting the treadmill at 4 miles per hour, and increasing the speed by one mile per hour each minute. In the initial visit, subjects were familiarized with the equipment and the vertical jump test protocol. Their individual heights and weights were recorded, and a practice jump was completed. The general warm-up consisted of 5 minutes of treadmill jogging, starting the treadmill at 4 miles per hour, and increasing the speed by one mile per hour each minute.

When completing the no-stretching protocol, subjects were instructed to sit quietly for 15 minutes before performing the vertical jump test. The subjects in the static and dynamic stretching trials then performed their respective stretches with a focus on the primary muscles used to perform a vertical jump (quadriceps, hamstrings, gluteals, and calf muscles).

Static Warm-up

Participants completed the static stretching trial by performing five static stretches, each targeting different muscles used in the vertical jump test. Each stretch was held for thirty seconds for two repetitions, with ten-second rest intervals.

To stretch the quadriceps, the subjects performed a standing quadricep stretch, where they stood and lifted and held their heel to their glutes. The subjects stretched their calves by executing a standing calf stretch. To carry out this stretch, the subjects stood facing a wall and placed their hands against it. They then placed the leg they were stretching about a step behind their other foot and bent their front knee while leaning their body into the wall, keeping their back leg straight and heel on the floor. The subjects then repeated this stretch on the opposite leg. When stretching the hamstrings, the subjects performed a seated hamstring stretch. To do this, subjects were instructed to sit on the floor and extend one leg out in front of them with their back flat and the other leg bent with their foot resting on their mid-thigh. Once in position, the subjects reached both their hands toward their ankle until they felt a stretch in their hamstrings and then repeated this on the opposite leg. To stretch the glutes and lower back, the subjects did a standing knee-to-chest stretch. To complete this stretch, the subjects were instructed to stand upright and lift one leg up and pull that knee to their chest until they felt a stretch. This stretch was then repeated on the opposite leg. The last stretch the subjects executed was a kneeling hip flexor stretch. This stretch required subjects to kneel on one leg with the other bent out in front of them with their foot flat on the floor. Next, the subjects pushed their body forward keeping their back straight and knee behind their toes until they felt a stretch. They then repeated this stretch on the opposing leg.

Dynamic Warm-up

Participants in the dynamic stretching group performed 8 exercises of increasing intensity which included forward lunging while alternating legs, walking knee to chest while alternating legs, squatting, backward running, skipping with arm swings, straight and lateral leg swings, carioca, and gradual accelerations. The following exercises were fulfilled over a distance of 20 meters: forward lunging while alternating legs, walking knee to chest while alternating legs, backward running, skipping with arm swings, carioca, and gradual accelerations. Lateral and straight leg swings were completed against a wall and squatting was done in one spot, with each set being 20 repetitions. This set of exercises was repeated two times.

Vertical Jump Protocol

To measure the subjects' vertical jump ability, the Vertec testing device was used. The Vertec device was adjusted for each subject so that the lowest vane was at the point where the subject's arm was fully extended while both feet were on the ground. Following the end of each warm-up session listed above, the subjects performed two vertical jumps immediately. The subjects were given one minute of rest in between each jump. To execute the jumps, the subjects were instructed to get into a squatting position with their knees bent at a ninety-degree angle and feet shoulder width apart. Once in this position, they held it for one to two seconds before commencing a maximal vertical jump. The subjects positioned their arms behind their torso and used them to thrust upward during the jump to touch the highest vane on the Vertec device. The jump where the subject reached their maximal height (highest vane reached) was recorded for that warm-up protocol. Statistical analysis was used to determine if vertical jump heights varied significantly among the different stretching protocols.

Results

Table 1. Average and standard deviation of each jump trial

Protocol	No Stretching (Inches)	Static Stretching (Inches)	Dynamic Stretching (Inches)
Average	17.55555556	18	18.83333333
STD	2.006525303	2.222875721	2.706202027

Table 1 provides a comprehensive summary of the results obtained from each jump trial, which were utilized to perform statistical analysis to ascertain the model's significance. The protocol where subjects did not stretch resulted in an average jump height of 17.56 inches. The average jump height for static stretching was 18.00 inches, while the average for dynamic stretching was 18.83 inches. To assess whether the differences in the means of the various jump trials were significant or not, a one-way repeated measures ANOVA test was conducted, and the findings are presented in Table 2. The obtained P-value was 9.29643×10^{-5}, which is less than the conventional significance level of 0.05, indicating that there was a significant difference between the average values of the different jump trials. Therefore, the null hypothesis was rejected.

Table 2. One-way repeated measures ANOVA

ANOVA	Column 1	Column 2	Column 3	Column 4	Column 5	Column 6
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	256.092593	17	15.0642702	24.5630551	2.85728E-14	1.93320683
Columns	15.1481481	2	7.57407407	12.3499112	9.29643E-05	3.27589799
Error	20.8518519	34	0.61328976			
Total	292.092593	53				

The determination of significant differences between each group required further analysis through pairwise comparison using t-tests. To set the hypothesized mean difference at zero and maintain an alpha level of 0.05, a Bonferroni correction was utilized to adjust the alpha level for the t-tests. Since the original ANOVA analysis aimed to determine a significant difference among the three groups, the alpha level was divided by three, resulting in a new alpha level of 0.0167. The p-values from the t-tests were then compared to this adjusted alpha level to determine the significance of the relationship between each group.

Table 3. t-Test: Paired Two Sample for Means

Comparison	p-value
No Stretching vs. Static	0.015973
Static vs. Dynamic	0.00688903
No Stretching vs. Dynamic	0.0009777

As shown in Table 3, the p-values for each comparison were all found to be less than the adjusted alpha level of 0.0167. For no stretching vs. static stretching the p-value was 0.016, for static stretching vs. dynamic stretching the p-value was 0.0069, and for no stretching vs. dynamic stretching the p-value was 0.00098. This provides evidence to support the conclusion that there was indeed a significant difference between each comparison. Thus, the results of the pairwise t-tests confirm and strengthen the findings from the ANOVA analysis and support the hypothesis that the jump trials were significantly different from each other. Overall, these results provide valuable insight into the relationship between each jump trial and can be used to inform future research in the field.

Discussion

The present study aimed to investigate the effect of two different stretching protocols, static and dynamic stretching, on the vertical jump performance of 18 female track and field participants. The results indicated a significant difference in the average vertical jump heights among the different stretching protocols. Specifically, the dynamic stretching group demonstrated a higher mean jump height compared to the no stretching and static stretching groups. This finding is consistent with previous research that suggests dynamic stretching may be more effective than static stretching in improving explosive power and jump performance (Behm et al., 2016; Chaouachi et al., 2017). The dynamic stretching group performed a series of eight exercises of increasing intensity, targeting various muscle groups used in the vertical jump test, which may have activated the neuromuscular system and prepared the participants for the explosive movements required during the jump test. In contrast, the static stretching group performed five stretches, each targeting different muscles, which may have lengthened the muscles and decreased their contractile capacity, leading to a decrease in jump performance (Kokkonen et al., 2007). Although static stretching did not result in a higher average jump height compared to dynamic stretching, subjects still performed significantly better than those when they did no stretching at all.

Limitations of this study may have included a small sample size, participant lifestyle factors, and variations in execution of protocols. Firstly, the sample size was relatively small and consisted of only healthy college level female track and field athletes, though this was done purposefully due to prior research leaving this demographic out. Even so, the results of this study may not be generalizable to other populations, such as older adults, or individuals with specific health conditions. This study did not control for factors such as diet and sleep, which may affect jump performance. Additionally, the study did not measure muscle activation or fatigue, which could provide insight into the mechanisms underlying the observed differences in jump performance. Finally, this study used a standardized warm-up protocol for all participants, so there may have been variations in the execution of the stretching exercises, which could have affected the results. Future studies may want to consider using more controlled methods of stretching to minimize variability in the stretching technique across participants.

One possible avenue of investigation could be to further examine the optimal duration and frequency of static and dynamic stretching routines to enhance vertical jump performance. The present study utilized a single session of stretching prior to the jump test, and future research could explore the potential benefits of longer-term stretching interventions. This could involve comparing the effects of shorter versus longer stretching programs on vertical jump performance, as well as examining the effects of different frequencies of stretching. Future studies could also investigate specifically which dynamic stretches are the best when it comes to performing explosive movements. Another area of potential research could be to explore the effects of stretching on vertical jump performance in different populations. For example, the present study focused exclusively on healthy college level female track and field athletes, and future research could investigate the effects of stretching on jump performance in younger athletes, elderly individuals, or individuals with specific medical conditions.

Additionally, future research could investigate the potential benefits of combining static and dynamic stretching protocols to enhance power and jump performance. Previous research has suggested that combining different types of stretching may lead to greater improvements in flexibility and athletic performance compared to single mode stretching (Simic et al., 2013). Lastly, it may also be worthwhile to examine the effects of stretching on other measures of power and athletic performance beyond the vertical jump test. This could involve exploring the effects of stretching on sprinting, agility, and other measures of explosive power. Overall, future research on the effects of static and dynamic stretching on power using a vertical jump test could help to further refine our understanding of the best practices for warm-up routines and athletic performance enhancement.

Conclusion

In conclusion, this study provides evidence that dynamic stretching may be more effective than static stretching in improving vertical jump performance among female track and field athletes. The findings support previous research indicating that dynamic stretching may better prepare the neuromuscular system for explosive movements compared to static stretching. However, limitations such as a small sample size and variations in the execution of protocols suggest caution in generalizing the results. Furthermore, exploring the effects of stretching on other measures of power and athletic performance beyond the vertical jump test could provide a more comprehensive understanding of the benefits of stretching in athletic settings. Overall, this study contributes to the ongoing discussion regarding the role of stretching in athletic warm-up routines and highlights the need for further research in this area.

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