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Effects of Static Stretching on Proprioception and Muscle Power Production

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Effects of Static Stretching on Proprioception and Muscle Power Production

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School of Health and Kinesiology

By

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ABSTRACT

With widespread use of pre-exercise stretching methods in many sports, recent studies have questioned how effective these implications are (Kay, Blazevich 2012, Cramer, J. T., et al.2005, Curry, B. S., Chengkalath, D., Crouch, G. J., Romance, M., & Manns, P. J. 2009). It has been found that certain types of stretching before performance negatively impact muscle power production. However, the reasoning behind why stretching is doing harm to athletes' performances is still unanswered. The purpose of this study is to explore how stretching affects proprioception, and how this in turn affects muscle power production. Using the Biodex 2 dynamometer, passive and active repositioning was used to determine each participant's proprioception in the ankle joint. The accuracy of proprioception was dependent on stretching before and after testing. A Stretching Group (n=7) statically stretched by placing the right foot on an incline board and maximally dorsiflex the ankle joint while keeping the bottom of their foot flush with the board's surface and the knee fully extended. The Control Group (n=5) remained seated for the same amount of time. Straight leg vertical jumps before and after the stretch determine that the stretch created a loss of power in the jump. Results in the *p* value between the stretching and control group were not significant ($p>0.05$). However, effect size between these are significant, mostly falling into medium magnitude. This study provides the explanation that altered joint proprioception due to stretching has an effect of muscle power production.

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CHAPTER 1

INTRODUCTION

Publications have shown the effects of pre-exercise stretching and what it does for the body. The widespread use of stretching and warm-up routines before exercise is the idea that it can decrease the risks of injury. However, recent studies have found that certain methods of stretching can be detrimental to certain sport and exercise performances. Power production of performance is decreased when certain stretches are implemented, this could change many ways in which athletes conduct their warm-up routines. The reason behind what stretching affects that in turn reduces power production is not yet specified in any published works.

Three common methods of stretching are ballistic, proprioceptive neuromuscular facilitation (PNF), and static. The purpose of stretching is to increase the range of motion (ROM) in the body. It is known by researchers and experts that proper pre-exercise warm-up routines will adjust both the risks of injury and the performance itself. Evidence suggest that this pre-exercise stretching can reduce the risk of injury regarding acute muscle strains. Finding the correct pre-exercise routine that includes specific elements that both improve performance and reduce the risk of injury are deemed impossible to determine. (2014. Konrad, Gad, Tilp)

Many publications report that acute passive static muscle stretching causes a reduction in strength, power and speed force productions. With this information, the use of static stretching in warm-up activities is known to negatively impact exercise performances that incorporate strength, power and speed. Since static stretching has an unfavorable impact on these performances, it should be used with discretion. (2012 Kay, Blazevich)

According to a meta-analytical review published in the *Scandinavian Journal of Medicine and Science in Sports,* it is concluded that static stretching before a performance has a significant negative impact on the performance of the athlete. The researchers state that this is completely universal and does not discriminate based on a person's training status, age and gender (Sarabon, Markovic, Simic 2012.). The avoidance of static stretching as the only part of a pre-exercise warm-up is suggested for sports requiring large amounts of muscle power production. (p. 131)

Proprioception is important to any form of movement and imperative to athletes and exercisers during performance. It can be defined in multiple ways. In a systematic review of possibilities published from the *American Society of Neurorehabilitation,* it can be defined as the sense of position and the sense of velocity/movement which is a part of cutaneous receptors and the vestibular and visual senses. Proprioception can also be described as having three compounds; kinesthesia, joint position sense, and sensation of force. Some other publications describe proprioception as having many more components including body segment static position, displacement, velocity, acceleration, and the muscular senses of effort, force or heaviness. With motor control, proprioception is crucial for feedback and feedforward operations of movement that are used along with other or instead of other sensory systems (Hillier, Imminick, Thewlis p. 2).

In clinical scenarios, the degradation of proprioception leads to the need of the individual relying solely on visual senses for feedforward and feedback processes, which causes a loss in the control of movement (Hillier, Imminick, Thewlis p. 2). Not only are these tasks affected when there is a loss of proprioception but also tasks including locomotion and balance, despite constant visual and vestibular input. (p. 2) Typically, loss of proprioception is due to medical circumstances including stroke, age-related falls, peripheral neuropathy and movement disorders (p. 2-3).

Proprioception is difficult to measure. In a study published by *The Journal of Athletic Training,* passive and active repositioning was done using a *Biodex 2 isokinetic dynamometer*. The individuals were in a supine position on the machine with a platform attached at their foot of the leg that was being tested. Certain angles were used for the talocrural joint in plantar flexion for the starting position. Two inversion positions were tested. The leg was secured on the platform and the subjects were blindfolded. The leg was tested both actively and passively. Passively, the foot started in a specific position and moved passively to maximal eversion, the subject was instructed to press a button when the machine brought the foot back to its original test position. For active repositioning, the foot was placed passively in a start position then again moved passively to maximal eversion. The subject then actively moved their foot back to where they believed the start position to be. Like the passive repositioning, the button was also used. The study then examined three types of errors regarding the capability of each subject's joint position sense. These included absolute, exact, and variable error. (Willems et al. 2002.)

To stretch the tricep surae complex, static passive stretching can be used on an inclined platform to effectively stretch this muscle group. In *Acute effects of stretching on the neuromechanical properties of the tricep surae complex,* participants placed their foot on an inclined board in two ways: with the knee straight and completely extended and with the knee bent. When the foot is placed on the board, it should be maximally dorsiflexed. This is done three times for a period of 30 seconds each. The knee is then bent to effectively stretch the soleus, the three times of 30 seconds of stretch is then repeated (Cornwell, Nelson, Sidaway. 2002.).

A hypothesis due to published literature is that certain types of stretching, including static stretching, alters the proprioception in exercisers or athletes during performance. Findings show that bouts of stretching held to the point of discomfort have negative effects on balance. It is hypothesized that detrimental effects on balance and stability are due to the stretch causing impairments on the ability to detect and react to the changes in muscle length and force. This in turn negatively impacts muscle power production in activities like vertical jumping and sprinting.

CHAPTER 2

METHODS

Participants

A total of 17 healthy adults from age 18-28 began this study. The participants were recruited from Georgia Southern University's School of Health and Kinesiology. Exclusion criterion included any lower extremity injuries or restrictions that may inhibit abilities to statically stretch. A set of PAR-Q questions screened participants for eligibility in this study.

Vertical Jump

A straight leg vertical jump was required so only the gastrocnemius soleus complex would be in use. The knees were required to stay locked so muscles of the upper leg would not have an impact on the jump. The jumps were performed on a force plate and a Vertec (Sports Imports Inc. Columbus, OH) was used to determine the jump height. Flight time, height of the jump, and force of the jump was collected. Force of the jump was the difference in the force exerted on the force plates during standing and during the jump. Three maximal jumps were performed by the participant and the highest of these jumps was recorded. Participants performed a single jump and a rapid jump pre- and post- stretch. Single jump was just one jump with the maximum power output the participant could do. Rapid jump was completed by the participant continuously jumping for 3-5 jumps. A difference in jump force after the stretch verified that the stretch had a negative impact on muscle power production for jumping. The jump height was collected as an exclusion criteria. An increase in the jump height would mean that a participant may have used their knees and not followed the straight leg protocol.

Stretch Protocol

A static stretch was performed on an incline board where participants maximally dorsiflexed their ankle joint three times for 30 seconds. Participants were required to keep their knee fully extended and the heel of their foot flush with the board's surface (Cornwell, A., Sidaway, B., Nelson,A. 2002).

Effectiveness of the Stretch

The ROM was measured for each participant prior to static stretch. An increase in ROM was required of each participant before they went to the post stretch testing. This was measured using a weight bearing lunge technique (Konnor, 2012) which is done in a standing position with the heel remaining in contact with the ground. The great toe was 10 cm away from the wall and the knee was kept in line with the great and second toe. The participant allowed two fingers from each hand to be in contact with the wall to maintain balance. The participant was told to lunge forward towards the wall until their knee touched the wall. Once the participant accomplished this, they would be moved away from the wall 1 cm progressively. If the participant could not reach the wall with their knee at 10 cm, the foot would be moved forward 1 cm progressively. The increase of the 1 cm distance pre- and post- static stretch equaled *4.1 of the dorsiflexion ROM to consider the stretch effective. (Konnor, 2012) If this ROM was not reached, the participant would be stretched again for another 3 sets of 30 seconds on the incline board.

Biodex

Passive (PAP) and active ankle proprioception (AAP) was evaluated using the *Biodex 2 dynamometer* and the *Biodex Advantage Software Package* (Biomedical Systems Inc., Shirley, NY.) The ankle joint was used to measure proprioception before and after the static stretching protocol in the gastrocnemius muscle. The participants were placed in a supine position with their knees bent depending on the height and length of the individual's legs. Participants were then blindfolded to avoid visual feedback. The right ankle would be correctly aligned with the axis of dynamometer in a Dorsiflexion/ Plantarflexion attachment.

The neutral position for this study was 90º angle of the ankle joint measured using a goniometer. The three target angle positions from the initial 90º angle are 10º of plantar flexion, 10º of dorsiflexion and a target of the original 90º angle starting from 10º plantar flexion. Each angle was tested twice, both before and after the static stretching protocol. In AAP, the movement speed was set at 45º/s and in PAP the velocity was set at 5º/s. The participant was given a stop button used to stop the movement of the attachment when the participant believed they were at the target angle and to release the machine to begin movement during PAP. Each test for these was given in a randomized order to attempt to avoid a learning effect.

Data Analysis

The difference in the actual angle from the target angle was compared before and after the stretching protocol. A 2-way ANOVA was done to compare the stretching group versus the control group.

Microsoft Excel was used to calculate the mean, standard deviation, standard error of the mean, T-test and the effect size of each position. The sample t-test was used to compare the results between the Stretching Group and Control Group.

CHAPTER 3

RESULTS

Data from 5 participants was excluded from the study due to not executing trials correctly during the force plate jumps. Of the 12 sets of data that was useful, 7 of these were in the Stretch Group (4 women, 3 men, age 21.29 ±1.8 years, height: 171.27±12.52 cm, weight: 70.71±18.04 kg) and 5 were in the Control Group (4 women, 1 man, age: 21.2 ± 0.82 years, height: 166.12 ± 10.72 cm, weight: 61.38 ± 10.83 kg).

Shown in Table 1, the static stretch was shown to be effective because there was a decrease in power in the vertical jump. Mean power output pre-stretch was 3020.97 ± 2216.33 N. Mean power output post-stretch was 2369.68± 1524.47 N. The rapid jumps were excluded from the study due to difficulty for participants to follow the protocol and keep their knee straight during these jumps.

Statistical analysis for AAP and PAP is shown in Table 2. These numbers represent the error of the actual angle compared to the target angle. A negative number in the Mean value indicates a decrease in error from the pre- and post- tests as a positive number represents an increase in error. *P* values for the simple t-test were not significant (p>0.05). The effect size was evaluated using Cohen's d. Four of the six comparisons fall in the medium magnitude of effect size. Two fall into a small magnitude category. (Cohen, J., 1988).

	Stretching Group	Control Group
Pre-	3020.97 ± 2216.23	1434.06 ± 796.66
Post-	2369.68 ± 1524.47	1582.06 ± 876.05

Table 1: Power output (N) in the straight leg jump pre- and post- for the Stretching Group and the Control Group

Position	PAP/AAP	Group	Mean (^{0})	SD (^{0})	SE (^{0})	T-test	Effect size
10^0 Dorsiflexion	Active	Stretch	-0.25	2.86	1.08	0.16	0.41
		Control	-1.90	5.22	2.34		
	Passive	Stretch	0.66	1.93	0.73	0.20	0.36
		Control	-0.26	3.24	1.45		
90^0 Neutral	Active	Stretch	1.61	5.16	1.95	0.45	0.05
		Control	1.87	4.14	1.85		
	Passive	Stretch	0.18	3.19	1.20	0.14	0.45
		Control	-1.24	3.07	1.37		
10^0 Plantarflexion	Active	Stretch	-2.90	7.01	2.65	0.11	0.52
		Control	0.26	4.27	1.91		
	Passive	Stretch	-1.88	5.05	1.91	0.47	0.03
		Control	-2.03	6.40	2.86		

Table 2: Statistical Analysis of Dorsiflexion, Neutral and Plantarflexion positions for PAP and AAP for the Stretch vs. Control groups. The numbers represent the error between actual angle and target angle before and after the stretch or control.

CHAPTER 4

DISCUSSION

Effective Static Stretch

From this research, it has been found that the static stretch method used was effective in reducing muscle power production, supported by previous literature. The force during the maximal straight leg jump decreased when the stretch was implemented. The Control Group increased during their second trial, showing that the static stretch implemented had a significant effect on power output.

Controversial Proprioception Decrease with Stretch

Ankle proprioception can be reported to be affected in some way by static stretch. Slight increases in error were found when comparing the Stretch Group to the Control Group, however, more significant differences would have been ideal for this study. These findings match with the findings of (Torres R. et al. 2012) in which the *p* values alone were not significant enough to confirm the hypothesis. However, *p* values in this research study were closer to the goal (p<0.05) and the effect size was of mostly medium magnitudes. The lack of increases in error during repositioning can be credited to a learning effect.

P values are important in studies because they inform us if a significant effect exists. However, *p* values are limited in explaining how significant of an effect there is. The effect size is described as the magnitude of differences between the groups being compared. Not typically cited in literature, researchers have argued that the effect size is an important piece to quantitative studies that is often overlooked (Sullivan, Fienn, 2012.).

Practical Relevance

This study concluded that static stretch can have adverse effects on performances requiring large amounts of muscle power production, like an explosive straight leg vertical jump exemplified in this study. As previous literature has recommended, it may be beneficial for athletes to avoid statically stretching for periods greater than 60 seconds (Kay, Blazevish, 2012). With some other research, it has been found that periods of even 45 seconds had a detrimental effect on vertical jumping (Young, Elliot, 2000.).

Some studies conclude that static stretch should not be the sole activity of pre-exercise warm up (Simic, Sarabon, Markovic, 2012.). Pre-exercise warm up routines that are generally implemented include low intensity exercise such as a light jog. This is followed by stretching limbs to their maximum ROM to increase ROM before the event-static stretching. Warm up is usually completed by dynamic movements which are specified based on the movements of the sport (Young, Elias, Power, 2006.). Static stretching is typically not the only type of stretch that is incorporated into a single pre-exercise routine. Other stretching methods like proprioceptive neuromuscular facilitation or dynamic stretching can have benefits that static stretching has and might be preferred methods before certain performances (Young, Elliot, 2000.). Important factors must be considered for warm up including any risk of injury involved, ROM, and aspects of healthy and safe sport or physical activity participation (Young, Elias, Power, 2006.).

By specifically studying the effects of static stretching on proprioception and joint position sense, the current research determined whether proprioception is a possible reason why static stretching has a detrimental effect on power output. By taking into account effect size, the significance of the errors was mostly of medium magnitude. Joint position sense helps exercisers and athletes in their performance. Degradation of proprioception can have a negative impact on exercise activities since proprioception affectes how an individual controls their movement.

Limitations and Future Research

This study was structured for minimal limitations; however, some issues are unavoidable. Although participants were randomly assigned each target angle, they became familiar with the *Biodex* and the testing procedure. In the future, this finding should be studied in more depth, as *p* values were not significant. The study could be improved by including more participants in the study and including a trial before the pre-stretch trial for participants to become familiar with how the study works beforehand.

Conclusion

The purpose of this current research was to determine a potential mechanism for why static stretch has a negative impact on power output. The use of static stretching prior to straight leg vertical jump lead to a decrease in power output from what was seen in this study. As far as the degradation of proprioception being a potential mechanism for why static stretch has a negative impact on muscle power production, this is supported by the effect size of our data but not the *P* values. Further research in ankle proprioception and static stretching on the gastrocnemius and soleus is needed.

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