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## LOWER EXTREMITY PERFORMANCE WITH PROPRIOCEPTIVE NEUROMUSCULAR FACILITATION

LEE DE JARLAIS<sup>1</sup>, JENNIFER GONSTEAD<sup>1</sup>, THERESA LYNCH<sup>1</sup>, LAURA MASBRUCH<sup>1</sup>, ROBERT SCHULDT<sup>1</sup>, DAVID ZORN<sup>1</sup>

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### ABSTRACT

**De Jarlais LR, Gonstead JR, Lynch TM, Masbruch LL, Schuldt RC, Zorn DA.** LOWER EXTREMITY PERFORMANCE WITH PROPRIOCEPTIVE NEUROMUSCULAR FACILITATION. *Journal of Undergraduate Kinesiology Research* 2007; 2(2):32-39. This study observed the effectiveness of proprioceptive neuromuscular facilitation stretching or no stretching prior to performance. **Purpose:** To determine if PNF stretching has a positive impact on performance of running economy and one repetition maximum leg press test. **Methods:** The subjects consisted of 16 active college aged students, 8 males and 8 females (mean  $\pm$  SD, age  $20 \pm 1.2$ ; height  $175.5 \pm 8.2$  cm; weight  $70.9 \pm 11.5$  kg; body fat %  $15.7 \pm 8\%$ ). The subjects performed a five minute warm up on a treadmill prior to PNF stretching or their specific test. Each subject performed their specific test twice, either with or without stretching. Each test was held at least 48 hours apart in the presence of at least two test technicians. Each test was performed using the same equipment. **Results:** Subjects in the running economy test showed no significant difference in terms of the 4-min. (M= 23.7mL/kg/min stretching, M= 23mL/kg/min no stretching) and 8-min. (M= 35.3mL/kg/min stretching, M= 36.4mL/kg/min no stretching) intervals. For the subjects in the 1-RM test, there was no significant difference between the stretching and non-stretching trials. **Conclusion:** Our study's results would imply that PNF stretching is more beneficial for long duration running economy yet provides no significant benefit for lower extremity maximal strength.

**Key Words:** Stretching, VO<sub>2</sub> Maximum, 1 Repetition Maximum, Running, Leg Press, Flexibility

## INTRODUCTION

PNF (proprioceptive neuromuscular facilitation) stretching is a mixture of isometric and passive stretching where the muscle is contracted and lengthened. Traditionally stretching was used as part of a warm-up to increase flexibility or pain-free range of motion about a joint in attempt to promote better performance (1). PNF exercises are designed to enhance the response of neuromuscular mechanisms by stimulating proprioceptors (2). Today static is the easiest and most used form of stretching, but PNF stretching characteristically yields greater gains. PNF stretching represents a better flexibility technique while static stretching is still debatable (3). There have been numerous studies that have been done that show the detrimental effects of static stretching on performance with a wide range of subjects. According to a previous study on females and vertical jump showed that overall there was a decrease in jump height (7). Also in another study by Young & Behm that researched jump height and peak force also showed that there was a decrease in performance with a bout of static stretching (8). We found two previous studies on PNF stretching and performance. The first study examined peak torque and mean power output. The subjects performed four lower body PNF stretches before testing and the results showed that there was a significant decrease in peak torque, mean power output and EMG signal amplitude. The second study examined force production and jumping performance with a bout of PNF stretching and a bout of static stretching and the results show no significant difference between the two types of stretching (6). It has been shown that static stretching before performance is detrimental however, PNF stretching has not been studied enough to determine its effects on performance. The purpose of our study was to compare contract-relax forms of PNF with performance tests of 1-RM leg press and running economy with  $\text{VO}_2$  submax. It was hypothesized that PNF stretching will increase performance in both the running economy and leg press tests.

## METHODS

### Subjects

The subjects in both experiments of 1-RM and running economy tests consisted of eight active college students (four male, four female). The age, weight, and height were measured as well as body composition using a skinfold caliper (3 site skinfold). These subjects were selected at random by a flyer that was posted. The subjects have previously participated in a minimum of 30 min a day at moderate intensity for three days per week resistance or aerobic training program for the past three months. For this study, the subjects were not University of Wisconsin-Eau Claire student varsity athletes. The study was approved by the University Human Subjects Institutional Review Board, and all subjects signed a written informed consent before volunteering for the study.

**Table 1.** Descriptive data of the subjects.

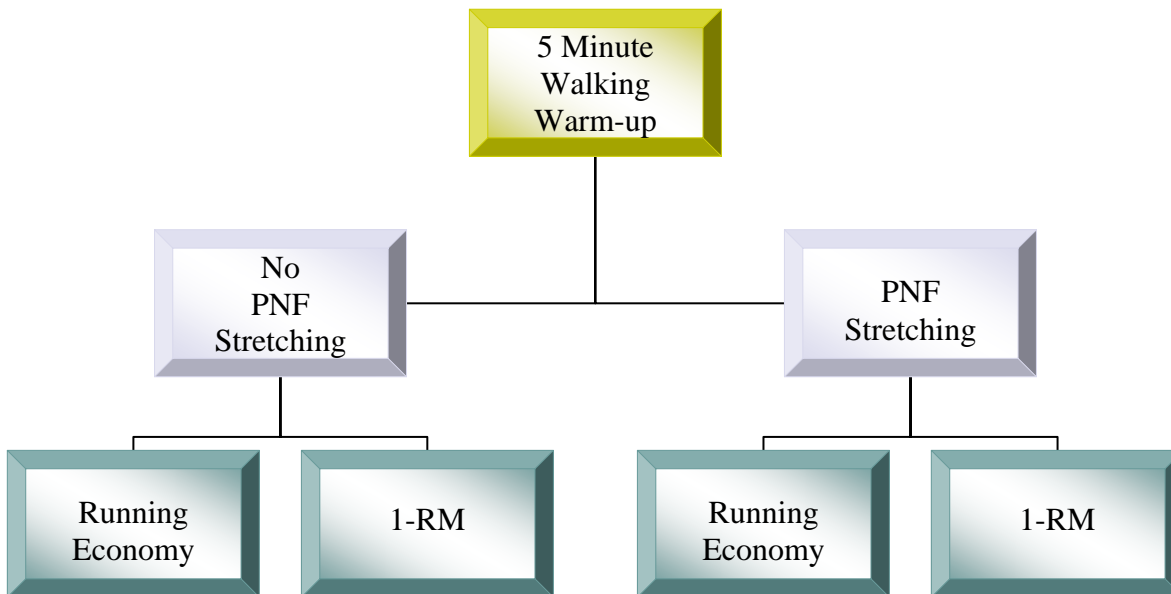
	<b>N</b>	<b>Range</b>	<b>Minimum</b>	<b>Maximum</b>	<b>Mean</b>	<b>SD</b>
Age (yrs)	16	5	18	23	20	1.2
Height (cm)	16	29.2	161.3	190.5	175.5	8.2
Weight (kg)	16	40.9	56.8	97.7	70.9	11.5
% Body Fat	16	23.3	6.1	29.4	15.7	8

### Instrumentation

The instrument that we used for percent body fat was the Lange skinfold caliper manufactured by Beta Technology Inc. (Cambridge, Maryland). The Hammer Strength uni-lateral leg press model # SKU- ILLP manufactured by Life Fitness in Franklin Park, IL was used to determine 1-RM performance test. The treadmill was used for the running economy test was the Trackmaster by JAS model number TMX425CP made in Newton, KS for the running economy test. The instruments used to analyze gas exchange data was the Analyzer Assembly Vmax Encore 229C Metabolic Cart manufactured by Viasys Health Care Company in Palm Springs, California. We used a three liter

Calibration syringe manufactured by Hans Rudolph Inc., in Kansas City, MO in order to calibrate the mass flow sensor. The oxygen and carbon dioxide analyzers were also calibrated prior to each testing session against known gas concentrations.

All of the testing done for running economy was performed in the exercise physiology lab at the university. All students who performed the study followed the proper criteria demonstrated the proper procedures used in the study and were qualified to administer the protocol. The instruments were tested in order to ensure reliability and validity, and were calibrated prior to all testing. The tests yielded a reasonable range of scores based upon the results of our pilot testing.



**Figure 1.** Flow sequence of PNF stretching tests.

### Procedures

Before the test was administered we instructed subjects to come well hydrated and well rested. We requested they come in a "good state of mind," meaning that they come ready and willing to participate in the study. We also required the participants to refrain from alcohol within 24 h of testing, and are currently not ill. They were also instructed to come in proper exercise attire (t-shirts, shorts, running shoes). All of the subjects met twice for about 30 min. at the university's Exercise Physiology lab. The subjects then had their skinfolds taken, performed a five minute walking warm up at moderate intensity of 40-60% heart rate reserve on the treadmill. Finally, the subjects were chosen at random and either performed two bouts of contract-relax PNF stretching on each leg or no stretching at all. After the warm-up and stretching/no stretching, the subjects were broken down into two separate groups. One group performed a 1-RM test in the university weight room and a second group performed a running economy test and the results were recorded.

The contract-relax procedure was administered by having the subjects lie on their back and a passive pre-stretch of the hamstring will be held at a point of mild discomfort for 10 seconds. Next, the subject will extend the hip against the resistance of the partner through the full range of motion. Lastly, the subject relaxed and the passive stretch was applied for 30 s, which was performed twice.



**Figure 2.** Relax Phase of PNF.

**Figure 3.** Contract Phase of PNF.

The Running Economy protocol:

For the running economy protocol, we first turned on the O<sub>2</sub> and CO<sub>2</sub> gas tanks. After the tanks were turned on, we needed to check the relative humidity, temperature, and barometric pressure against our instruments on the wall of the Exercise Physiology Lab. Next we placed a 3L syringe on the platform in front of us on the cart. Then the white flex hose was connected to the clear plastic flow sensor tube that was on the arm of the cart. We then purged two strokes to expel any stored air inside the syringe. Once the computer instructs us, we perform five full strokes (varying in speed) on the syringe. For each of the yellow flow rate bands at least 50% of one stroke needed to be within one of those bands. If a green bar appears after a stroke, it means that stroke was successful in completion of that flow rate. The five strokes are then repeated on a smaller graph to verify that the flow sensor is calibrated correctly.

Once everything is calibrated, a new subject was entered into the computer, making sure we got their correct age, gender, height, and weight. Once all of the subject's information was entered we chose the protocol. We chose a manual protocol for the treadmill test so we could manipulate and control the test. Once the protocol was selected, we attached the mouthpiece to the saliva trap and attached that to the flow sensor, which attaches to the headgear. Once the subject was ready, the headgear was attached to their head, and the mouth piece inserted into their mouth.

For the test, the first minute was a baseline for the subject; the second minute was a warm up. After the warm up, the subject was put through three 4-min stages at 4mph, 5mph, and 6mph. After the test, the subject went into a five minute recovery. For all running economy tests, two testers were present. One of the testers was monitoring the subjects VO<sub>2</sub> and RQ, and would verbally monitor the subject. The second tester was monitoring the subject and was in charge of changing the speed on the treadmill. Once the test and recovery was finished, the results were printed and interpreted.



**Figure 4.** Running Economy Test.



The 1 repetition max test protocol: (1)

The 1-RM started with a warm up of light resistance that allowed subject to perform 5-10 reps easily; after the completion of the warm up a one minute rest period is administered. We then estimated a warm up load that allowed subject to perform 3-5 reps by adding 30-40 lbs with a 2-min rest period afterwards. Again we estimated a near max load that would allow the subject to perform 2-3 reps by adding 30-40 lbs with a 2-4 min rest period. The next load increase was at 30-40 lbs and the subjects attempted a 1-RM. If the subject was successful, a 2-4 min rest period was provided and then an additional 30-40 lbs. was added. If the subject failed to complete 1 repetition with the given weight, we provided a 2-4 rest period and decreased the load by 15-20 lbs and then the subject attempted another 1-RM. We continued to increase or decrease the load until the subject was able to perform a 1-RM with proper technique.



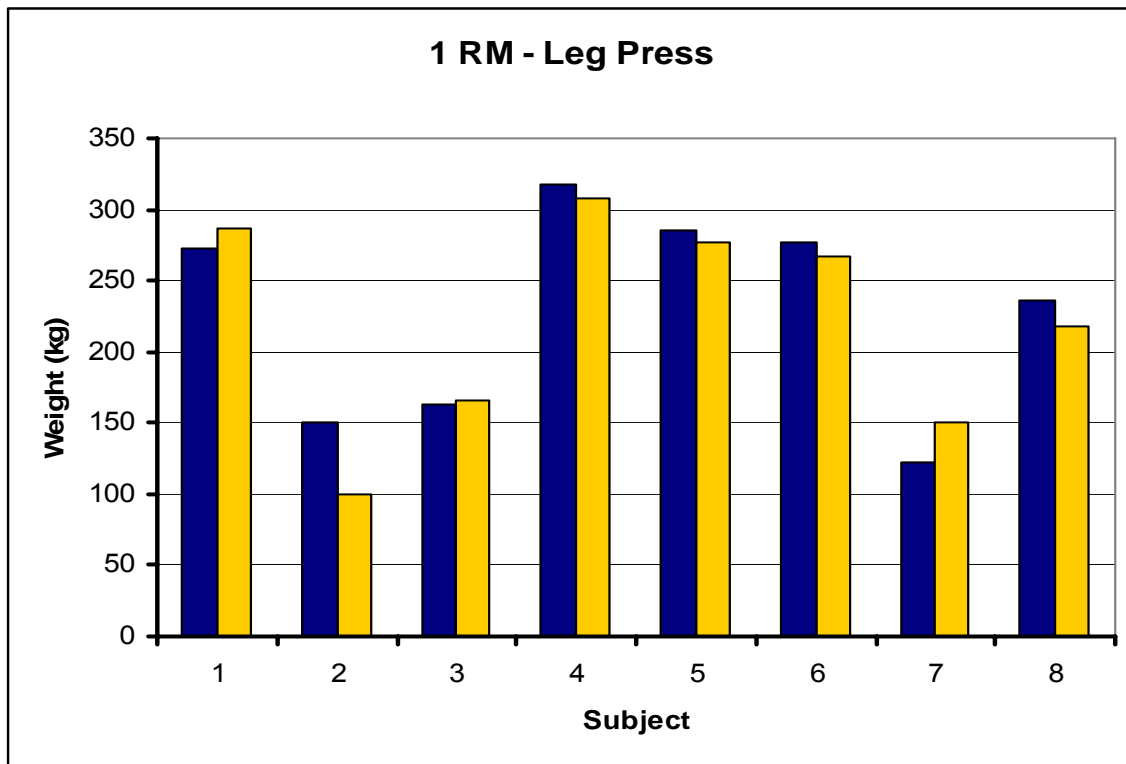
**Figure 5.** Leg Press.

### Statistical Analysis

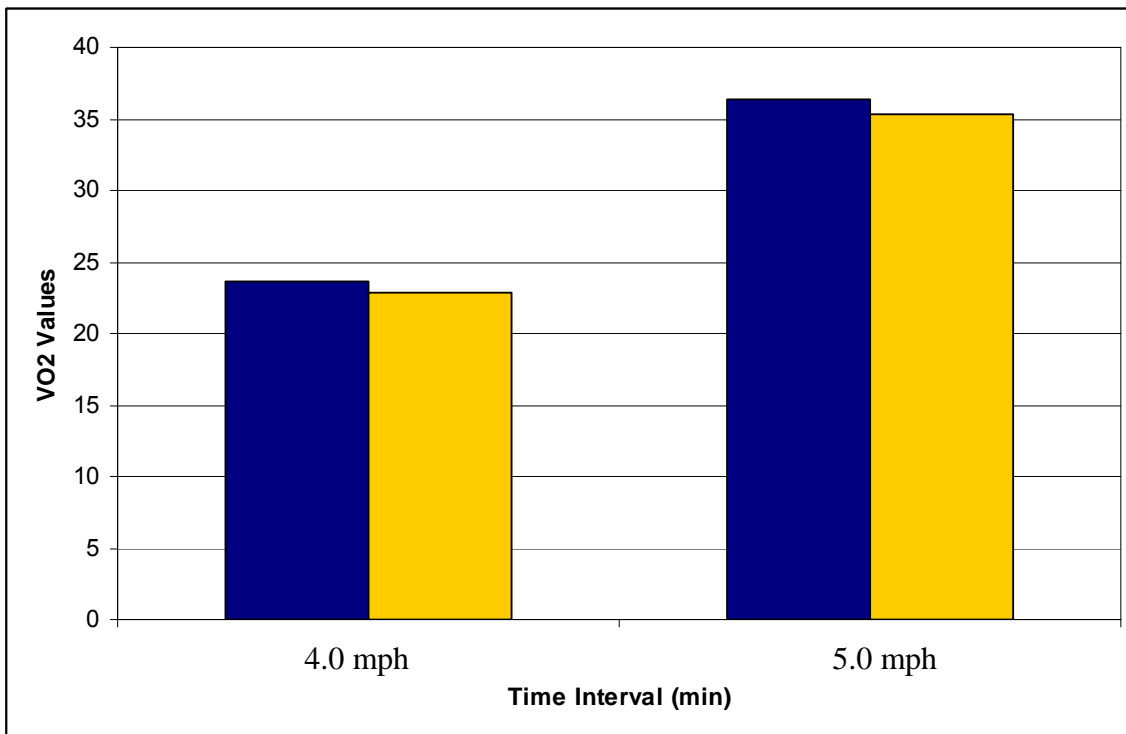
Paired t-tests were used to compare 1-RM leg press tests and running economy max  $\text{VO}_2$  tests between two bouts of exercise with and without PNF stretching (contract relax). The Level of significance was set at  $p \leq 0.05$ . All analysis of results was performed by using SPSS 14.0 for Windows.

### RESULTS

The differences between 1-RM leg press for stretching and not stretching are presented in Figure 1. There was no significant difference in 1-RM testing between the eight subjects in the stretching group ( $M = 228$ ) and the no stretching group ( $M = 221.5$ ),  $t(8) = .808$ ,  $p > 0.05$ . The Participants who performed the 1 rep max test showed no significant difference in weight lifted whether they performed a bout of PNF stretching (contract relax) before lifting or not. Figure 3 shows the differences in running economy at 4 and 8 min with stretching vs. no stretching. Figure 3 also shows no significant difference between stretching ( $M = 23.7 \text{ mL/kg/min}$  at 4 min,  $M = 35.3 \text{ mL/kg/min}$  at 8 min) and no stretching ( $M = 23 \text{ mL/kg/min}$  at 4 min,  $M = 36.4 \text{ mL/kg/min}$  at 8 min).  $t(8) = .75$ ,  $p > .05$  at 4 min,  $t(8) = 1.9$ ,  $p > 0.05$  at 8 min.



**Figure 6.** Blue: Stretching Yellow: No Stretching.



**Figure 7.** Running Economy Test 1: 4.0 minutes 2: 8.0 minutes Blue: Stretching Yellow: No Stretching

## DISCUSSION

After the conclusion of our study we have decided to reject our initial hypothesis that PNF stretching will improve performance in both the 1-RM and running economy tests. The purpose of the present investigations, 1 RM leg press and running economy, was to determine the effect of PNF stretching on performance outcome. The main finding in 1 RM leg press was that there was no significance in stretching or not stretching and neither was found to be beneficial nor detrimental to the outcome of performance. As stated in a previous study done by Marek et al. (decrease of 2.8% in peak torque and 3.2% decrease in mean power with static and PNF stretching), their results were contradictory to ours in that peak torque and mean power output decreased with PNF stretching (9). In another previous study performed by Young & Elliot that compared PNF and static stretching on jumping performance (weighted jump height with static stretching was 35.9 cm and with PNF it was 35 cm) showed that there is no significant difference between the two stretching techniques (10). Comparing our study to Young & Elliot and Marek et al. our results agreed with Young & Elliot in that PNF stretching had no effect on performance while Marek et al. concluded that there was a detrimental effect to performing PNF stretching before performance.

We assumed that all of our college-aged subjects were regularly active based upon our study's criteria. We also assumed that no external factors contributed positively or negatively to the results of the study (drugs, alcohol, caffeine, etc.). According to previous studies it is noted that static stretching of prime mover muscles of a particular skill should not be undertaken prior to any event in which success is related to maximum strength output (5). Even though 1-RM can be reduced by engaging in a thorough bout of acute stretching, our study found that PNF stretching is safe and effective to perform prior to activity because there was no significant difference in maximal strength or running economy.

## CONCLUSION

Overall we found that for 1 RM leg press and the running economy at 4 and 8 minutes with PNF stretching vs. no stretching showed no significant difference in males and females. In the running economy test at 12 minutes it showed that there was significance between stretching and not stretching. Because of our finding of 1 RM these results can suggest that PNF stretching will not help or hinder the individual and can be used as a pre-exercise stretch for the active college age individual, without any drawback in performance. At the 12 minute stage for the running economy test at 6 mph, our statistical analysis of the data showed an increase in  $VO_2$  values, indicating that PNF stretching actually improves  $VO_2$  in long term running economy, which is not economical. However, a steady state was never achieved in this stage; therefore any data that we used for comparison would be invalid. Due to this fact, we chose not to include the third stage of the running economy experiment in our results.

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