# DYNAMIC VERSUS SELF-PROPRIOCEPTIVE NEUROMUSCULAR FACILITATION STRETCHING ON VERTICAL JUMP PERFORMANCE

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Most warm-up routines are performed without the help from coaches or trainers. Warm-up routines often include a stretching component. The purpose of this study was to determine whether self-PNF is comparable to dynamic stretching prior to performing a vertical jump. Twelve participants performed pre- and post-intervention vertical jumps in random order and at least 48 hours apart. Interventions included dynamic stretching, self-PNF and a control. No significant differences ($p > 0.05$) were found between or pre- versus post-intervention for vertical jump height and peak force. However, there was a slight increase in both measures for post-dynamic stretching and a slight decrease post-self-PNF. Coaches should continue to use dynamic stretching and avoid self-PNF, especially prior to an anaerobic-power event.

**KEYWORDS:** self-PNF, warm-up, force, power.

**INTRODUCTION:** It is well known that a warm-up prior to a sporting activity increases athletic performance and reduces the chances of injury. Furthermore, the more power the performance requires, the more important the warm-up (Jefferys, 2021). A general warm-up typically consists of low to moderate aerobic exercise (e.g. jogging, biking or sport specific) and stretching exercises (Park et al., 2018). Stretching could improve the performance of athletic tasks requiring high-intensity short-stretching cycles, due to storing of elastic energy during stretching itself, and to the subsequent release from muscles and tendons during the concentric phase (Cè et al., 2008). However, including static stretching exercises as part of a warm-up routine may decrease muscle strength (Simic, Sarabon & Markovic, 2013). The consensus seems to suggest that dynamic stretching should be favoured over static stretching (Walsh, 2017).
Proprioceptive neuromuscular facilitation (PNF) is another form of stretching that might have an advantage over static stretching because of its neural mechanisms. Surprisingly, little is known about the effects of PNF in a warm-up routine on performance. Of the studies examining PNF stretching on anaerobic performance, there has been conflicting outcomes. Fett et al., (2020) suggested that PNF stretching may improve anaerobic power similar to that of a traditional warm-up. Young & Elliot (2001) found no significant effects of passive PNF stretching on a squat jump test, whereas Bradley et al. (2007) found negative effects on vertical jump height for both static and passive PNF stretching for up to 15 minutes post-stretch. Variations in testing protocols, including the type of PNF may have contributed to these differences.
The goal of this on-going study is to examine the differences in vertical jumps after dynamic and self-PNF stretching. From a practical perspective, most stretching prior to performance is administered by the individual themselves (i.e. active stretching). Self-PNF may have fatiguing effects (Colosio et al., 2020) that would not be seen from passive PNF stretching. It was hypothesized that because PNF is similar to static stretching and the potential fatiguing effects of self-PNF, no improvement compared to a control in vertical jump performance would be seen for this intervention.

**METHODS:** Six female (age: 24 ± 2.8 years; height: 1.70 ± 0.79m; weight 70.0 ± 20.3 kg) and six males (age: 26 ± 7.4 years; height: 1.84 ± 0.61m; weight 90.5 ± 13.8 kg) participated in this study. The testing protocol was explained to each participant and a consent form approved by the institutional review board where the study was conducted was signed. For inclusion, participants had to be injury free for at least three months and be familiar with vertical jumping and stretching exercises. There were three testing sessions (control, proprioceptive

neuromuscular facilitation (PNF) and dynamic) for each participant (repeated-measures design) in randomized order that were spaced a minimum of 48 hours apart.
The warm-up for all testing sessions included a four-minute walk/jog on a treadmill starting at 5.6 kph (3.5 mph) and increasing by 0.16 kph (0.1 mph) each 15 seconds at a constant slope of 2%. Approximately 10 minutes were allocated as rest to allow for 30 joint markers to be placed at the level of the joint centres of the lower body (Leardini et al., 2007). An additional marker was placed at the tip of the longest finger to measure vertical jump height. Ground reaction forces were measured at a rate of 1000 Hz for each foot separately with two force plates (Bertec™, FP6090-15-TM-4000). Joint marker positions were captured at 250 Hz using a 20-camera (OptiTrack™ Prime 17W) system and Motive™ (Optitrack™ version 3.0.3) was the motion capture system used to synchronize and record the data.
For all three testing sessions, an initial set of three vertical jumps were performed after the markers were placed on the body. Instructions to the participants were to keep their feet stationary on the force plates prior to take-off, perform a counter-movement with their own preferred style of arm swinging and jump as high as possible. One-minute rest between jumps was given.
The dynamic stretching intervention included four exercises that targeted the major muscles of the lower body and included quadriceps swings, standing lunges for the gastrocnemius muscle, hamstring swings, and standing lunges with a dorsi-flexed foot for the soleus muscle (Alter, 2004). Each exercise was performed twice at a rate of 30 beats per minute (using a metronome) for 30 seconds and a 10 second rest between each. The self-PNF stretching intervention included four stretches that mimicked that of the dynamic intervention in terms of time and target muscles (Alter, 2004). Participants were asked to initially (static) stretch the target muscle for 10 seconds, followed by an isometric contraction of that muscle for 10 seconds at an effort of 7-8/10 (or moderately hard) and then a (static) stretch for an additional 10 seconds, totalling 30 seconds. The control intervention included participants sitting for 10 minutes (the approximate time the two stretching interventions took). Immediately following each intervention, an additional three vertical jumps were performed using the same protocol as the initial set of jumps.
Visual3D (C-Motion™) was used for all data processing. For all sets of three jumps, the highest jump was chosen for analysis and right and left leg data was averaged. A repeated-measures analysis of variance (with a Greenhouse-Geisser correction) was used to determine whether there were any significant differences in the height jumped and peak force across the three interventions for both the pre- and post-intervention jumps. Post-hoc analysis was performed using the Bonferroni test. Alpha for all testing was set at 0.05.

**RESULTS:** A slight but negligible increase of approximately 0.7 cm for the control group was seen between pre- and post-jumps (Figure 1). The dynamic intervention had the greatest improvement with over one centimetre increase in vertical jump height. The PNF intervention resulted in an average decrease in vertical jump height of over one centimetre. No significant differences were observed across the jump heights, $F(3.2,55)=2.89$, $p=0.39$. Partial Eta square was 0.14, indicating a small effect size.
Average peak force (Figure 2) for both legs yielded similar results to that of average vertical jump heights. However, one surprising outcome was the larger average peak force seen in the pre-intervention jump for the control compared to its post-intervention (by approximately 2 N/kg). This was the reciprocal to the vertical jump heights measured pre- versus post-intervention for the control group. The dynamic intervention yielded a negligible increase in average peak vertical force whereas the PNF intervention resulted in a decrease of approximately 1 N/kg). No significant difference between pre- and post- and between interventions were found for this measure, $F(2.1,17.1)=0.99$, $p=0.40$. Partial Eta square showed a small effect size (0.11).

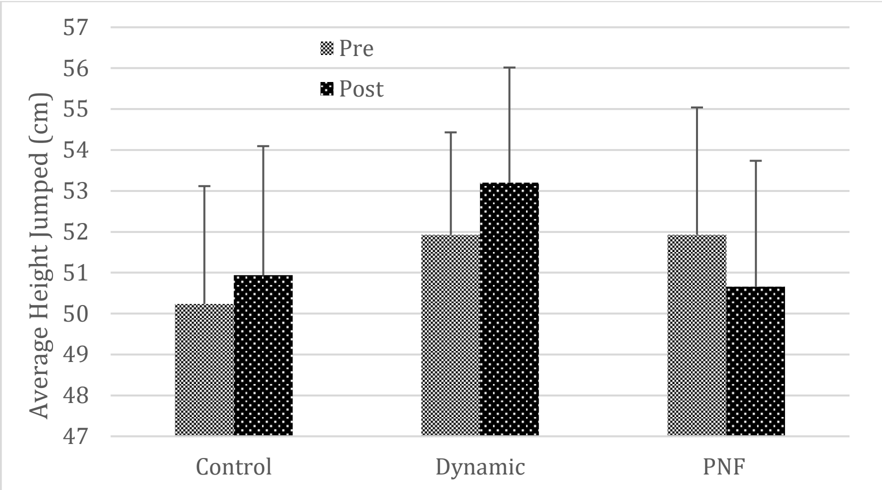


**Figure 1: Average peak vertical jump heights (cm) for the three interventions.**

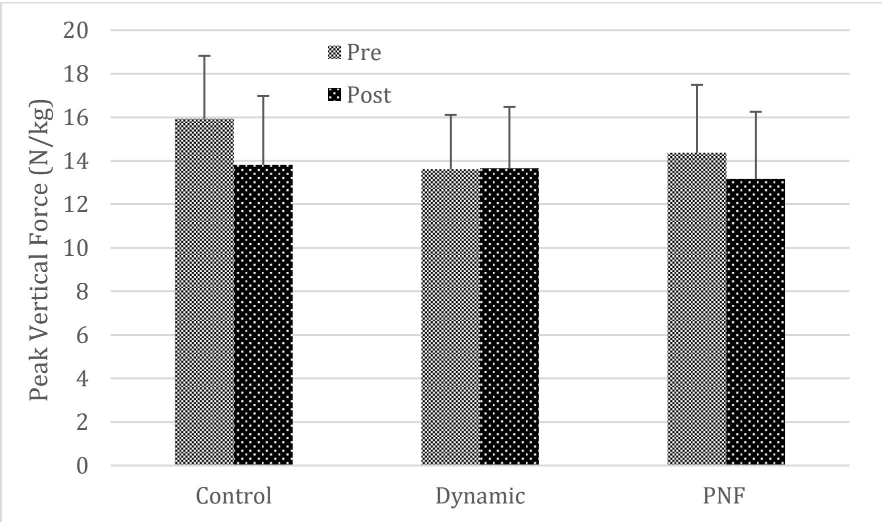


**Figure 2: Average peak vertical force normalized to body weight for the three interventions.**

**DISCUSSION:** Vertical jump height decreased by approximately 2.5% and peak force production decreased by approximately 9% after self-PNF stretching. This negative (although not significant) outcome coincides with studies using passive PNF stretching (e.g. Bradley et al., 2007). PNF reduces stiffness in the musculotendinous unit, reducing the ability to store and release elastic energy which may explain the negative outcomes found. In contrast, other studies (Young & Elliot, 2001; Fett et al., 2020) found no detriments of PNF stretching on anaerobic power. Reasons for contradictory findings could be due to the type of PNF stretching utilized, the length of each component of the PNF stretch and the protocols for the actual jump performance. There are different forms of PNF stretching such as hold-relax, contract-relax-contract and many more (Alter, 2004) and the length of that each component can be altered. This study also allowed for arm-swing during the vertical jump performance whereas other studies isolated the jump to only the use of the trunk and legs. One of the primary differences in this study was the use of self-PNF. In most cases, individuals perform a warm-up routine on their own, and any stretching that may be included could introduce a fatiguing effect (Colosio et al., 2020).

The dynamic stretching intervention improved vertical jump height by nearly 6% but the peak force production by only 1%. The improvement in vertical jump height after dynamic exercise is similar with other studies (e.g. Bradley et al., 2007). In all cases, there were improvements from the dynamic stretching, but not significantly greater than that found from a control or static stretching intervention.

One surprising outcome was seen in the control where participants sat for 10 minutes after performing the initial three vertical jumps. There was a negligible (1.4%) improvement in vertical jump height after the 10-minute rest period but a 14% decrease in average peak force produced. This discrepancy along with that from the dynamic stretch intervention suggests that peak force production may not be the best measure for vertical jump performance and perhaps other kinetic indicators such as impulse or rate of force development may be required.

**CONCLUSION:** The goal of a warm-up is to reduce the chance of injuries and improve performance prior to performing exercise. Stretching is often incorporated into a warm-up routine. This study examined the potential of including a self-PNF stretching protocol within a warm-up. Although there was no significant change pre- versus post-stretching for either self-PNF nor dynamic stretching, there was a decline in vertical jump performance for self-PNF that was not seen for dynamic stretching. Based on this outcome, coaches should avoid self-PNF stretching in a warm-up, especially prior to an anaerobic power exercise.

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