ABSTRACT
The aim of this study was to determine the effects of static stretching (SS) and myofascial release (MFR) on anaerobic power. Cycling (30-sec Wingate) tests assessed power output in 9 male and 14 female study participants. Peak power output (PPO) and percent power drop (PPD) were examined among study participants to determine the differences between interventions. In female study participants, PPO was significantly reduced following SS, compared to control. PPD was significantly decreased with SS and MFR treatments compared to the control trial. In male study participants, PPO significantly increased following SS, in comparison to control. PPD significantly increased in MFR compared to the control trial. The effects of MFR on anaerobic power output remain inconclusive. Due to limited research, the possible mechanisms can only be speculated, including the alteration of the length-tension relationship from massage causing decreased muscle strength along with differences in muscle mass of the lower extremities between genders.

Key Indexing Term: warm-up, Wingate, gender differences, massage

Introduction
Studying the effects of pre-exercise strategies used to enhance muscular performance has remained a major focus in sports physiology and fitness research. The overall effects of one strategy, static stretching (SS), has been examined extensively in research. This particular warm-up technique has produced varied results according to recent literature reviews (Behm and Chaouachi, 2011; Kay and Blazevich, 2012; Simic et al., 2013). The general consensus from these reviews was that the more detrimental effects of SS were volume related (total duration the stretch is held) versus the intensity of the stretch. However, because of the association of SS to decreases in exercise performance, the overall conclusion was to avoid pre-exercise stretching as a precaution.

The influence of SS and other warm-up methods on performance variables such as muscular strength and power anaerobic power output has garnered the majority of interest in recent studies (Arroyo-Morales et al., 2008; Arroyo-Morales et al., 2009; Brandenburg et al., 2007; Ce et al., 2008; Jagoes et al., 2008; La Torre et al., 2010; Manoel et al., 2008;
Perrier et al., 2011; Ramierz et al., 2007; Samuel et al., 2008; Signorelli et al., 2008; Taylor et al., 2009).

Using countermovement vertical jump ability, Brandenburg et al. (2007) concluded that jumping ability was reduced with pre-exercise SS in comparison to no activity. Samuel et al. (2008) found similar effects of SS on their study participants and recommended other forms of pre-exercise activities to avoid decreasing lower-extremity power. Needham et al. (2009) found that dynamic stretching was more effective than SS in increasing anaerobic power performance (i.e. vertical jump trial and 20 meter sprint time). Jaggers et al. (2008) demonstrated an increase in jumping power in study participants following a dynamic stretching routine compared to more ballistic type stretching. Taylor et al. (2009) compared the effects of a SS to dynamic warm-up on vertical jump and sprinting ability. Interestingly, to determine if the detrimental effects of SS could be abolished, both conditions were followed by a high-intensity, sport-specific and skill based warm-up. The researchers concluded that if athletes were to follow a SS routine prior to competitive play that they also engage in a sport-specific warm-up following the stretching program to negate any effects of stretching activity. Manoel et al. (2008) compared the effects of two different types of flexibility training strategies (proprioceptive neuromuscular facilitation (PNF) and SS) to dynamic stretching on muscle power in women. The data from this study showed greater improvements in isokinetic power following dynamic stretching compared to both static and PNF stretching.

Despite the abundance of information showing SS decreases power output, these conclusions have not been widely applied to the field of sport performance as SS is often recommended as a universal warm-up method. One alternative procedure that is growing in popularity in the sport and fitness field as a pre- and post-exercise modality is myofascial release (MFR). The MFR technique was first developed and practiced by Ida Rolf (Remvig et al., 2008). Myofascial release is a therapist or self administered muscle manipulation technique that stimulates both muscle and fascia surrounding the muscle (Sefton, 2004). Fascia is a dense connective tissue that surrounds and pervades muscle and other tissues and contains mechanoreceptors, proprioceptors, and blood vessels (Remvig et al., 2008). The physical application of this technique is proposed to stimulate neuroreceptors and these receptors in the fascia proper elicit soft tissue and neural reflex modifications when repeated over time (Remvig et al. 2008).

Other physiological effects of MFR are not fully understood, although many theories exist (Paolini, 2009; Weerapong et al., 2005). One theory proposed by Curran et al. (2008) stated that the manipulation of fascia triggers a myotatic stretch reflex. In addition to mechanical changes that occur in the fascial structure, enhancement of the stretch reflex may lead to an increase in anaerobic power. Myofascial release may also increase the range of motion within a joint, helping to correct functional imbalances within muscles surrounding a given joint, and increase the extensibility of the musculotendinous junction to improve performance (Clark and Russel, n.d). Furthermore, MFR may increase alpha-motor neuron activity and output without altering the length-tension relationship that exists within the muscle. In comparison, following SS, musculotendinous stiffness within the muscle and alpha-motor neuron activity are both negatively altered to a point; thus, decreasing the ability of the muscle to generate power.

Two types of MFR techniques currently exist: therapeutically applied release and self administered MFR (Mathew et al., 2008; Paolini, 2009). Therapeutically applied MFR involves a trained therapist who manually manipulates the patient’s fascia by exerting pressure using their hands or other devices. This pressure can vary greatly depending on the therapist and patient. In contrast, the self administered MFR involves an individual who utilizes their own bodyweight against an object (e.g. foam roller) to apply pressure to the soft tissue and fascia.

Limited research exists demonstrating the effects of MFR on neuromuscular performance or other physiological variables prior to or after exercise. Arroyo-Morales et al. (2008b) evaluated the effects of therapist administered myofascial release (TAMR) on neuromuscular recruitment, heart rate variability...
Effects of Self Myofascial Release and Static Stretching on Anaerobic Power Output

(HRV), and diastolic blood pressure (DBP) after high intensity exercise. A Wingate anaerobic power test was performed following either a TAMR intervention or a placebo treatment. The researchers found TAMR helped return HRV to pre-exercise levels and improve DBP recovery. In addition, it was suggested that TAMR may induce a temporary change in the muscle fiber tension-length relationship contrary to other theories. However, the effects of TAMR were measured post-exercise; therefore, it is unknown if MFR before exercise benefits power output. It is important that more research be conducted to investigate the effects of a MFR intervention, either therapist administered or self applied prior to exercise. Additionally, this technique should be compared to multiple pre-exercise interventions (i.e. SS, PNF stretching, dynamic warm-up, ballistic stretching, etc.) should be examined for their effect on power output.

Currently, no evidence exists in the research literature comparing the outcomes of SS and MFR prior to exercise on anaerobic power output. From an evidence-based practice standpoint, virtually little is known regarding the application and effectiveness of MFR as a valuable warm-up technique prior to exercise performance. Therefore, this study aimed to determine the effects of pre-exercise SS and MFR on anaerobic power performance in young adult using the Wingate anaerobic power test. It was hypothesized that absolute and relative peak power output (PPO), average power output (APO), and minimum power output (MPO) would decrease following SS and increase following MFR compared to control (no intervention). It was also hypothesized that percent power drop (PPD) would increase following SS and decrease following MFR compared to control.

Methods

Study participants

The study population consisted of 23 (nine males and 14 females), healthy young adults (Ht: 172.47±9.38 cm, Wt: 70.98±12.40 kg, Age: 19-23 years). Table 1 presents the overall study participants characteristics. Participants were recruited by word of mouth on the university campus and all participants voluntarily consented to be involved in this study. Exclusionary criteria consisted of recent musculoskeletal injuries (within 6 months) and high risk stratification according to the American College of Sports Medicine guidelines for exercise testing (ACSM, 2010). Study participants were instructed to refrain from alcohol, caffeine, creatine and vigorous exercise 24 hours before testing. This information was obtained in a 24-hour food log. In addition, self reported activity level questionnaire, PAR-Q and health history questionnaire were completed. The research study design and its potential risks/benefits were fully explained to each participant before

<table>
<thead>
<tr>
<th></th>
<th>Total (N = 23)</th>
<th>Females (n = 14)</th>
<th>Males (n = 9)</th>
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</thead>
<tbody>
<tr>
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<td>20.4 (1.6)</td>
<td>20.2 (0.9)</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>174.5 (9.4)</td>
<td>166.1 (5.2)</td>
<td>182.3 (4.3)</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>70.9 (12.4)</td>
<td>63.5 (4.8)</td>
<td>82.6 (11.7)</td>
</tr>
<tr>
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<td>5.1 (0.4)</td>
<td>6.6 (0.9)</td>
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</tbody>
</table>
providing written informed consent according to the guidelines of the university’s Institutional Review Board.

**Baseline Testing and Instrumentation**

A Monark 894E Peak Bike (Varburg, Sweden) and Anaerobic Test Software (v 1.0) were used to measure anaerobic power. Body mass was measured to the nearest 0.1 kg using a digital weighing scale (Seca 220, Hamburg, Germany) and height was measured to the nearest 0.1 cm using a standing stadiometer (Seca, Hamburg, Germany). Study participants completed a 30-sec Wingate anaerobic power test with numerical analysis coming from the Anaerobic Test Software. The variables measured included PPD plus absolute and relative PPO, APO, and MPO.

**Experimental Design and Procedures**

**Overview**

Participants were instructed to arrive at the testing site normally hydrated and having consumed a small meal two hours prior to testing. A single blinded, randomized cross-over design was employed in which the study participants performed Wingate anaerobic power tests following three, pre-exercise conditions: control, SS, and MFR. The researchers who conducted all anaerobic power tests were blinded to the pre-exercise condition. One week exactly separated each trial through the duration of the study. Trials were performed at the same time of day to promote consistency of measurement. Each participant first completed a control trial with no intervention employed prior to anaerobic power testing. Following this trial, the participants were randomized to complete either: 1) SS followed by a MFR trial or 2) MFR followed by a SS trial. Each intervention was designed to utilize the same seven muscle groups in this specific order: quadriceps, hamstrings, IT band, adductors, gluteus, hip flexors, and calf muscles. Refer to Figures 1 and 2 for visual depictions of each SS and MFR exercise.

**Wingate Testing Procedures and Control Trial Day**

On the initial day of testing, study participants were asked to sign an informed consent and complete a PAR-Q, 24 hour food log, health history questionnaire, and lifestyle evaluation form. Following discussion of possible risks involved with the experimental procedures, height and weight were measured. The participants’ food logs were reviewed to determine if any exclusionary criteria were present prior to testing.

Next, the Monark cycle ergometer seat was appropriately fitted to the individual. Fitting was done by adjusting seat height to ensure 5-100 knee flexion at the leg when the pedal was in the down position. Handle bar position was based on participant preference to maintain a comfortable, upright position on the bike. In consistency with the Wingate anaerobic power test protocol, the study participants performed a 5-min self-paced warm-up set at a resistance equal to 2% of body weight. At minute 1:30, 3:00, and 4:30 of the warm-up, study participants sprinted for intervals lasting five seconds. Following this period, resistance was removed from the flywheel and the participant rested briefly while the testing resistance was loaded. For each test, the resistance was set at 8% of each participant’s total body weight. To begin the test, each participant was instructed to pedal at their volitional maximum revolutions per minute. When this point was reached, the flywheel was loaded and the participant began to pedal against resistance for the duration of the test. In order to elicit consistency in effort, all participants were given verbal encouragement during the duration of the test. After completion of the exercise trial, resistance was removed and the participant was instructed to continue pedaling for a 5-min cool down period.

The Wingate testing software provided calculated values for all variables, which were reported immediately following each test. Data points were generated every second during the duration of the test. Absolute power output variables were measured in Watts (W) and relative power output variables were measured as W per kg of body weight (W/kg). The PPO was calculated by averaging power output values over the first five seconds of the test. The MPO was calculated by averaging power output values calculated across the full duration of
Figure 1: Static stretching exercises.

- Gastrocnemius
- Hip Flexors
- Piriformis
- Illiotibial (IT) Band
- Quadriceps
- Adductors

Figure 2: Myofascial release exercises.

- Gluteus Maximus
- Quadriceps
- Hip Flexors
- Hamstrings
- Gastrocnemius
- Adductors
- Illiotibial (IT) Band
the test. Finally, PPD was calculated by dividing the difference between absolute PPO and MPO by absolute PPO. This value was reported as a percentage (%) and represented the percentage of power lost over the course of the 30-sec power test.

**Intervention Trials**

Study participants were familiarized with all SS and MFR exercise during a 20-min session following all testing on the control trial day. During the intervention trials, study participants were closely monitored and critiqued to ensure proper technique of each exercise. The duration of the SS or MFR exercises was timed by a researcher for consistency purposes. Each exercise repetition was performed for 30 seconds and was repeated three times for each muscle group. A five second rest period was allowed between repetitions. The total time to complete each SS and MFR protocol was matched at 20 minutes in order to keep volume consistent.

For the SS exercises, study participants were instructed to slowly move into the stretch position and hold to the point of mild discomfort for the full 30 seconds. For the MFR exercises, participants were instructed to roll against a 92 x 15 cm, high density foam roller (Aeromat, San Jose, CA) over the entire length of the muscle. The pressure provided during MFR was specific to the bodyweight of the individual. The timing of each repetition began when the participant was in proper position for each MFR exercise.

Following each exercise intervention, the participant performed an anaerobic power test according to the procedures for the control trial. The anaerobic power test began within 30 seconds of the completion of the last exercise in each intervention.

**Statistical Analyses**

Descriptive statistics were used to determine means and standard deviations for subject characteristics. Comparisons among the control, MFR and SS trials for each dependent variable (PPD and absolute and relative PPO, APO, and MPO) were made using a one-way repeated measures analysis of variance (RMANOVA) with the intervention as the independent variable. If the RMANOVA revealed a significant F-ratio, a Tukey’s HSD post-hoc test was used to determine which groups were significantly different. Alpha level was set at p < .05 to determine statistical significance. Data were analyzed using SPSS version 19.0 (IBM-SPSS Corporation, USA).

**Results**

All of the study participants originally recruited and selected to be in the current study completed all trials. Adverse effects to testing included two study participants with some minor dizziness after completion of a single Wingate test. Otherwise, the majority of participants tolerated the anaerobic power testing and intervention exercises without any complaints.

Table 2 presents mean values for all anaerobic power variables for the total group, male participants, and female participants. When analyzing anaerobic power within the full sample population (N = 23), no significant (p > .05) differences in PPD and relative and absolute PPO, APO, and MPO were found among the trial conditions. When the participants were grouped by gender, differences were revealed between each intervention and the control trial on the anaerobic power variables specific to gender. Figure 3 illustrates the absolute PPO in female participants among the control group, SS, and MFR treatments. Absolute PPO was significantly (p < .05) reduced following SS in comparison to control (control: 536.9 ± 69.1 W; SS: 508.3 ± 67.1 W). Figure 4 shows absolute PPO in male participants for the control group, SS, and MFR treatments. Absolute PPO was significantly (p < .05) increased following SS and MFR in comparison to control (control 850.6 ± 165.4 W; SS: 881.1 ± 169.3 W; MFR: 891.1 ± 202.4). In contrast, absolute PPO was not significantly (p > .05) affected following MFR compared to the control trial in women (see Figure 3). Relative PPO, absolute and relative MPO, and absolute and relative APO were not significantly (p > .05) altered by either treatment modality compared to the control trial in both men and women.

Figures 5 and 6 present the PPD values for both men and women following the control condition and SS and MFR interventions. Recall that PPD
Table 2. Anaerobic power output values for control, SS, and MFR intervention trials for the total group (N = 23), female participants (n = 14), and male participants (n = 9). Absolute power output values are represented in Watts (W) and relative values are represented in Watts per kg of body weight (W/kg). All values are reported as means (SD).

<table>
<thead>
<tr>
<th>Variable</th>
<th>Total</th>
<th>Female</th>
<th>Male</th>
<th>Total</th>
<th>Female</th>
<th>Male</th>
<th>Total</th>
<th>Female</th>
<th>Male</th>
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<tbody>
<tr>
<td>PPO (W)</td>
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<td>536.9</td>
<td>850.6</td>
<td>654.2</td>
<td>508.3*</td>
<td>881.1*</td>
<td>669.1</td>
<td>526.3</td>
<td>891.1*</td>
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<td>(169.3)</td>
<td>(225.5)</td>
<td>(69.3)</td>
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<tr>
<td>PPO (W/kg)</td>
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<td>10.3</td>
<td>9.0</td>
<td>8.0</td>
<td>10.5</td>
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<td>(0.95)</td>
<td>(1.6)</td>
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<td>(0.96)</td>
<td>(1.6)</td>
<td>(1.0)</td>
<td>(1.3)</td>
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<tr>
<td>APO (W)</td>
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<td>645.5</td>
<td>492.8</td>
<td>391.3</td>
<td>650.6</td>
<td>499.5</td>
<td>399.6</td>
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<td>(152.1)</td>
<td>(48.4)</td>
<td>(126.5)</td>
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<td>(50.1)</td>
<td>(106.4)</td>
<td>(156.9)</td>
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<td>(135.9)</td>
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<tr>
<td>APO (W/kg)</td>
<td>6.8</td>
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<td>7.8</td>
<td>6.8</td>
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<tr>
<td></td>
<td>(1.03)</td>
<td>(0.54)</td>
<td>(0.82)</td>
<td>(1.0)</td>
<td>(0.65)</td>
<td>(0.34)</td>
<td>(1.1)</td>
<td>(0.68)</td>
<td>(0.75)</td>
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<td>MPO (W)</td>
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<td>288.8</td>
<td>468.5</td>
<td>366.5</td>
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<td>467.3</td>
<td>363.5</td>
<td>306.7</td>
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<td>MPO (W/kg)</td>
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<td>5.1</td>
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<tr>
<td></td>
<td>(0.89)</td>
<td>(0.68)</td>
<td>(0.75)</td>
<td>(0.71)</td>
<td>(0.58)</td>
<td>(0.55)</td>
<td>(0.78)</td>
<td>(0.58)</td>
<td>(0.91)</td>
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<tr>
<td>PPD (%)</td>
<td>44.8</td>
<td>44.9</td>
<td>44.7</td>
<td>42.5</td>
<td>40.6*</td>
<td>45.8</td>
<td>44.4</td>
<td>41.5*</td>
<td>48.9*</td>
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<tr>
<td></td>
<td>(6.2)</td>
<td>(5.3)</td>
<td>(7.7)</td>
<td>(7.8)</td>
<td>(6.7)</td>
<td>(8.7)</td>
<td>(7.7)</td>
<td>(6.0)</td>
<td>(8.3)</td>
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*Intervention (SS or MFR) trial significantly (p < .05) different than control trial

represents the overall percent change in power output from the start to the finish of the anaerobic power test. A higher value would reveal an increase in fatigue and more rapid decline in power output during the Wingate test. Figure 5 demonstrates that PPD in female participants was significantly (p < .05) decreased after the SS and MFR treatments compared to the control (control: 44.9 ± 5.3%; SS: 40.6 ± 6.7%; MFR: 41.5 ± 6.0%), but similar between SS and MFR. Thus, women improved their ability to maintain power output during anaerobic testing following both interventions. In comparison, Figure 6 shows that PPD in males was significantly (p < .05) increased following MFR compared to the control trial (control: 44.7 ± 7.7; MFR: 48.9 ± 8.3%). Consequently, anaerobic power output dropped at a faster rate over the course of the 30-sec Wingate test compared to control.

**Discussion**

The current study offers the first comparison of the acute effects between SS and MFR on anaerobic power output. Past research has indicated that engaging in SS prior to power and strength activities leads to decreases in muscular performance (Behm and Chaouachi, 2011; Kay and Blazevich, 2012; Simic et al., 2013); however, no conclusive evidence has been published demonstrating the effects of MFR on anaerobic power output even though it is becoming more common as a pre-exercise warm-up activity. It was hypothesized that power output variables (PPO, MPO, and APO) would be reduced following SS activity, but potentially improve following a MFR treatment period. Likewise, it was hypothesized that PPD would be negatively affected by SS and
Figure 3: Mean PPO for female participants for each condition. Mean PPO was significantly (p < .05) condition.

Figure 4: Mean PPO for male participants for each condition. Mean PPO was significantly (p < .05) increased following SS compared to the control trial. Myofasical release exercise increased PPO, but this change was not statistically significant.
Figure 5: PPD for female participants following each condition. Static stretching and myofascial release activity significantly (p < .05) lowered PPD compared to control.

Figure 6: PPD for male participants following each condition. Myofascial release significantly (p < .05) increased PPD compared to control.
enhanced by MFR exercise. The main finding of this study was that there was no influence of either treatment on PPD or measures of power output during the Wingate anaerobic power test in the participant sample as a whole. Interestingly, when the sample was divided by gender, significant differences were observed in power output variables following both SS and MFR treatments within the male and female study participants. These findings more clearly suggest a potential gender difference with respect to both SS and MFR on measures of PPO and PPD in particular.

The primary measurements examined that were most influenced by the two treatments in the current study were PPO and PPD. The PPO is the maximum power produced and averaged across the first five seconds of a Wingate anaerobic power test. The PPD measurement is best described as a fatigue index or the rate that power output decreases from the point of maximum to the point of lowest power output. In the current study, female study participants demonstrated a significant decrease in PPO following SS compared to control and no change following MFR compared to control (Figure 3). Moreover, the data showed that PPD was improved in women following the treatment trials (Figure 5) compared to control. This most likely reflects a higher PPO obtained within the control period. However, PPO following MFR was also not reduced compared to control while eliciting an improvement in PPD. Therefore, compared to SS, MFR was superior as a pre-exercise strategy to maintain PPO and decrease rate of fatigue in women.

In contrast, male participants showed a significant increase in PPO following both MFR and SS (Figure 4), with MFR eliciting a higher PPO (see Table 2), in comparison to control. Therefore, in relation to maximizing anaerobic power output, SS and MFR were not detrimental in this sample of male volunteers, with MFR holding a potential superiority to SS. Although MFR produced a higher PPO in male participants, a significant increase in PPD was also observed following this particular treatment (Figure 6). These findings suggest that a trade-off exists regarding the use of MFR and improvements in muscular performance. While MFR may prompt an increase in maximal power output, the fatigability of the muscle, as measured by rate of power output decrement over time (PPD), was actually significantly higher compared to control and static stretching to control. Thus, if the goal of exercise performance is to maintain power output over an extended period of time, pre-exercise MFR may need to be used more cautiously. What is not known is how prolonged this enhanced rate of power decline may remain over time, especially with repeated bouts of anaerobic exercise as is observed with some sport performance.

The SS intervention data are partly in contrast with past research employing a SS treatment model to study physiological effects on power output (Brandenburg et al., 2007; Ce et al., 2008; Kay and Blazevitch, 2012; La Torre et al., 2010; Manoel et al., 2008; Perrier et al., 2011; Ramierz et al., 2007; Samuel et al., 2008; Signorelli et al., 2008; Simic et al., 2013; Taylor et al., 2009). The most common explanation given in the literature for power decrements attributed to SS is alterations in the length-tension relationship and neural activation of the muscle. In the current study, pre-exercise SS more negatively altered peak power output in women compared to men as women demonstrated a significant decrease in maximal power output following SS. In addition, pre-exercise MFR appeared to be beneficial for anaerobic power performance in both men and women depending on the variable in question. In a study by Arroyo-Morales et al. (2008a), electromyographic (EMG) amplitude was examined following a therapist-administered massage (MFR) treatment. It was found that EMG responses decreased following this treatment when compared to baseline values. Additionally, a change in the functional capacity of the myofasical tissue was attributed to altering the length-tension relationship within the muscle fibers that would have the potential to cause decreases in muscle strength and an increased state of relaxation. In a review by Weerapong et al. (2005), it was suggested that massage techniques (some similar to MFR) could potentially lead to changes that effect the biomechanical (e.g. increased muscle compliance,
decreased passive and active stiffness) and neurological (e.g., decreased neuromuscular excitability) properties of the targeted muscle tissue. Although the authors stated that further research needs to be completed in this area, it is possible that changes such as diminished neural activation and temporary loss of active stiffness in the muscle could lead to decreases in power and strength performance, which are also related to the inhibitory effects of SS provided that the volume dose is increased (>30-45 seconds per stretch) (Kay & Blazevich, 2012; Simic et al., 2013). In the current study, decreased neural activation and muscle stiffness within female participants could be the cause for decrement in PPO in women. For men, it was demonstrated that MFR and SS did improve PPO over control with a greater power output following MFR. It may be likely that the overall dose of SS and MFR was not sufficient to modify the neural activation and muscle stiffness in men.

Signorelli et al. (2008) found that PPO from Wingate anaerobic testing was significantly decreased following SS compared to dynamic stretching in 15 active male study participants. The SS program included three sets of 30 seconds per stretch targeting the hamstrings, quadriceps, and calves. However, when compared to control (no stretching), dynamic stretching, SS, and PNF did not significantly alter PPO in this group of males. In addition, PPD was not significantly different among the four treatment conditions. Ramirez et al. (2007) evaluated PPO and MPO from Wingate anaerobic testing in 10 active males following SS and conventional cycling warm-up. The stretching program consisted of two stretches performed on hamstrings, quadriceps, and calves and each stretch was held for 30 seconds. This was repeated four times for each leg. The results demonstrated a significant decrease in both PPO and MPO following SS as compared to cycling warm-up. In a systematic review of the acute effects of SS by Kay and Blazevich (2012), studies that employed SS exercise where the duration of hold per stretch was greater than 60 seconds showed significant decrements in maximal muscle performance. In contrast, when a static stretch was held for 30-45 seconds or less, it was found to not significantly affect muscle performance. In another review of the literature, Behm and Chaouachi (2011) found that factors such as shorter duration of holds per stretch at an intensity less than the typical point of mild discomfort were less likely to impair muscular performance. In a meta-analysis examining the effects of pre-exercise SS on muscular performance, Simic et al. (2013) demonstrated that SS duration held for greater than 45 seconds was the most detrimental to muscular performance. The authors concluded by determining that the usage of SS as the only activity performed prior to exercise should be avoided. It is clear that a dose-response relationship exists between SS and muscular activity with greater doses significantly affecting exercise performance compared to smaller doses of SS. What is not as clear in the literature is if a dose-response relationship exists between MFR and exercise performance; therefore, more work needs to be done to fully address this issue.

In the current study, SS and MFR produced somewhat different anaerobic power output outcomes for both men and women. A potential explanation may be that, overall, male participants were much more likely to have a larger muscle mass than their female counterparts. Perez-Gomez et al. (2008) examined the gender dissimilarity among muscle mass to evaluate if these distinctions would affect power performance during sprint cycling and running. The main conclusion of the study was that men were able to significantly generate more power compared to women due to the differences in muscle mass of the lower extremities. According to the authors, the PPO capability of muscle was similar between males and females when the data is adjusted for lower body muscle mass. Interestingly, this study demonstrated that differences in sprint performance during running were only partially explained by disparities in muscle mass, even when expressed as a percentage of total body mass. Thus, there are likely other factors at work that explain power output differences between men and women (e.g., neural activation patterns in the lower body muscles, biomechanical differences, etc.) (Landry et al., 2007; Medina et al., 2007). These factors could be influenced by SS and MFR to produce changes in
maximal power output, especially in women. Esbjornsson-Liljedahl et al. (2002) suggested that during repeated sprint activity women have a much smaller reduction in muscle ATP than men. Possessing a greater propensity to recover faster following repeated sprint activity could also mean that women hydrolyze less ATP during anaerobic activity, which could lead to lower PPO but similar PPD compared to men during heavy exercise. A past study by Miller et al. (1993) suggested that males have greater strength due to larger muscle fibers, which may play a role with the differential effects between men and women observed in the present study. Given there is very little scientific inquiry with respect to a gender influence regarding the effects of MFR and SS on maximum anaerobic power performance, these theories are mostly speculative. The current study has offered data which suggests the influence of gender on the effects of SS and MFR on power output.

In this research study there were various limitations. Although a 20-min familiarization period was given to all participants, it is possible that some remained relatively inexperienced with MFR. Close monitoring of technique was employed in order to minimize performance error. In future research, a longer familiarization period may be warranted. Another limitation may have been the unknown effects of the post-intervention warm-up activity prior to each Wingate test. Taylor et al. (2009) demonstrated that the detrimental effects of static stretching on muscular performance could be diminished by a sport-specific, high intensity warm-up. The warm-up activity in the current study was decidedly less intense than the activities employed by Taylor et al. and were much shorter in duration; thus, the warm-up in the current study may have had less effect on the outcomes of the interventions. Also, from a methodological perspective, eliminating the warm-up activity to test independent effects of these interventions would likely produce a greater negative impact on anaerobic performance and thus significantly modify the results. Lastly, the present study was not originally designed to examine differences between MFR and SS in men and women as separate gender groups. Thus, the sample size was small for this comparison and may have contributed to low statistical power needed to reveal differences between interventions if truly present.

Future research on this topic could focus on the examination of a potential dose-response relationship between MFR and anaerobic power output. The amount of MFR administered may change results due to inadequate or overstimulation of the facial tissue. Post-exercise MFR and the effect on subsequent performance of exercise could be further explored to highlight the timing (pre- or post-exercise) benefits of MFR. Monitoring of neural activation via EMG changes during MFR prior to and post-exercise is an important next step in this area of study to determine physiological effects compared to other warm-up or cool-down activities. Lastly, the acute or chronic effects of MFR on aerobic endurance and running economy, muscular strength, balance, or other activity and performance variables is warranted.

In conclusion, this study discovered differences between SS and MFR interventions and control on anaerobic power output and rate of fatigue in male and female participants. Contrary to previous research, SS significantly increased PPO in men compared to control. The MFR treatment also elicited similar results. The decrements observed in PPO in females are more consistent with previous findings on SS. Concerning PPD, SS and MFR decreased this measure in women compared to control. Interestingly in men, MFR significantly altered PPD during anaerobic cycling activity compared to control, but was not affected by SS. Therefore, although PPO was not negatively affected, employing MFR as part of a warm-up strategy prior to power activities that are limited by fatigue over time may not be advisable for men. Using MFR prior to shorter term power activities for men (e.g. power lifting, explosive strength movements) may be more beneficial for maximal PPO. Data to support the use of MFR prior to activity in order to improve PPO in women were less conclusive. However, it appears that MFR may improve the muscle’s ability to maintain power (less fatigue) over time as suggested by changes in the PPD measure. Thus, for women, performance of MFR could be more confidently recommended as a means to increase muscle power endurance and,
since there were no detrimental effects, concurrently maintain PPO during activity. The use of MFR could have the most positive effects on individuals seeking maximal power output over a short time frame, due to significant increases in PPD over the measured time interval.

**Conflict of Interest Statement**

No actual or potential conflict of interest exists that include any financial, personal or other relationships between the authors and other people or organizations.

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