THE EFFECTS OF STATIC STRETCHING ON MEASURES OF GROSS MOTOR COORDINATION DURING VIGOROUS CYCLING

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The purpose of this study was to assess the effects of static stretching on gross motor coordination patterns (GMCP) exhibited during vigorous cycling. The performance of 29 females between the ages of eighteen and thirty were analyzed during the Wingate Anaerobic Test (WAnT). The participants completed the test under two conditions, following static stretching and no stretching. Results showed statistically significant differences ($p \leq 0.05$) between conditions for dependent variables assessed throughout this common 30 second test of maximal cycling. These findings suggest that static stretching subtly influenced GMCP exhibited during the WAnT.

KEY WORDS: motor control, central pattern generator, critical power

INTRODUCTION: Musculoskeletal disorders (MSD) due to repetitive activity represent 50% of all injuries annually within the United States (Jacobs et al., 2008). Repetitive activities are also widely linked to injuries that commonly occur in sporting contexts. MSD are shown additionally to affect muscular force-generating capacities, and links exist between these effects and reduced performance, increased risk of musculoskeletal injury, or both. MSD are also associated with gross motor coordination patterns (GMCP) during vigorous physical activity. For example GMCP have been linked widely in the sport science literature as a contributing factor to ACL injuries among female athletes (Hewett, Ford, Hoogenboom, & Myer, 2010). Similarly, many studies have linked static stretching (STST) to decreased performance for many forms of high intensity, short duration activity (McLellan, Lovell, & Gass, 2010). Thus, it stands to reason, that given the diminished performance linked with STST, to investigate the impact of STST upon GMCP during vigorous physical activity given the latter's link to musculoskeletal injuries.

A common test of vigorous physical activity is the Wingate Anerobic Test (WAnT). This test is widely used in laboratory settings, as it reliably measures power output throughout a maximal 30 second cycling bout. The WAnT is used to assess anaerobic power and can assess a person's ability to produce maximal power while using both ATP-PCr and anaerobic glycolysis energy systems. While much research has been done to analyze anaerobic power, physiological responses to maximal exercise, the impact of riding positions, and many other topic, little research has been done on the biomechanics or GMCP exhibited during this test. This current void in the scientific literature stands out, in particular given the widespread familiarity of sport scientists with the WAnT. More research in this area may help facilitate greater understanding of the ways in which the biomechanics or GMCP change during vigorous physical activity. In turn, this may help to better prevent and rehabilitate injuries, such as the many ACL injuries that occur among female athletes.

The purpose of this study, then, was to assess the effects of STST on GMCP exhibited during short term, vigorous cycling.

METHODS: Data collection occurred at Western Kentucky University in Bowling Green, Kentucky (USA), and the study received approval from the Institutional Review Board (IRB) prior to its start. Inclusion criterion included individuals between the 18-30 years of age, assessed as low risk on the ACSM risk stratification guidelines, and who regularly exercise. Individuals with known lower extremity pathology or who regularly cycle were excluded. Participants included twenty-nine women (n=29) between the ages of eighteen and thirty (21.25±2.46 yr; 167.89±5.80 cm; 63.46±7.86 kg). Each participant performed the WAnT on two occasions, allowing for evaluation of a number of GMCP measures during the tests. Before and after each of two data collection sessions, participant's heart rate, blood pressure, and respiratory rate were taken. Using a counterbalanced design, each participant completed one session that included a standardized lower extremity STST protocol prior to the WAnT. The second trial, performed during another visit to the laboratory, did not contain the pre-test stretching regimen. The STST protocol used in this investigation was patterned after those used in previous studies on static stretching. The STST protocol consisted of four, 30-second repetitions each of 5 stretching exercises, which were performed with an average total stretching time of 20 minutes (Nelson, Kokkonen, & Arnall, 2005), and included stretches for the hip extensors, hip flexors, knee flexors, and knee extensors. The static stretches for these muscle groups were performed separately on each leg. In the no stretch condition, participants sat quietly for 20 minutes before beginning the WAnT protocol.

The WAnT was completed using an electronically-braked ergometer (Racermate, Seattle, Washington, USA), and all conditions were computer controlled. Independent variables included stretching condition (static stretching versus no stretching). Dependent variables used to assess GMCP included the following measures collected continuously during each WAnT: speed, watts, rpm, % power (% left vs right lower extremity), average torque angle (ATA), and SpinScan™ (SS). Repeated measures analysis of variance was conducted using SPSS 21 (IBM SPSS, Armonk, NY, USA). Statistical significance was set at the customary level ($p \leq 0.05$).

RESULTS: Significant differences were found between conditions for the entire 30 seconds of the WAnT for Combined SS ($F(1,27)=5.346$, $p \leq 0.029$) and Left SS ($F(1,27)=6.508$, $p \leq 0.017$). Significant interactions ($F(5,23)=42.99$, $p \leq 0.000$) were found for all dependent variables over time for the 30 second time frame. Post-hoc analyses of the data for the entire 30 second duration of the WAnT revealed that differences between conditions were most evident early in the performance of the WAnT. Significant differences were thus found during the first 10 seconds of the WAnT for left SS ($F(1,27)=7.345$, $p \leq 0.012$) and left ATA ($F(1,27)=4.332$, $p \leq 0.047$), as well as non-significance for SS ($F(1,27)=4.110$, $p \leq 0.053$). Significant interactions ($F(1,27)=24.248$, $p \leq 0.000$) again were found for all dependent variables of time from 0 to 10 seconds on the WAnT.

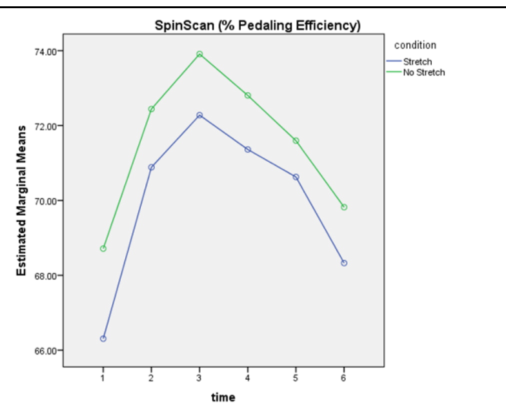

Figure 1: Significant differences (p ≤ 0.05) between conditions and over time for Combined SpinScan™. Analysis of estimated marginal means (n = 29).

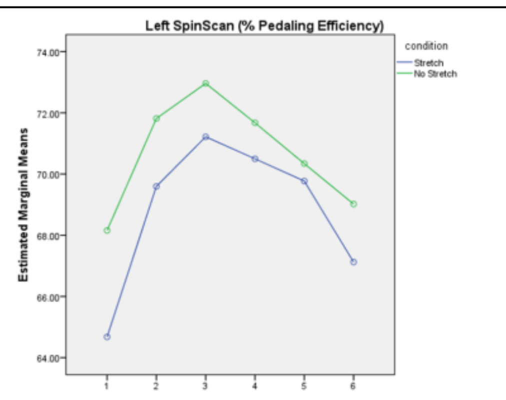

Figure 2: Significant differences (p ≤ 0.05) between conditions and over time for Left SpinScan™. Analysis of estimated marginal means (n = 29).

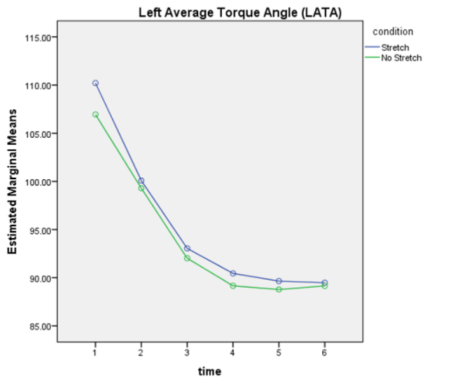

Figure 3: Significant differences ($p \leq 0.05$) between conditions for LATA during first 10 sec of WAnT. Analysis of estimated marginal means (n = 29).

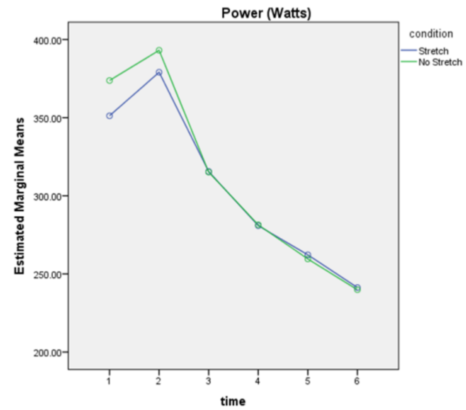

Figure 4: Significant differences ($p \leq 0.05$) over time for power output. NSD between conditions. Analysis of estimated marginal means (n = 29).

DISCUSSION: The findings in the present study suggest that STST produced both statistically significant and clinically meaningful effects upon GMCP measures during vigorous cycling, as the static stretching versus no stretching condition clearly had an impact on measures of GMCP assessed in this study. Participants exhibited statistically-significant lesser values in the Combined SS and Left SS values. Researchers have described the SS as a composite measure of pedaling efficiency while cycling (Dixon et al., 2013). Participants also produced decreased values for cycling speed (km/hr), power output (watts), cadence (rpm) and average torque values during the WAnT protocol that followed the STST protocol. While these particular findings were not statistically significant, they likely have clinical meaningfulness. For example, few, if any, cycling coaches with access to this information alone would likely encourage their athletes to engage in static stretching prior to maximal sprint activity or racing heats. Still, more research is needed to better understand the ways in which static stretching may negatively influence measures of GMCP during vigorous cycling.

The present findings are consistent with many studies that suggest STST negatively influences force production measures during short-duration, high-intensity activities. A number of papers have reported reduced muscular force production immediately following a STST session. Many authors have reported STST produced decreased force production measures for one repetition maximum (1-RM) leg press, knee-extensor concentric torque, 20-m sprint performance, and magnitude of vertical jump height (Young & Elliott, 2001). A consistent characteristic of such studies is the completion of a high intensity, short duration activity within a few minutes after participants execute a regimen of STST. Thus, the present findings support these earlier reports of diminished muscular force production following a bout of STST, as alterations in GMCP could be attributed to force production changes.

Evaluation of the GMCP variables showed that the differences between stretching and non-stretching conditions were most evident during the first 5-10 seconds of the WAnT. This difference may be due to the ATP-PCr energy system that predominates during the first few seconds of exercise. In short, STST may negatively influence the ATP-PCr system in some subtle way. An example of this can be seen in Figure 1 when more watts of power were produced during the beginning of the non-stretching condition. Authors have also attributed lesser force production following STST to factors such as stress relaxation of the muscle tissue, which leads to lower muscle-tendon stiffness and strength (Kubo, Kanehisa, & Fukunaga, 2001), or peripheral nervous system inhibition that results in lesser muscle activation (Cramer et al., 2005). Either of these factors may be at play in the present study, and may help to explain the differences in GMCP demonstrated for the full 30 second duration of the WAnT. Further study is needed to shed additional light on how these and other factors may contribute to changes in GMCP following STST.

Strengths of the present study include its treatment of a topic which broadens the spectrum of activities that have been assessed following STST, as few studies have investigated the impact of STST upon performance measures during cycling in general or the WAnT in particular. Similarly, while much is known about the impact of STST on muscular force production, little is known about the ways in which STST may influence biomechanics or GMCP. This is an important consideration given the role of force production in the creation and control of coordination motor activity, which has been linked to musculoskeletal injuries such as those to the ACL. A limitation of the present study is the delimitation of the participants to apparently healthy young women. They may have responded to STST in ways inconsistent with other populations. Consequently, future study should investigate the impact of STST on GMCP among other physically active populations.

CONCLUSION: Given the few studies on the effects of STST on GMCP, these results have both scientific and clinical value. The present findings support many previous studies indicating that performance measures for short duration, high intensity activities are often diminished immediately following STST. Participants demonstrated decreased laboratory measures of GMCP following the completion of the STST protocol done prior to the WAnT, when compared to a no-stretching condition. The findings may help sport scientists make better use of static stretching routines in training and rehabilitation.

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