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The Effects Of Static Stretching Warm-Up Versus Dynamic Warm-Up On Sprint Swim Performance

Michael Patrick Moran

THE EFFECTS OF STATIC STRETCHING WARM-UP VERSUS DYNAMIC WARM-UP ON SPRINT SWIM PERFORMANCE

by

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Bachelor of Business Administration, University of Wisconsin – Oshkosh 2003

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This thesis, submitted by Michael Patrick Moran in partial fulfillment of the requirements for the Degree of Master of Science from the University of North Dakota, has been read by the Faculty Advisory Committee under whom the work has been done, and is hereby approved.

Dr. James Whitehead - Chairperson

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This thesis is being submitted by the appointed advisory committee as having met all of the requirements of the Graduate School at the University of North Dakota and is hereby approved.

Dr. Wayne Swisher
Dean of the Graduate School

December 10, 2012
Date

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Michael Patrick Moran
November 29, 2012

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To my family: Jenny, Kyleigh, Rylan, and to my parents Pam and Pat.

ABSTRACT

Recent research has revealed that static stretching (SS) warm-ups may attenuate power performance compared to other warm-up protocols, but most studies have focused on dry land modalities. PURPOSE: To examine the effects of an SS warm-up versus a dynamic warm-up (DW) on sprint performance in competitive swimmers. Specifically, it was hypothesized that SS prior to a 50-meter sprint would attenuate results compared to DW. METHOD: Sixteen NCAA Division 1 swimmers (5 female, 11 male) participated. These swimmers had recently completed their collegiate season. In a randomized order crossover design, the participants swam a 50-meter freestyle sprint after two different warm-up protocols that were designed to mirror typical practice among competitive swimmers, while allowing any practically significant experimental effects from the SS versus DW contrasts to occur: Specifically, the warm-ups were Static Stretch + Swim (SS/S), and Dynamic Warm-up + Swim (DW/S). In each case the contrasting experimental warm-up exercises (nine static stretches versus nine dynamic movements) were immediately followed by a typical swimming warm-up (about 20-minutes). The two timed 50-meter sprints took place 5-minutes after the SS/S and DW/S warm-ups were completed, and they were conducted three days apart under simulated competitive conditions using standard starting commands, and electronic timing equipment. RESULTS: Separate analyses (paired t-tests) were conducted to test for treatment effects over the first 25 meters, the second 25 meters, and the overall 50-meter sprint time. There were no significant differences between mean times in any of those comparisons.

Examination of individual data revealed that the number of swimmers who were slower after SS/S was approximately equal to the number slower after DW/S. CONCLUSION: Unlike the detrimental effects shown in other performance modalities, SS in warm-up did not attenuate sprint swimming performance in this study. It is possible that the swimming warm-up done subsequently to the SS or DW component may have blunted any effects of the SS. Thus, future research might minimize the swimming component of warm-up to allow any effects of SS versus DW to emerge, and it might be preferable to conduct the study during the swimmers' competitive season.

CHAPTER I

INTRODUCTION

Warm-up procedures before physical activity have long been used with the intention of preparing athletes for the exercise to be completed (Schilling, 2000; Young and Behm, 2002; Mann and Jones, 1999). These procedures have been chosen by many coaches because they have been assumed to reduce the risk of injury, improve range of motion, decrease muscle soreness and have a positive effect on performance (Alter, 1998; Ninos, 1995; Young and Elliott, 2001; Yamaguchi and Ishii, 2005). However, with recent developments in research on stretching procedures and types of stretches, many coaches may now be split on the proper way to warm-up for athletic events. Some believe that regular static stretching will be most effective, while some coaches believe that a more dynamic warm-up, using movements mimicking those during exercise will be more effective (Young and Behm, 2002; Mann and Jones, 1999). During these stretching exercises, which are employed before the activity is started, it is important to stretch the appropriate muscle groups, specifically the ones that are going to receive most of the work during the desired activity (Ninos, 1999). Although several studies have already examined which type of stretch is the best, none, to date, have been found to show effects of any stretching and warm-up procedure on college level swimmers.

Stretching is used primarily in three different ways in sports. Stretching can be used as a part of a pre-event warm-up. Usually this is done with the intent of preparing the body for the upcoming exercises, practice or competition but it can also help prepare an athlete mentally for everything they are about to endure. Coaches also use stretching as part of routine conditioning. Many, if not all coaches, would strive to get their athletes to become flexible enough for the demands of their sport. Stretching is also often done as a part of cool-down procedures after an event or work-out. The use of these three applications of stretching raises separate issues. However, for the purposes of this study we looked at stretching from a pre-event standpoint to see if it affects subsequent anaerobic power performance in the water.

Stretching and Injury

Decreasing injury has long been cited as a good reason to implement a stretching program. Shrier (1999) examined 23 studies on acute bouts of stretching and the effects they had on performance, and 9 studies that investigated the effects of chronic stretching. In this same review, Shrier hypothesized that the scientific evidence found to date would show that stretching before exercise prevented injury. After conducting a search of all relevant articles, Shrier narrowed down his search to only 12 articles that would suffice because they were the only ones who used a control group. Of the 12 articles chosen, four found that stretching before exercise was beneficial; three showed that it would be detrimental, and five showed there was no difference. The main conclusion of this review was that "…basic science literature suggests that stretching before exercise would not reduce the risk of injury…(p.225)". Shrier also hinted in his discussion that effects on performance should be tested as they may depend on the sport that is in question.

Stretching Effects on Performance

Although many still believe that stretching included in a warm-up prior to exercise does prevent injury, Shrier (1999) has shown that pre-event stretching likely does not prevent injury. There is still some question if stretching facilitates performance. A literature review by Bracko (2002) suggested that stretching should not be done prior to maximum use of muscles (i.e.: 1 rep max lifts, strenuous workouts, etc.) but instead, stretching should be used only before low intensity exercises like jogging or light weight lifting. He also set out to test the widely held idea that stretching would reduce the chance of injury. Similar to Shrier (1999), Bracko (1999) concluded that stretching before exercise did not reduce the chance of injury. Bracko (2002) also suggested that people should only engage in low-intensity activities immediately following a bout of stretching. He explained that the low intensity muscle contractions helped to tighten the muscles which created a stronger contraction during the sports performance. Supporting evidence was provided by Faigenbaum et al. (2006) who suggested that static stretching along with a dynamic exercise would produce the best results in anaerobic performance.

Another review of the literature suggests that static stretching, specifically the reasons behind static stretching, may be questionable. Young & Behm (2002) reviewed recent literature, and they concluded that there is now evidence that static stretching can have negative effects on strength and power performance. They suggested that instead of static stretching before these activities, the athletes should perform a warm-up routine consisting of progressive sub-maximal exercise, focusing on the muscle groups that will be used.

Shrier's (2004) review of the literature suggested regular stretching will be more effective in increasing performance. In the second part of his review, Shrier explained that the "…review of the clinical evidence strongly suggested that pre-exercise stretching decreases force production and velocity of contraction for at least part of the range of motion...(p. 270)". Also in the second part of the article, he suggested that an acute bout of stretching will only increase running economy. However, in the first part of the review, Shrier found 23 articles related to acute bouts of stretching, 22 said that there was no benefit to performance. In all the 23 articles chosen, many different types of participants were used: children, adults, males, females, and even trained and untrained participants. A wide variety of participants may suggest that this review is useful in understanding that acute stretching does not help anyone improve performance.

Marek et al. (2005) set out to find the effects of static stretching along with proprioceptive neuromuscular facilitation (PNF), stretching and the effects of each on strength and power output. To do this, Marek used ten women and nine men to test stretching's effects on Peak Torque, Mean Power Output, Active Range of Motion, Passive Range of Motion, Electormyographic Amplitude (EMG) and Mechanomyographic Amplitude (MMG). During each trial, the subjects completed a warm-up procedure, pre-stretching isokinetic assessments, pre-stretching range of motion activities, the static or proprioceptive neuromuscular facilitation stretching procedure, post-stretching range of motion measurements, and post-stretching isokinetic assessments. Many different instruments were used to obtain and measure results, such as an isokinetic dynamometer to measure max torque production, stationary cycle ergometer to warm-up, and various software and computers to measure EMG and MMG signals. Marek used a randomized, counterbalanced within-subjects experimental design for his experiments. Time, stretch, velocity, and muscles were the independent variables and the dependent variables were Peak Torque, Mean Power Output, Active Range of Motion, Passive Range of Motion, Electormyographic Amplitude (EMG) and

Mechanomyographic Amplitude (MMG). This study is unique because of its significant findings that have not been shown elsewhere. Their experiments, showed a loss of Peak Torque and Mean Power Output derived from doing BOTH stretches. They also showed decreases in strength and power because of the two types of stretches.

Young and Elliott (2001) compared acute effects of two different static stretching protocols and the isometric maximum voluntary contractions (MVC) on explosive force production and jumping performance. To do this, 14 male participants were selected to conduct various warm-up procedures two to four days apart. Each group performed a short jogging warm-up followed by performing one of the different stretching protocols: static stretching, PNF stretching, MVC, or a control group. After the stretching, four minutes were used to cool down the body before the tests, which consisted of a squat jump and a drop jump. Results indicated that the drop jump performance was hindered by static stretching during warm-up. However, static stretching was also found to have a non-significant decrease in concentric explosive muscle performance. Thus, Young and Elliott agree that static stretching has a damaging effect on the performance of such activities that involve short bursts of energy provided by large muscles.

An issue that has made interpretation of recent research difficult is the frequent use of vague terminology. Traditionally, the three main types of stretching have been categorized as either static, PNF, or ballistic. Static stretching is a simple reach until you feel uncomfortable stretch, held for any varying amount of time. Proprioceptive neuromuscular facilitation (PNF) can be a wide variety of stretches that allow the muscle to contract during the stretch. Ballistic stretching is done by using body weight to move a body part past its normal range of motion. In some of the latest studies the term “dynamic stretching” has been used—and thus, the question arises as to whether this means ballistic stretching—or whether it just implies some sort of callisthenic regimen that does not really have a significant stretch component?

Dynamic warm-up versus static stretching has recently been a controversial topic when investigating the effects of a stretching program. Yamaguchi and Ishii (2005) recruited 11 male participants to compare the effects of static stretching for 30 seconds and dynamic stretching on leg extension power. The procedure subjected the participants to a static and a dynamic stretching regimen as well as a measurement without stretching, on the major lower body muscle groups on separate days. In this study, the authors referred to dynamic stretching even though one could make an argument that the exercises were a type of dynamic warm-up with the intention of stretching the muscles that were about be to used. Results indicated no significant difference with static stretching versus non-stretching, but the dynamic stretch was associated with a significant increase in leg extension power. From this, they have shown that either no stretching prior to performance or static stretching does not benefit muscle performance, but a dynamic stretching warm-up will have a positive effect on muscle performance.

Mann and Jones (1999) stressed in their research that dynamic stretching should be included because it is an important part of practicing. However, Mann and Jones refer to their warm-up period as a “dynamic stretch” which appears to be the same type of dynamic warm-up used later in this research. In Mann and Jones, dynamic stretching during a warm-up period incorporates the sport specific movements that are not only needed to complete the activity but best when used before competition. In their research, Mann and Jones agree that 10-15 minutes of dynamic stretching will be enough to properly stretch athletes once they know how to complete each exercise. Using a softball team as a pilot study, the implementation of a dynamic stretching routine within their warm-up showed an increase in range of motion in the hamstrings and quadriceps, also significantly lowering the injury rate compared to a static-based stretching regimen. Dynamic stretching should be included in warm-up procedures by starting slowly and progressing to faster and more advanced movements, while mimicking the movements to be made in the activity. The authors mentioned the dynamic stretches used should mimic what the body will do during the activity. This type of dynamic stretching is not the same as ballistic stretching, where a person is actively seeking to push the range of motion past its normal limit.

Nelson et al. (2005) investigated the effects of a stretching program on athletes in training. The purpose of their study was to examine the effects of pre-race stretching on a track athlete's ability to accelerate out of the starting blocks and thus hinder race performance. Participants were 11 males and five females. Appropriate electronic timing devices were used to obtain exact information about each sprint. Before the actual test, which was a 20-meter sprint on an indoor track, four stretching protocols were used. The different stretching protocols were as follows: no stretch (NS), both legs stretched (BS), forward leg stretched (FS), and rear leg stretched (RS). Nelson and his partners concluded that no stretching was better than any other stretching protocol, as stretching caused the athletes' times to increase. This study showed that stretching increased the time of the sprint compared to no stretching, and would indicate that stretching is detrimental to short, explosive sprints. Interestingly, those results were obtained even though some of the athletes participating in the study reported that they felt uneasy about not stretching prior to testing.

Little and Williams (2006) determined the effects of three stretching protocols on anaerobic performance using elite soccer players. Vertical jump, stationary 10-meter sprint, flying 20-meter sprint and agility performance were all used in the study. Static stretching was found to produce significantly faster times in the flying 20-meter sprint than compared to no stretching. Data indicated that a dynamic warm-up benefited the participants in two out of three tests when compared to static stretching. Dynamic warm-up was also found to produce better results in the agility test when compared to static stretching. The authors concluded that a dynamic warm-up would be beneficial to elite soccer players when compared to static stretching in test conditions.

Faigenbaum et al. (2006) also investigated how pre-event stretching affected athletic performance. Specifically, their study explored which type of stretching was better suited for anaerobic exercise immediately following an acute bout of stretching. To do this, they used 30 teenage athletes (15.5 ± 0.9 years) stretching in different conditions. Each group was randomly formed and counterbalanced. The three types of stretching (warm-up protocols) used in the study were: Static Stretches (SS), Dynamic Exercise (DY), and Static Stretching combined with Dynamic Exercise (SDY). Each static stretch was held for 30 seconds at a point of "mild discomfort" while the dynamic exercises were completed in 10 minutes, utilizing nine different exercises. Protocol SDY was equally incorporated five minutes of SS and five minutes of DY. To evaluate the three types of anaerobic exercises (power, speed, and agility), the authors used the vertical jump, seated medicine ball toss, 10-yard sprint, and the pro-agility shuttle run.

The best score from two trials was used. Electronic speed timing devices and vertical jump system height recorders were used when appropriate. The results of this study indicated what previous studies have shown: static stretching significantly reduces anaerobic performance when compared to a dynamic warm-up and a combined static stretch plus a dynamic warm-up in the med ball toss, 10-meter run and vertical jump. They also have found that “pre-event static stretching followed by dynamic exercise was just as effective as dynamic exercise alone…(p 71)” Another interesting point to this study was that dynamic exercise before an anaerobic event may have remediated the negative effects of static stretching. Faigenbaum stated that in order for this study to be conclusive, there must be future work conducted in this area.

In determining what the ideal warm-up might be for team oriented sports, Needham et al. (2009) used a small group of elite level soccer players to perform three different types of stretching routines prior to performance. This study compared Static Stretching, Dynamic Warm-up and a Dynamic Warm-up plus a resistance exercise to determine the best type of warm-up. As hypothesized, Needham showed that all Dynamic Warm-up protocols always produced significantly effective results in both 10- and 20-meter runs and with vertical jump performance.

Hypothesis

A review of the literature suggests that a static stretching prior to dry land anaerobic power performance will have a negative effect on the performance. Therefore, the purpose of this study was to examine the effects of the different kinds of stretching on anaerobic performance in college level swimmers. It investigated if the research on dynamic versus static warm-up and those effects on power performance held true in an aquatic environment – would static stretching produce negative results in the pool as suggested on dry land? Consistent with Faigenbaum et al. (2006), it was hypothesized that static stretch prior to the anaerobic swimming performance would produce inferior results compared to dynamic warm-up procedure. This study set out to try to determine if static stretching used prior to the anaerobic performance would increase swimming times and thus have a negative effect on the swimmer. It was also hypothesized that a dynamic warm-up would facilitate faster times. Extensive literature searches on this topic have not found any research on the effects of warm-up static stretching on anaerobic sprint swimming performance.

CHAPTER II

METHOD

Purpose

The purpose of this study was to investigate the effects of static stretching versus dynamic stretching warm-ups on anaerobic sprint swimming performance.

Participants

A total of 16 current swimmers from an NCAA Division One swim team were recruited to participate - five female swimmers (mean age = 19.6) and 11 male swimmers (mean age = 21.3). These participants had recently completed their collegiate swimming season (30-60 days removed from season). During one of the trials, computer error led to data being incomplete for one participant. Therefore, all data reported represented a total of 15 participants.

Procedures

During recruitment, possible participants were informed about what the study would encompass, and were invited to join the study. Approval for this study was granted by the University of North Dakota's Institutional Review Board, and all participants were required to sign the consent form before participation began (see Appendix A).

After consent was obtained, the participants were randomly assigned to conditions with different warm-up protocols: Static Stretch/Swim (SS), and Dynamic Warm-up/Swim (DW). Once each participant was assigned a condition for that day, the warm-up procedure for that particular group was executed as shown in the warm-up protocols section. Upon completion of the warm-up procedures, participants had five minutes to rest before being placed into heats to conduct the trials. Each swimmer then swam a 50-meter sprint in a 25-meter pool. For each of their swims, participants were instructed to swim using only the freestyle stroke. Data that was collected included a first 25 meter split, second 25 meter split and a total 50 meter split. All times were recorded to the nearest hundredth of a second. All participants completed both trials, three days apart (See Figure 1 on next page).

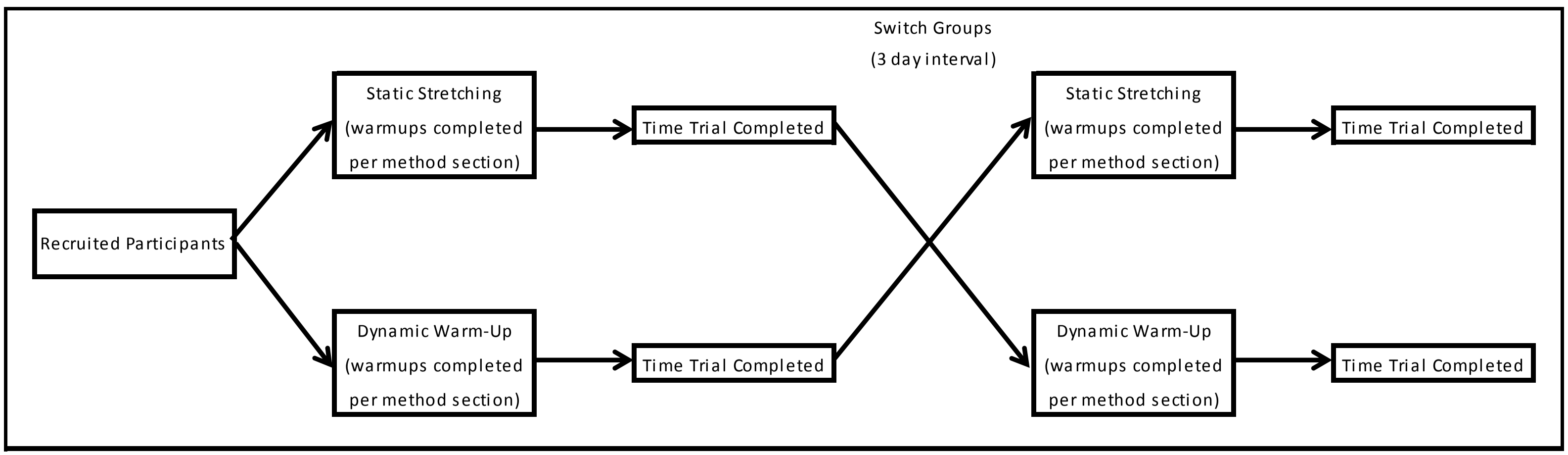

Figure 1: Flowchart of Process From Recruitment Through Both Trials.

Instruments

This experiment made use of an indoor eight lane, 50-meter pool with anti-wave lane line dividers. For this experiment, the pool length was set to a 25-meter course, meaning the swimming portion required each participant swimming two laps for a total of 50-meters. The starting end of the pool was approximately 13 feet deep, while the turning end was approximately eight feet deep. Starting blocks used were 30" in height, located in the middle of each lane, with 10 degrees of negative angle from back to front. All normal competitive swimming conditions were utilized. The timing system that was used to measure sprint times is the Daktronics Omnisport Timing System (Daktronics, Inc., Brookings, SD) with in-water touch pads. In each lane, touchpads were placed at both ends of the pool to record swimming times. All results were sent from the in-water pad to a computer console and displayed on a video board located above and behind the starting blocks. The timing system was recently recalibrated by a Daktronics computer technician. Along with the timing computer, loudspeakers were connected to the starter's microphone to enable participants to clearly hear the commands. There were two speakers placed on either side of the pool along with eight other speakers, one per lane, placed directly underneath each starting block.

Warm-up Protocols

Static Stretch Trial

There were two different types of warm-up protocols used in the experiment: dynamic warm-up (DW) and static stretch (SS). The participants completed the stretching protocols of the assigned trial followed by a warm-up swim. The test followed immediately after the swimming warm-up. A swimming warm-up, according to

Maglischio (2003) should include: an easy swim, approximately 10-20 minutes in length, followed by some pace swimming, sprints, and timed starts to increase blood flow and oxygen intake (Maglischo, 2003). The swimming warm-up procedure was the same each day. Figure 2 shows the complete swimming warm-up:

600 Swim

8 x 50 on 1:15
1-4: Drill / Swim by 25's
5-8: Freestyle Swim

200 Kick

4 x 50 Kick on 1:20

4 x 100 on 1:45
Swim Freestyle, Build the Last 50 to Fast

8 x 25 on 1:00
15 Meter Sprint, 10 Meter Swim Easy

2 x 25 Fast From Blocks

100 Easy

Figure 2: Swimming Warm-Up Used in Both Trials

The static stretching procedure included nine stretches that each participant completed. Each stretch was held at mild discomfort for 30 seconds, rest for five seconds, and then completes the same stretch again for another 30 seconds. The nine types of static stretches are shown in Figure 3.:

Type of Stretch	***Description***
Hip and Low Back	In a seated position with one leg extended, cross the other leg over the extened leg; wrap arms around crossed leg and pull towards chest.
Chest	In a standing position, place both arms behind the back, clasp hands together and lift arms upwards.
Quadriceps	While lying on your side with body erect, bend top knee and hold the foot with one hand while pulling foot towards buttocks.
Calf Stretch	In a standing position with feet staggered about 2-3 feet from a wall, place both hands on wall and lean forward; keep the back leg straight with heel to floor and the front leg slightly bent.
Horizontal Flexion I	With a straight elbow, thumb pointed upwards and the palm facing the body, exhale and reach arm towards top of opposite shoulder. Use the opposite hand to assist at the end of the elbow.
Horizontal Flexion II	Reach around to opposite side of neck. Place hand on top of shoulder, raise elbow to shoulder height without elevating shoulder of arm. Walk fingers down the upper back as far as possible.
Triceps	With elbow flexed at 90 degrees in front from vertical position, move flexed arm as far upwards as possible.
Hyperextention Singe Arms	With palms facing upwards, reach both arms backward as much as possible and have a partner extend the arms upwards.
Hamstring Stretch	In a seated position with both legs extended straight out, grab the legs with hands and extend upper body as far forward as possible.

Figure 3: Static Stretches Utilized in SS Trial

After the stretching procedure was completed, the participants were instructed to enter the pool to complete the designated swimming warm-up. Each participant's warm-up was conducted on his or her own, with a clear timeline of when the tests would begin. Following the warm-up, the participants were assigned to lanes, and completed the 50-meter sprint.

Dynamic Warm-up Trial

The second group completed the dynamic warm-up first in the adjacent gymnasium and then swam the in-water portion of the designated warm-up (see figure 2 above). This group is labeled DW. The DW group made use of nine different types of exercises designed to warm-up all areas of the body. Figure 4 shows all the exercises used in the DW trial:

Type of Stretch	***Description***
Speed Skips	Rapidly skip forward.
Heel-ups	Rapidly kick heels towards buttocks while moving forward.
In and Out	Rapidly turn toes in/heels out and toes out/heels in while hopping forward.
Trunk Twists	With arms behind head and body erect, rapidly hop forawrd as hips are turned to one side then the other, focusing on truck rotation.
Skipping Toe Touches	With arms extended in front of the body, lift one foot toward the extended arms and then skip as the extended leg returns to the floor and the other leg is lifted.
Drop Squat/Carioca	From a standing side stance, hop and land with feet at shoulder width and body lowered to semisquat position; move laterally while rapidly crossing feet over each other.
Power Pushups	After performing 3 pushups, perform 3 power pushups by quickly pushing your upper body off the ground and clapping your hands.
Sprint Series	While standing erect, fall forward and begin to sprint to the 5 yard mark, then accelerate as fast as possible through the 10 yard mark.
High Knee Skip	While skipping, emphasize high knee lift and arm action.

Figure 4: Dynamic Warm-Up Exercises Used in DW Trial.

Sprint Test

The actual sprint test was conducted following a five minute break after the designated swim warm-up protocol was completed by each group. The sprint test involved the participant swimming a total of 50-meters swimming freestyle.

After the appropriate stretching protocol and warm-up swim was completed, the swimmers were instructed to the blocks to complete the sprint test. Using the NCAA swimming rules and interpretations (2006) as a guide, the swimmers followed the commands of the starter to begin the sprint test. After each heat of sprint tests, the swimmers were instructed to warm-down at their own discretion in the adjacent 20 yard pool. Data for the sprint test was received by the computer timing system immediately after the swimmer presses each touch pad at the end of the swimming pool. The final time of the sprint was recorded, but not shown on the video board.

A last minute modification had to be made to the sprint test because the touchpad did not fit in the opening at the turn end of the pool. At the turn end of the pool (after 25 meters) there was a bulkhead, and the bulkhead had a space to pace a touchpad in the water like usual, only this opening was not large enough to hold the touchpads. In order to utilize the touchpad, it had to be hung from the top of the bulkhead, raising the pad about 5 inches out of the water. Because it was not certain that if in the course of these trials when swimmers completed their normal flip turn at this end of the pool, that their feet would touch the pad the swimmers were instructed to utilize a hand-touch and turn rather than the usual flip turn.

Design and Statistical Analysis

The procedures took place over a four day time period, conducting the first test on day one and then the following test three days later. Each person served as his or her own control, using a randomized order. Descriptive statistics were calculated using the Statistical Package for the Social Sciences version 14 (SPSS, Inc., Chicago, Ill.). Correlated samples *t*-tests were used to test for differences in mean times for the test conditions with $p < .05$ set as the standard for statistical significance.

CHAPTER III

RESULTS

The purpose of this study was to determine if a pre-race static stretching warm-up affected anaerobic swimming performance compared to a dynamic warm-up. Paired samples *t*-tests were computed to test for effects of the static stretching versus dynamic warm-up in the first 25-meters performance time, second 25-meters performance time, and the overall 50-meter performance time. The mean times for the first and second 25-meter lengths, and for the overall 50-meter sprint time after the DW trial and the SS trial are shown in Figures 5, 6, and 7 below. Figure 8 is a graphic illustration of the differences between the dynamic warm-up 50-meter time and the static stretching 50-meter time for each individual swimmer.

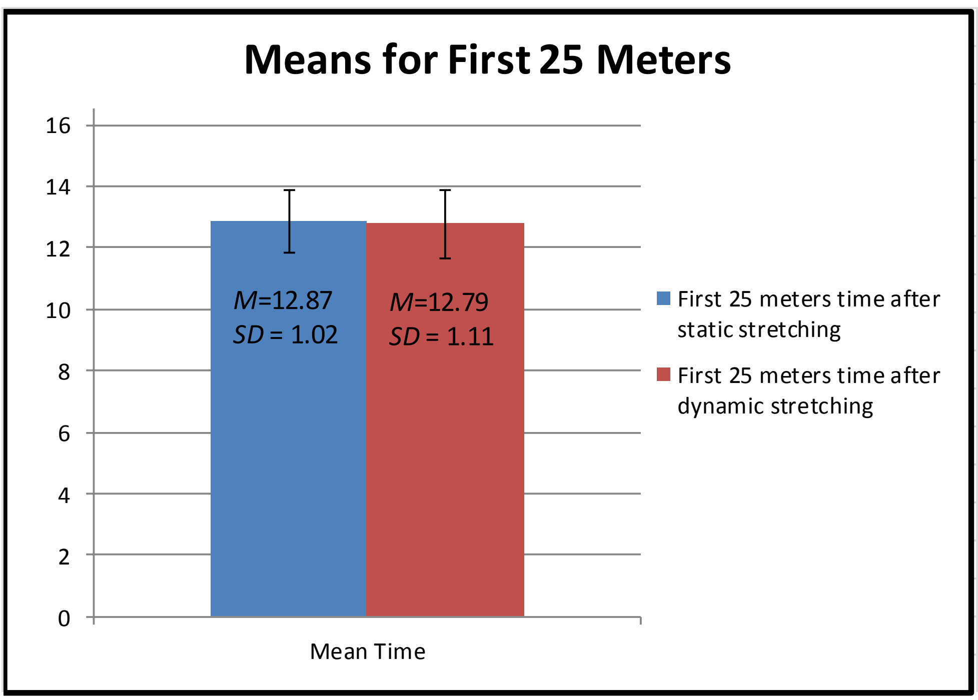

Figure 5: *t*-test Results Comparing The Mean Times For The First 25-Meter Sprint Performance For All Participants

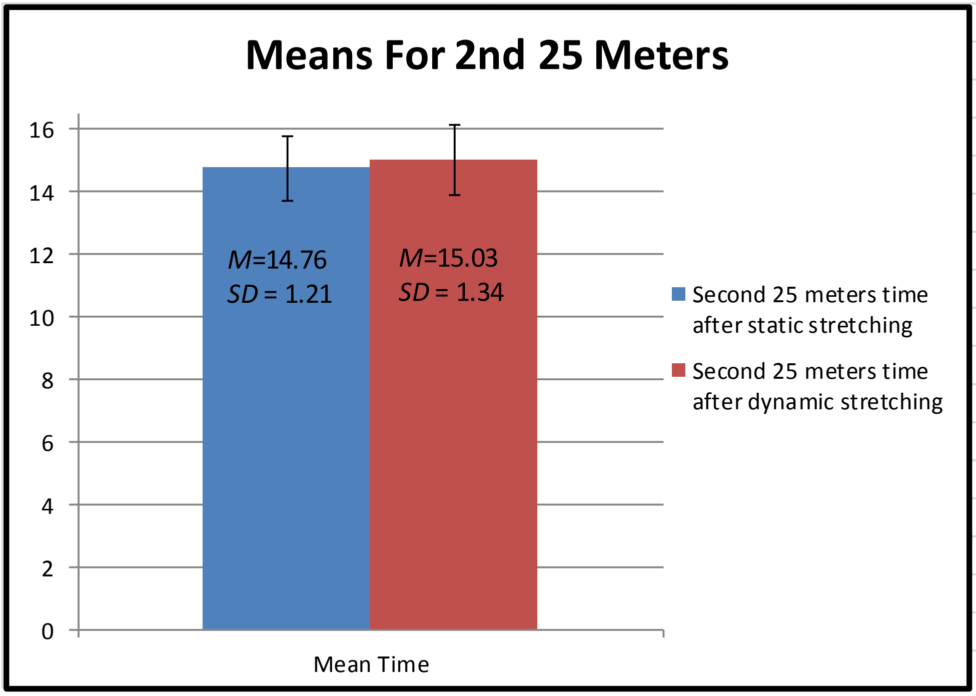

Figure 6: *t* -test Results Comparing The Mean Times For The Second 25-Meter Sprint Performance For All Participants

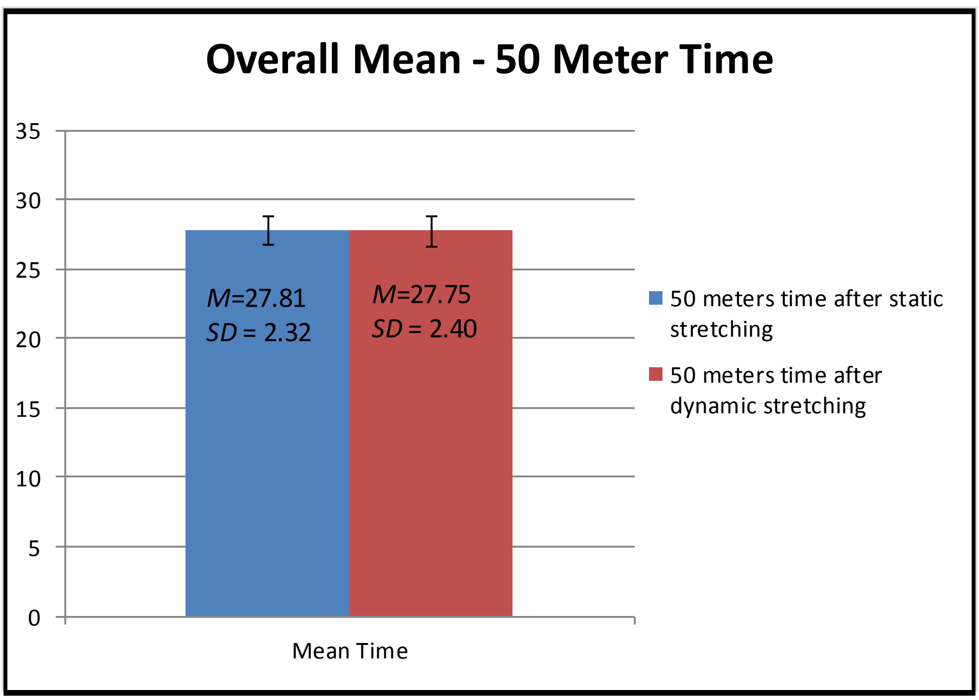

Figure 7: *t* -test Results Comparing The Mean Times For The Overall 50-Meter Sprint Performance For All Participants

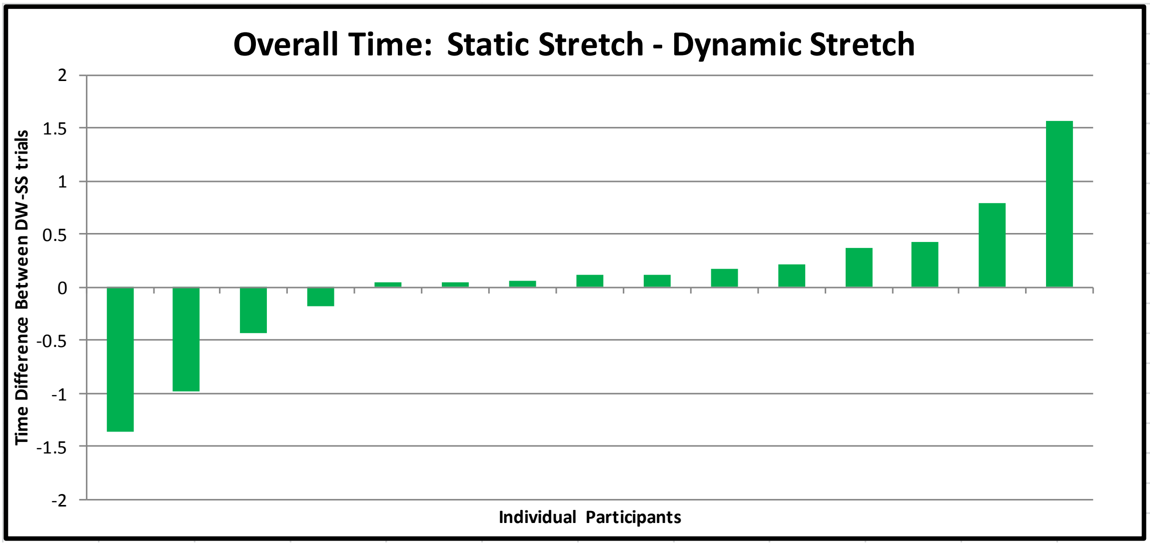

Figure 8: Illustration of The Differences In Overall 50-Meter Sprint Time For All Participants

No statistically significant differences were found when comparing means between static stretching and dynamic warm-up for all three distances: first 25-meter, second 25-meter times, and overall 50-meter. The *p*-values of all three distances are shown in Table 1 below.

Table 1: Paired Samples *t*-test - Significance Values of Each Distance Measured

Pair	Distance	*p*-value
Pair 1	First 25-meters time after static stretch warmup - 25 meters time after dynamic warm-up	0.28
Pair 2	Second 25 (of the 50) meters time after static stretch warmup - Second 25 (of the 50) meters time after dynamic warm-up	0.08
Pair 3	Overall 50-meters time after static stretch warmup - 50 meters time after dynamic warm-up	0.73

Strong positive correlations between the two types of stretches were found in all the distances calculated: first 25-meter, second 25-meter, and overall 50-meter times. Those correlation coefficients are shown in Table 2.

Table 2: Paired Samples Correlation Coefficients

Pair	Type	Correlation
Pair 1	First 25-meters time after static stretch warmup - 25 meters time after dynamic warm-up	$r = 0.96$, $p < .001$
Pair 2	Second 25 (of the 50) meters time after static stretch warm-up - Second 25 (of the 50) meters time after dynamic warm-up	$r = 0.92$, $p < .001$
Pair 3	Overall 50-meters time after static stretch warmup - 50 meters time after dynamic	$r = 0.96$, $p < .001$

CHAPTER IV

DISCUSSION

A review of the literature suggested that static stretching prior to dry land anaerobic power performance produces inferior results compared to dynamic warm-up procedures (Nelson et al., 2005; Yamaguchi & Ishii, 2005). This study was designed to show if there are similar inferior performance effects of static stretching versus dynamic warm-up on anaerobic sprint swimming power—specifically, on sprint freestyle—in the pool. In this study, based upon the results of the extant literature, it was hypothesized that a static stretch warm-up would produce inferior results compared to a dynamic warm-up. The results showed that there were no statistically significant differences between the mean sprint times following the two warm-up conditions, and thus, in this study, pre-performance static stretching was not shown to produce an inferior anaerobic power performance in the pool.

There are some factors that may have affected the results of this study. One factor in this study was the timing of the study. The study was conducted after the conclusion of the collegiate swim season, and consequently, all participants had taken one to two months off from intense swim training on a daily basis. Because the participants were not in hard training during this study, it is possible that they may have been less motivated and more inconsistent with their swimming than during a regular season. These possibilities were not formally investigated during, or after the procedures of the study, so in the absence of further research, can only be taken as conjecture.

Another factor that may have influenced the results of this study is that the participants had to perform a relatively unfamiliar skill during each test. As noted in the method section, because of a problem with the siting of the electronic touch pads, the participants were asked to perform a one-handed touch-and-turn at the 25-meter mark instead of the normal flip turn. This may have introduced error because the participants were not used to completing a 50-meter race in a short course pool with a hand touch-and-turn versus the conventional flip turn. Participants may have slowed down in their trials when approaching the turn in order to properly execute the one handed touch. Since there was no practice for this skill given to the participants prior to the test, and since all of them do not compete and practice this distance with a one-handed touch, this could have affected the results.

Because a typical warm-up prior to swimming competition has the athletes stretch before completing an in-water warm-up to get ready for their performance, that sequence was followed in this study so as to maximize its ecological validity. Thus, it may be that any positive or negative effects of both dynamic warm-up and static stretching could have been "remediated" or blunted by the subsequent in-water swimming warm-up. This possibility is suggested by the results of the study by Faigenbaum et al. (2006), which showed that dynamic exercise performed after static stretching in warm-up could have remediated the static stretching effects. Of course, it is also possible that any benefits of a dynamic stretch may have been blunted by the in-water warm-up. Alternatively, it is also quite plausible that any effects—positive or negative—of the warm-up modalities could have waned in the time interval between their completion and the sprint swim—about 20-30 minutes in this study. Clearly the timing of warm-up before competition, as well as the modality issues explored here are of interest to coaches and swimmers, and more research is warranted on those topics.

Of course, the hypothesis was not supported in this study as evidenced by the fact that there was simply no difference between the effects of static stretching and a dynamic warm-up when it comes to 50-meter sprint swimming performance. However, given the limitations of this study, further research utilizing stronger experimental designs is needed to provide better evidence on the topic.

Specifically, it would be preferable to conduct future studies on the topic during a point of the regular swim season where swimmers are more likely to be able to produce consistent sprint performances—perhaps following a major meet that the swimmers have tapered for. Obviously, it would also be preferable to ensure that the participants could utilize their usual flip turn during the 50-meter sprint performance race as they do in actual competition.

In order to determine whether or not in-water warm-up after static stretching or dynamic warm-up remediates and/or blunts their effects, future studies could be designed to contrast the different sequences head-to-head. For example, the traditional in-water warm-up could be performed before either static stretching or dynamic dry land warm-up—or the in-water warm-up could be deleted entirely.

In conclusion, because this study found no difference between experimental conditions, and because it also had several obvious limitations, its results cannot be used to support a case for or against the use of static stretching versus dynamic warm-up procedures prior to sprint swimming competitive performance. Further studies utilizing the stronger design suggestions given above are warranted given the implications to competitive swimmers and coaches alike.

APPENDICES

Appendix A
Consent Form

INFORMED CONSENT

TITLE:	*The effect of static stretching versus dynamic movement warm-ups on sprint performance in swimming.*
PROJECT DIRECTOR:	*Michael Moran*
PHONE #	*701-777-2454*
DEPARTMENT:	*Physical Education and Wellness*

STATEMENT OF RESEARCH

A person who is to participate in the research must give his or her informed consent to such participation. This consent must be based on an understanding of the nature and risks of the research. This document provides information that is important for this understanding. Research projects include only subjects who choose to take part. Please take your time in making your decision as to whether to participate. If you have questions at any time, please ask.

WHAT IS THE PURPOSE OF THIS STUDY?

You are invited to be a part of a research study about the effects of static stretching versus dynamic movement warm-ups procedures and their effects on sprint swimming performance. Because you are a member of the University of North Dakota Swimming Team, you have been selected as potential participants for this study.

The purpose of this research study is examine the effects of static stretching versus dynamic movement warm-up and the effects each will have on your sprint swimming performance. Based on the results of this study, it may help coaches determine which is better for their athletes. To date, there is no research on supporting a claim as to which is better. Approximately 40 people will be asked to take part in this study. Your participation in the study will last a total of 3 hours. You will need to report to the Hyslop Swimming Pool two times to complete each procedure. Each visit will take about 1.5 hours.

WHAT WILL HAPPEN DURING THIS STUDY?

You will report to the Hyslop Swimming Pool at the time designated to begin the study. Each participant will be randomly selected to complete each condition of the study. After selection, you are required to swim an in-water warm-up similar to what you do when you compete at swim meets. This should take no longer than 45 minutes. Once finished, you will be asked to complete nine different stretches or movements as required by the investigator for each condition. Both static stretching and dynamic movement warm-up will take no longer than 15 minutes to complete. After each condition is completed, a five minute break will be given followed by the completion of a 50-meter sprint. Data will be collected at both the 25-meter and 50-meter mark, however, you will not be able to see the results until after all research is completed. Following the main part of the study (stretching protocols and sprints) you will be asked to fill out a questionnaire about your experience in the study.

WHAT ARE THE RISKS OF THE STUDY?

There may be some risk from being in this study, which include fatigue, muscle soreness, and the possibility of pulled muscle(s). All of such risks are not viewed as being in excess of "minimal risk".

WHAT ARE THE BENEFITS OF THIS STUDY?

You may or may not benefit personally from being in this study. However, we hope that, in the future, other people might benefit from this study because the results of this study may be used by other swim coaches who are looking for answers as to what type of stretching may be more beneficial for their swimmers.

WILL I BE PAID FOR PARTICIPATING?

You not be paid for being in this research study.

WHO IS FUNDING THE STUDY?

The University of North Dakota and the research team are receiving no payments from other agencies, organizations, or companies to conduct this research study.

CONFIDENTIALITY

The records of this study will be kept private to the extent permitted by law. In any report about this study that might be published, you will not be identified. Your study record may be reviewed by Government agencies, the UND Research Development and Compliance office, and the University of North Dakota Institutional Review Board. Any information that is obtained in this study and that can be identified with you will remain confidential and will be disclosed only with your permission or as required by law.

If we write a report or article about this study, we will describe the study results in a summarized manner so that you cannot be identified.

IS THIS STUDY VOLUNTARY?

Your participation is voluntary. You may choose not to participate or you may discontinue your participation at any time without penalty or loss of benefits to which you are otherwise entitled. Your decision whether or not to participate will not affect your current or future relations with the University of North Dakota. Your decision to participate or not participate in this study will have no effect on your status as a member of the University of North Dakota Swim Team. Furthermore, it will have no bearing on future events that the UND Swim Team will participate in.

If at any time you wish to withdraw from this study, you may do so at any time. Also, if you experience health related problems such as pulled muscles, muscle strain, pain, or overuse, you may be asked to leave the study.

CONTACTS AND QUESTIONS?

The researchers conducting this study are Michael Moran and Dr. James Whitehead. You may ask any questions you have now. If you later have questions, concerns, or complaints about the research please contact Michael Moran at 701-777-2454 during the day and at 920-203-3560 after hours. You may also contact Dr. James Whitehead at 701-777-4347.

If you have questions regarding your rights as a research subject, or if you have any concerns or complaints about the research, you may contact the University of North Dakota Institutional Review Board at (701) 777-4279. Please call this number if you cannot reach research staff, or you wish to talk with someone else.

Your signature indicates that this research study has been explained to you, that your questions have been answered, and that you agree to take part in this study. You will receive a copy of this form.

Subjects Name: ____

___________________________________ ____________________
Signature of Subject Date

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