A COMPARISON OF AN ACUTE BOUT OF STATIC OR DYNAMIC STRETCHING ON A MEASURE OF FUNCTIONAL MOVEMENT

By

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Maryann Sibrizzi

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ABSTRACT

MARYANN SIBRIZZI: A Comparison of an Acute Bout of Static or Dynamic Stretching on a Measure of Functional Movement

(Under the direction of Dr. Edward Robinson)

Objective: To determine the effects of a single bout of either static or dynamic stretching on the range of motion in the joints of the lower extremities, like the knee and ankle< during an assessment that tests functional movement. **Design and Setting:** An experimental cross-over design was used to compare static stretching, dynamic stretching, and a control group (n=20) on acute changes after a single bout of warm up. **Subjects:** Twenty recreationally trained women (21.50 ± 2.50y, 163.89 ± 9.80cm, and 67.63 ± 18.14KG) enrolled at Meredith College between the ages of 18 and 35 volunteered to participate. **Measurements:** Flexibility of the knee, ankle, hamstring, and lumbar spine were evaluated. A repeated-measures model analysis of variance and the Friedman Test were used for statistical analysis. **Results:** There were no significant differences between the control, static, and dynamic for the Sit-and-Reach distances with $F = 2.478$, $p = 0.106$, ankle range of motion with the In-Line Lunge with $F = 0.794$, $p = 0.422$, the knee range of motion with $F = 0.903$, $p = 0.385$, or ankle range of motion with the Deep Squat with $F = 0.606$, $p = 0.545$. There were also no significant differences between the control, static, and dynamic for the Functional Movement Screen Deep Squat with $p = 0.449$, Functional Movement Screen In-Line Lunge with $p = 0.867$, Functional Movement Screen Active Straight-Leg Raise of the left leg with $p = 0.565$, Functional Movement Screen Active Straight-Leg Raise with $p = 0.321$, or the Hurdle Step with $p = 0.054$. **Conclusion:** The results suggest that an acute bout of dynamic stretches, static stretches, or no stretches does not improve overall flexibility.

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CHAPTER 1 - INTRODUCTION

Stretching as a portion of warm-up before participating in various types of physical activity is a common practice and is often considered mandatory prior to physical activity. The most prevalent reason cited for stretching as a warm-up before participating in physical activity is to prevent injury. Athletic trainers and physical therapists state, "If the body is not adequately prepared for the demands of the upcoming sport or activity, injury is more likely to occur" (Ransom 2015). Proper warm-up has been suggested to decrease the likelihood of enduring an injury. The main purpose of stretching is to increase the pliability and flexibility of the muscles with "an increase in flexibility acutely over time generally thought to reduce the incidence of injury" (Aguilar, 2006). There are many different types of stretching that can be done before physical activity. An active warm-up (like jogging) and an added static stretching, or an active warm-up and dynamic stretching are the most common types of warm-up. There have been debates and numerous studies comparing static and dynamic stretching and how they affect the body. Each person or athletic program may have their own rituals on how to perform warm-ups but the studies "suggest that dynamic stretching may increase acute muscular power to a greater degree than static and proprioceptive neuromuscular facilitation (PNF) stretching" (Manoel, 2008). The dynamic warm-up is an alternative to the static warm-up because it involves a combination of multiplane movement, muscular force production and bodily momentum to aid in the stretching of a muscle group through its full range of motion, while the traditional, static stretch simply involves maintaining a prolonged stretch on a single muscle or muscle group (Mahrova, 2014). In addition to the differences in the nature and biomechanical aspects of the two forms of

stretching, it has been reported that limitations may exist for the ability of static stretching to aid athletes in avoiding muscle strains or enhance their performance.

The Functional Movement Screen (FMS) is a widely used apparatus in the world of athletic training and performance. "The Functional Movement Screen assesses seven basic movement patterns to identify tightness and weakness in the body – so you can correct them before they cause major problems" (Liu 2009), and it is mostly used to determine the likelihood for a person or athlete to undergo and injury during an athletic season. It has recently gained more popularity and usage because of its user-friendly apparatus and because it "gives a good baseline of abilities and, through rescreening, provides a consistent measure of progress" (Liu 2009). Deep squat, hurdle step, in-line lunge, shoulder mobility, active straight-leg raise, trunk stability, and rotational stability are the seven movements performed during the FMS. Each movement is scored from a zero to a three. A zero is scored if any pain occurs during the movement, while the one through three scoring is up to the principle investigator's discretion.

To date, no study has compared the effect of a single bout of either static or dynamic stretching on the range of motion in the joints of the lower extremities (knee, ankle) during an assessment that tests functional movement.

Statement of Purpose

Stretching is a commonplace practice before or after a bout of exercise. The purpose of this study is to determine the effects of a single bout of either static or dynamic stretching

on the range of motion in the joints of the lower extremities (knee, ankle) during an assessment that tests functional movement.

Dependent Variables

1. Flexibility of lower extremity joints measured by the FMS
    a. Deep Squat score on 0-3 scale
    b. In-Line Lunge score on 0-3 scale
    c. Active Straight-Leg Raise score on 0-3 scale
    d. Hurdle Step score on 0-3 scale
2. Degrees of range of motion measured by ImageJ
    a. Angle of knee and ankle during deep squat
    b. Angle of ankle during in-line lunge
3. Flexibility of hamstrings by measure of sit-and-reach test
    a. Maximum distance of reach

Independent Variables

1. Group – control group, static stretching, or dynamic stretching

Hypothesis

1. Static and dynamic stretching prior to performing the FMS will result in a better score than no warm-up.
2. Dynamic stretching prior to performing the FMS will result in a better score than static stretching.

Definition of Terms

1. Static stretching: Common stretches of the lower extremity muscle groups used for pre-activity warming up. The subject lengthened a muscle group to its end range of motion until they felt a mild "stretch", then they statically held the position for 30 seconds. Subjects performed the stretch with both legs (Aguilar, 2006).
2. Dynamic stretching: Also a common stretch of the lower extremity muscle groups used for pre-activity warming up. The subject performed the four different stretches, holding each for five seconds (typically to the muscle's end of range of motion), and then switched to opposite leg. This was repeated for five repetitions.
3. Functional Movement Screen (FMS): Grading system that documents movement patterns that are key to normal function.
4. Sit-and-Reach: Common measure of flexibility, which typically measures the flexibility of the lower back and hamstring muscles

Operational Definitions

1. Recreationally trained woman: Woman who actively participates in physical activity on a daily basis (running, jogging, dancing, weight-lifting, etc.)
2. Flexibility: Active range of motion to end range for the hamstrings, knee, and ankle. An imaging software and a sit-and-reach test was used to measure flexibility.

3. ImageJ: imaging software that was used to measure the degrees of range of motion at the knee and ankle.

CHAPTER 2 - REVIEW OF LITERATURE

Static and Dynamic Stretching

Aguilar, Distefano, Brown, Herman, Guskiewicz, Padua (2006)

A Comparison of a Standard Warm-Up Model and a Dynamic Warm-Up Model on Flexibility, Strength, Vertical Jump Height, and Vertical Jump Power

The aim of this study was to compare the acute effects of a dynamic warm up and standard warm up on hamstring, quadriceps, and hip flexor flexibility, quadriceps and hamstring strength, and vertical jump height power. Aguilar hypothesized that the dynamic warm up would be a better option than the standard warm up if the dynamic warm up could positively affect injury risk factors. The data showed significant group and time interaction for hamstring flexibility, with hamstring flexibility within the dynamic warm up group being significantly greater at post-test than at pre-test. Overall, the study was concluded with an improvement in hamstring flexibility and eccentric quadriceps strength with an acute bout of a dynamic warm up.

Mahrova, Hrasky, Zahalka, Pozarek (2014)

The Effect of Two Types of Stretching on Flexibility in Selected Joints in Youth Soccer Players

A study was performed to compare the effects of only using a static stretching program with a combination of dynamic and static stretching program on flexibility in selected lower-extremity joints. Included in the study were 25 boys under the age of 13, with

12 in one group and 13 in another group. The stretching program for the boys lasted 6 months. Group one performed static stretching only, while group two performed static and dynamic stretching. Post-test data after static stretching and for static/dynamic showed improvements in shortening of numerous muscles. The average ROM in the ankle for group two reached population standards.

Manoel, Harris-Love, Danoff, Miller (2008)

Acute Effects of Static, Dynamic, and Proprioceptive Neuromuscular Facilitation Stretching on Muscle Power in Women

The purpose of this study was to analyze the acute effects of static, dynamic, and PNF on peak muscle power output in women. Each subject performed five minutes of stationary cycling before performing one of the four treatments. None of the stretching protocols caused a decrease in knee extension power. Dynamic stretching, however, produced somewhat of an increase in peak knee extension power, more so than static stretching and PNF stretching. In conclusion, the findings suggest that dynamic stretching may cause more muscular power than static and PNF stretching.

Page, Phil (2012)

Current Concepts in Muscle Stretching for Exercise and Rehabilitation

Page compares the different types of stretching for a particular goal or outcome. The purpose of his article was to discuss the current norms of muscle stretching interventions and explain evidence where those stretches are used in exercise and rehabilitation. He goes on to explain the importance of ROM in the joints, where on the contrary, limited ROM may create

muscle imbalances. The most important stretches he discusses are static, dynamic, and pre-contraction stretching, with the most common being static. He has analyzed other studies that are categorized into either acute or training effects, studies with different muscle groups of importance, and variety of populations. In whole, static stretching as a part of a warm-up immediately prior to exercise has shown to be detrimental and has shown a loss of strength in participants of studies.

Ransom, Jon (2015)

Dynamic Flexibility vs. Static Stretching for Warm Up

The aim of this article was to inform readers with tips for good static and dynamic stretching before a bout of physical activity. Just as stated previously, static stretching used to be the "go-to" stretching protocol for a warm-up. However, there have been more programs now utilizing the dynamic warm up. The article also goes into detail of which elements of the body are being affected by the different types of stretching protocols.

The Functional Movement Screen

Cook, Burton, Hoogenboom (2006)

Pre-Participation Screening: The Use of Fundamental Movements as an Assessment of Function – Part 2

The Functional Movement Screen (FMS) is used to demonstrate the ability to perform movements that are typically done in the everyday life of an individual. It is mostly performed on athletes for pre-season to determine the likelihood of injury. For a majority of

the article, the seven different movements of the FMS are broken down into detail, along with how to score each of the functional movements.

Kraus, Schutz, Taylor, Doyscher (2014)

Efficacy of the Functional Movement Screen

This is another research study that researched articles that involved the FMS and how often it is used nowadays. There were more than 400 citations within a 9 year period, making the FMS a reliable tool to use for pre-testing athletes and for usage by clinicians. The lowest score of a movement that tested the left side and the right side of the body was used in the overall score. It was also recommended that the same person proctor the FMS testing each time to reduce the amount of intra-rater and inter-rater reliability. In conclusion, the FMS was suggested to be a reliable method for estimating the probability of an athlete injuring themselves.

Song, Woo, So, Kim, Lee, Kim (2014)

Effects of 16-week Functional Movement Screen Training Program on Strength and Flexibility of Elite High School Baseball Players

Preventing injuries is a common denominator for many sports programs. The FMS training program, to find the effects on flexibility and strength, was used determine the likelihood of injury for a certain group of boys. 62 elite male high school baseball players were included in the study: 31 in the control group and 31 in the training group. It was specified that if an athlete's total score is less than 14, then they are more likely to get injured. Subjects performed hand grip strength, back muscle strength, bench-press and squat

(one max rep) to measure strength, and trunk extension and splits measured flexibility. According to the results, when armed with functional movements, an athlete is expected to show an improvement in motion performance capability and techniques, and that if an athlete lacks functional movement patterns, it can deteriorate the efficiency and effectiveness of exercising power. With regard to flexibility, all factors except for body flexion showed significant improvements after the 16-week FMS training program.

CHAPTER 3 - METHODS

Experimental Design

To investigate the effects of dynamic stretching versus static stretching on flexibility, a crossover design with a repeated measures model was used with one between factor (control, static stretching, or dynamic stretching). Data was collected for each treatment of control, dynamic, or static stretching.

Subjects

Twenty recreationally trained women (21.50 ± 2.50y, 163.89 ± 9.80cm, and 67.63 ± 18.14KG) enrolled at Meredith College between the ages of 18 and 35 were recruited for this study. Because of the crossover design, each subject participated in the control, static stretching, and dynamic stretching group. Prior to testing, participants consented to physical activity and filled out a Confidential and Activity History questionnaire and to ensure she was free of any physical limitations. Each subject self-reported of being a recreationally trained woman. Subjects' height and age were self-reported as well, with weight being measured by the principle investigator after all documents were filled out. All procedures were reviewed and approved by the Meredith College Institutional Review Board.

Procedures

All subjects were asked to report to the Human Performance lab a total of five times. The initial visit consisted of participant screening (informed consent and medical history form). Next, the participant reported for a 20 minute familiarization session prior to the testing session. The session was performed at least 24 hours after the initial visit. The

familiarization session was necessary in order to acquaint the subjects with the dynamic warm-up, static warm-up, and FMS protocol for increasing subject safety, warm up effectiveness, and testing time efficiency. On each of three subsequent visits, subjects performed one of the two experimental protocols (static warm up or dynamic warm up-for protocol) followed by the functional movement screen or control (no stretching warm up) followed by the functional movement screen. The order in which the individuals performed the experimental and control days, were randomly assigned for each individual. Testing occurred after each of the three different stretching warm-ups. Each warm-up was performed and the Functional Movement Screen assessed. Measurement of ROM included markers placed on the skin of the participant at specific anatomical points (knee, ankle, and fifth metatarsal of the right leg). These markers allowed the investigators to determine the ROM at various lower-extremity joints with the use of digital image software. Distances of a Sit-and-Reach test were taken three consecutive times at each visit, with the farthest distance being used in the data set. Data was collected and stored on password protected computers and was analyzed with statistical models to find their significance, and to compare dynamic and static stretching.

Data collection

Range of Motion Assessment

Ankle and knee ROM were assessed using the ranking scale of the FMS and by degrees ROM at each of the joints. A marker was placed on the lateral epicondyle, lateral malleolus, and fifth metatarsal head of the right leg. A video recording was taken of the participant during the Deep Squat and In-Line Lunge of the FMS. In the video of the Deep

Squat, and image was taken at the point where the participant was as deep in the squat as she could be, and the dowel, knees, and toes in line. During the video of the In-Line Lunge, an image was taken when the participant had her left knee touching the floor, the upper-body as upright as possible, and the right heel still stationed on the floor. Those images were then uploaded to ImageJ, where the degrees of ROM were calculated. To assess the ROM at the knee, a line was drawn from the hip joint, to the knee, and then to the ankle (see Image 1 in Appendix B), and for the ankle, a line was drawn from the knee, to the ankle, and finally to the fifth metatarsal head (see Image 1 and Image 2 in Appendix B).

Flexibility Assessment

Ankle, knee, and hamstring flexibility were assessed with the Functional Movement Screen and Sit-and-Reach test.

1. The Deep Squat was used to assess knee and ankle flexibility. The participant was asked to place the back of her heels on the FMS apparatus, hold the FMS dowel above her head with arms fully extended, and squat down as deep as she could go without bending over at the waist or putting her knees over her toes. Subject received a 0 if there was any pain involved, a 1 if she lost her balance at any time or if she bent over at the waist too much, or if her back wasn't straight, a 2 if there was slight variation from a 1, and a 3 if she could squat down as deep as possible with a straight back, dowel above her head at all times, and knees not over the toes.
2. The In-Line Lunge was used to assess ankle flexibility, and for other purposes, assesses lumbar spine flexibility. Participant was scored with a 0, 1, 2, or 3 depending on the execution of the lunge. A 3 was given is the participant could lunge down with the back straight, and dowel kept vertical the whole time while lunging down and

coming back up. The score of 2 and 1 follow from the 3, and the subject received a 0 if there was any pain during the movement.

3. The Active Straight-Leg Raise was used to assess hamstring flexibility. The participant received a 3 if she could raise her leg past the dowel that I was holding between her knee and hip. If the foot was right at the dowel, she received a 2. If she could not get it near the dowel, she received a 1 and 0 if there was any pain produced during the movement.
4. The Hurdle Step was used to assess the knee and ankle. If participant could step over the hurdle without compensating at the hips or back, kept the foot flexed the whole time, and did not lose balance, she would receive a score of 3. A score of 2 or 1 was given if she could not perform the hurdle step as stated earlier, and she was given a 0 if she had pain during the movement.
5. The Sit-and-Reach was used to assess hamstring flexibility. Participant's reach was measured three consecutive times in centimeters. The farthest distance was used for data.

Stretching Procedures

Static Stretching

1. Ankle: Wall Stretch – Right leg forward (slightly bent) with left foot back and fully extended. Place both hands on the wall and apply pressure with hands. Push left leg back and right leg forward. Hold for 30 seconds. Repeat the same with the legs switched.

2. Hamstring: Standing Wall Stretch – With the body facing the wall, place both hands on the wall. Put the left leg forward and right leg back. Left foot should be resting on its heel and leg is fully extended. Right leg should be bent and leaning forward. To feel stretch, lean back while still having hands on the wall. Hold for 30 seconds and switch legs for other side.
3. Lumbar: Sitting Spine Stretch – Buttocks on the floor with legs straight out. The body should make an L shape. Cross the left leg over the right leg. Left leg is bent and close to the chest. Left foot should be flat on the floor. Place the right arm and elbow on the outside of the left leg. Push to the opposite (right direction) and head should face to the left. Hold for 30 seconds. Repeat same scenario with opposite side.
4. Knee: Quad Stretch – With the left hand on the wall, grab the right ankle with the right hand and reach back, with heel touching the buttocks (if possible). Hold for 30 seconds. Switch to other side and hold for 30 seconds.

Dynamic Stretching

1. Hamstring: Dipping Birds – Step forward with the right foot, bend forward at the waist, and reach left hand to the right foot without bending the knee. Return to standing position, then step forward with the left foot, bend forward at the waist, and reach right hand to the left foot without bending the knee. Do 10 reps for each leg.
2. Knee: Hamstring Curls & Knees to Chest – Take right leg and bend, bringing to chest or as high as possible. Squeeze leg with both arms extended and bring toward the body. Hold for 5 seconds and repeat 10 times. Repeat similarly to the left leg.
3. Lumbar: Lunge with Body Twist – Lunge with right leg forward, left leg back. Right knee should be over the ankle and left leg straight, toes on the ground. Place right

hand on the inside of the right leg with the left arm extended into the air. Twist body with head facing to the left. Hold for 10 seconds and switch arms. Repeat 10 times, with each right and left hand touching the ground as one repetition.

4. Ankle: Ankle Bounce - Stand facing a wall, 1 to 2 feet away from the wall. Lean forward so the hands touch the wall. While placing weight on feet, rather than on hands, elevate the heels 1 or 2 inches off of the floor. Lower back to the ground after heels have been elevated. Repeat ankle bounces five to 10 times.

The Functional Movement Screen

1. Deep Squat – Participant will be asked to hold a dowel rod directly above the head to keep hands and arms in place, and squat as low as possible with good form. Ideally, the upper torso will be parallel to the shins, thighs will be below horizontal, and the knees and dowel will be aligned over the feet. In faulty movement patterns, the heels might be off the ground, the dowel might fall forward, the squat might be too high, or there's twisting, leaning or other asymmetries.
2. In-Line Lunge - Used to screen ankle and knee stability, as well as abductor or adductor weakness. Once the administrator positions the participant's feet, she will do a basic lunge while holding the dowel behind her back, one hand near the neck, one hand near the lower back. Feet are pointed straight forward and in line with each other, until the back knee hits the floor. Return to starting position.
3. Active Straight Leg Raise – Used to assess hamstring flexibility. While lying on back, arms at sides, participant will be asked to raise one leg as high as it can go without bending the knee, while leaving the other leg on the floor (Liu 2009).

4. Hurdle Step – Used to screen hips, knees, and ankles. Step over a hurdle that's a little below knee height. While holding the dowel across the shoulders, step over with one leg. Touch the heel down on the other side. Return to starting position.

Data Analysis

A repeated measures analysis of variance (ANOVA) was used to investigate possible main effects and interactions between static and dynamic stretching and for each dependent variable. Interaction effects were subsequently tested by Bonferroni *t* tests. The Friedman Test was used to analyze the differences between static and dynamic stretching in regards to the FMS score. SPSS 23 for Windows was used to analyze all data.

CHAPTER 4 - RESULTS

Sit-and-Reach Distance

There was no significance between the control, static, and dynamic for the Sit-and-Reach distances with $F = 2.478$, $p = 0.106$. Estimates for the mean, standard error, and confidence interval can be found in the appendix (Table 1).

Knee and Ankle ROM

There was no significance between the control, static, and dynamic for the ankle ROM with the In-Line Lunge with $F = 0.794$, $p = 0.422$. Estimates for the mean, standard error, and confidence interval can also be found in the appendix (Table 2). There was no significance between the control, static, and dynamic for the knee ROM with $F = 0.903$, $p = 0.385$. Estimates for the mean, standard error, and confidence interval can also be found in the appendix (Table 3). There was no significance between the control, static, and dynamic for the ankle ROM with the Deep Squat with $F = 0.606$, $p = 0.545$. Estimates can be found in Table 4 of the appendix.

Functional Movement Screen Scales

A Friedman Test revealed no significance between the control, static, and dynamic for the Deep Squat with $p = 0.449$. There was no significance between the control, static, and dynamic for the In-Line Lunge with $p = 0.867$. Once again, no significance between the control, static, and dynamic for the Active Straight-Leg Raise of the left leg with $p = 0.565$. For the right leg, the Active Straight-Leg Raise had no significance between the control, static, and dynamic treatments with $p = 0.321$. There was no significance between the control, static, and dynamic for the Hurdle Step with $p = 0.054$. The median score for all Functional Movement Screen movements was 2.00.

CHAPTER 5 - DISCUSSION

The findings indicate that there was no difference between static and dynamic stretching with the amount of flexibility each participant achieved. This may be due to the fact that there was such a small sample size, or because there were not enough stretches in each treatment performed. There was not a change from day to day in ROM of the knee for the Deep Squat and ankle for In-Line Lunge. Further, there was no difference in scores of FMS testing scores from day to day. However, although non-significant, there might be a difference with the hurdle step from day to day because of the amount of flexibility required to perform the movement correctly. All of the participants stretched or sat for approximately five minutes, which may have not been enough time for the necessary muscles to warm up and get flexible, thus not showing any changes when doing the movements of the FMS. A longer bout of stretching or additional stretches to each treatment may have shown significant results.

In addition to the lack of significance between treatments to affect the FMS, this study also demonstrated that there was no difference between stretching technique and no stretching on the measure of lumbar-thoracic flexibility as measured by the sit-and-reach test. This result may have been influenced by a lack of focus on the stretches that could be applied to the back and upper body. Future studies may wish to incorporate a whole body stretching program to determine if sit-and-reach scores can be affected by warm-up protocol among active, college aged women.

The results of this study suggest that a single bout of stretching, either static or dynamic, did not provide enough of a biomechanical advantage to affect a measure such as

the FMS. The current study demonstrates that among college-aged women who are recreationally active, the style of stretching that is performed prior to physical activity may not result in an advantage to functional movement.

APPENDICIES

APPENDIX A

TABLES

Table 1 – Estimates for Sit-and-Reach

Factor1	Mean	Std. Error	Lower Bound 95% CI	Upper Bound 95% CI
1	37.950	1.352	35.119	40.781
2	38.525	1.225	35.961	41.089
3	39.288	1.111	36.962	41.613

Table 2 – Estimates for Ankle ROM (In-Line Lunge)

Factor1	Mean	Std. Error	Lower Bound 95% CI	Upper Bound 95% CI
1	87.975	1.299	85.256	90.694
2	89.505	87.220	84.562	94.448
3	87.220	1.606	83.858	90.582

Table 3 – Estimates for Knee ROM

Factor1	Mean	Std. Error	Lower Bound 95% CI	Upper Bound 95% CI
1	77.635	5.091	66.980	88.290
2	75.770	5.545	64.164	87.376
3	73.260	5.431	61.892	84.628

Table 4 – Estimates for Ankle ROM (Deep Squat)

Factor1	Mean	Std. Error	Lower Bound 95% CI	Upper Bound 95% CI

1	100.581	2.471	95.409	105.753
2	98.563	1.740	94.922	102.204
3	99.382	2.308	94.551	104.214

Table 5 – Descriptive Statistics for Sit-and-Reach

	Mean	Std. Deviation	N
Distance 1	37.9500	6.04838	20
Distance 2	38.5250	5.47777	20
Distance 3	39.2875	4.96850	20

Table 5 – Descriptive Statistics for Ankle ROM (In-Line Lunge)

	Mean	Std. Deviation	N
Squat 1	87.9750	5.81023	20
Squat 2	89.5050	10.56157	20
Squat 3	87.2200	7.18328	20

Table 6 – Descriptive Statistics for Knee ROM

	Mean	Std. Deviation	N
Squat 1	77.6350	22.76686	20
Squat 2	75.7700	24.79907	20
Squat 3	73.2600	24.28938	20

Table 7 – Descriptive Statistics for Ankle ROM (Deep Squat)

	Mean	Std. Deviation	N
Squat 1	100.58140	11.051024	20
Squat 2	98.56320	7.779911	20
Squat 3	99.38225	10.323638	20

APPENDIX B

ROM IMAGES

Lines drawn for degrees ROM at knee and degrees ROM at ankle (Deep Squat)

Image 1

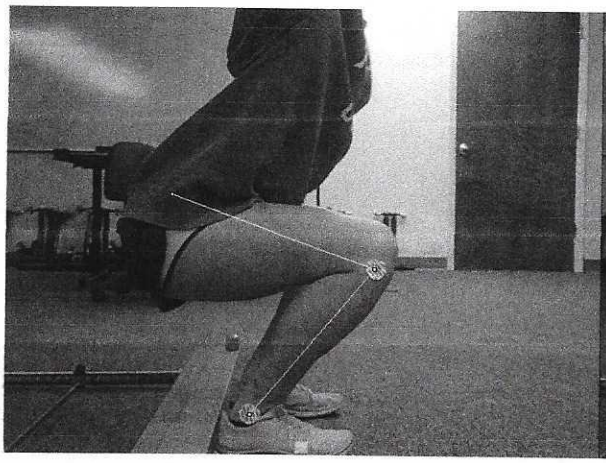
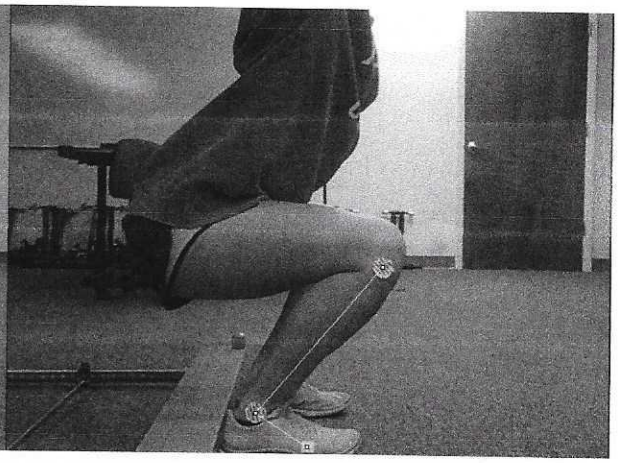
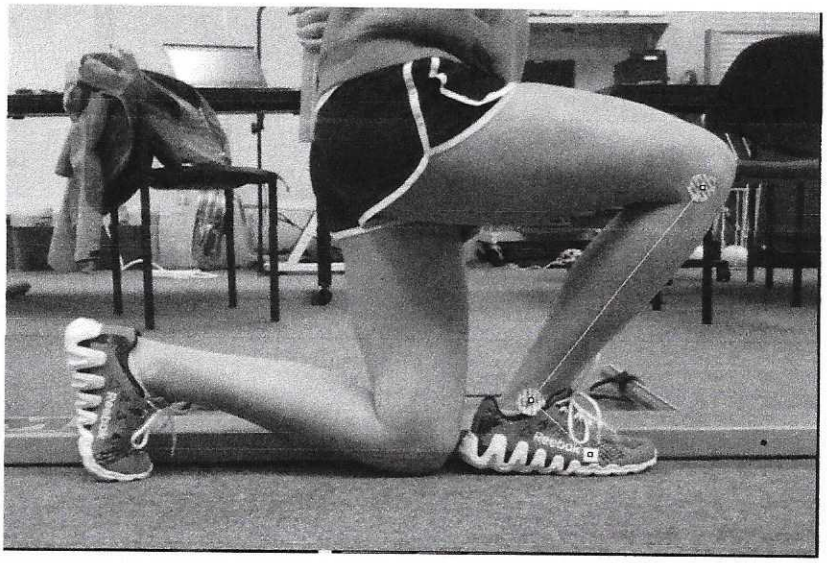


Image 2



Lines drawn for degrees of ROM at ankle (In-Line Lunge)

Image 3



APPENDIX C

IRB MATERIALS

A comparison of an acute bout of static or dynamic stretching on a measure of functional movement

Participant Population

Twenty women between the ages of 18 and 35 will be recruited for this study.

Rationale

Conducting studies to compare static versus dynamic stretching is widely known, but different areas of measurement need to be used. The Functional Movement Screen will provide a safe and accurate way to assess the flexibility of a participant when doing a static warm-up versus a dynamic warm-up. Using the Functional Movement Screen will provide an example of a dynamic movement, which may be performed during the course of an exercise regime or athletic event. Video will be used to capture the motion of participants and digital imaging software to measure the range of motion in the joints of lower-extremities will be employed. The participant group as a whole will benefit in the long run, by knowing their functional limitations and asymmetries, along with which type of stretching increases their flexibility in order to reduce injury.

Participant safety:

The risks involved with this study are minimal, but may include musculoskeletal injuries occurring during the stretching protocol. These injuries include muscle

strains and pulls. However, the stretching and functional movement portion of the study is similar to movements performed during average training sessions that all recreationally trained individuals have previously performed during exercise.

Provisions to maintain the privacy of the participants and confidentiality of data:

Participant's privacy will be protected at all times. Participants will be provided locker room access to change into their workout clothes if needed. All phlebotomy will be conducted in a private room. Participants will remain dressed in exercise clothes (shorts, t-shirt, socks and shoes) at all times. Video recording will be conducted to use in the analysis of range of motion, however, recording of participants will only take place from the umbilicus and below to ensure the anonymity of the participants. Recordings of participants will be labeled via subject number and will be maintained and analyzed on a password-protected computer.

The results of this study will be published as a group as part of a scientific publication. No individual results will be published or shared with any person or party. All information attained from the medical and activity questionnaires or performance tests will be held in strict confidence. Individual results will remain confidential and only be relayed to the participant upon request. All medical and activity questionnaires, as well as data collection sheets will be kept in a locked cabinet during and following the study. All information will be destroyed five years from the end of the study and not used for other research purposes. Participant

folders will be marked with an I.D. number to protect against a breach of confidentiality, and the ID number will be removed upon disposal.

Risk/Benefit

Although there is no direct benefit of the study to the participants, the use of a stretching regime before and after bouts of athletic performance is a commonplace practice. The type and nature of the stretching that occurs is often inserted simply as a rote designation without regard to the actual effect the program has on athletic performance, functional movement ability or range of motion.

Project Description

All subjects will be asked to report to the Human Performance lab a total of 6 times. The initial visit will consist of participant screening. Next, the participant will report for two familiarization sessions (20 minutes each) prior to the testing session. These sessions will be on separate days, and will be separated by no less than 24 hours and no more than a week. These familiarization sessions will be necessary in order to acquaint the subjects with the dynamic warm-up, static warm-up, and Functional Movement Screen protocol for increasing subject safety, warm up effectiveness, and testing time efficiency. On each of three subsequent visits, subjects will perform one of the two experimental protocols (static warm up or dynamic warm up-for protocol, see below) followed by the functional movement screen or control (no stretching warm up) followed by the functional movement screen. The order in which the individuals perform the experimental and control days will be randomly assigned for each individual. Dynamic stretching is actively moving a joint through the range of

motion required for a sport. While static stretching refers to holding a stretch with no movement. The Functional Movement Screen is a ranking and grading system that documents movement patterns that are key to normal function. Testing will occur before and after each of the three different stretching warm-ups. Each warm-up will be performed and the Functional Movement Screen assessed. Measurement of ROM will include markers placed on the skin of the participant at specific anatomical points. These markers will allow the investigators to determine the ROM at various lower-extremity joints with the use of digital image software. Data collected and stored on password protected computers and will be analyzed with statistical models to find their significance, and to compare dynamic and static stretching.

Protocol

Static Stretches:

Ankle: Wall Stretch – Right leg forward (slightly bent) with left foot back and fully extended. Place both hands on the wall and apply pressure with hands. Push left leg back and right leg forward. Hold for 30 seconds. Repeat the same with the legs switched.

Hamstring: Standing Wall Stretch – With the body facing the wall, place both hands on the wall. Put the left leg forward and right leg back. Left foot should be resting on its heel and leg is fully extended. Right leg should be bent and leaning forward. To feel stretch, lean back while still having hands on the wall. Hold for 30 seconds and switch legs for other side.

Lumbar: Sitting Spine Stretch – Buttocks on the floor with legs straight out. The body should make an L shape. Cross the left leg over the right leg. Left leg is bent and close to the chest. Left foot should be flat on the floor. Place the right arm and elbow on the outside of the left leg. Push to the opposite (right direction) and head should face to the left. Hold for 30 seconds. Repeat same scenario with opposite side.

Knee: Quad Stretch – With the left hand on the wall, grab the right ankle with the right hand and reach back, with heel touching the buttocks (if possible). Hold for 30 seconds. Switch to other side and hold for 30 seconds.

Dynamic stretches

Hamstring: Dipping Birds – Step forward with the right foot, bend forward at the waist, and reach left hand to the right foot without bending the knee. Return to standing position, then step forward with the left foot, bend forward at the waist, and reach right hand to the left foot without bending the knee. Do 10 reps for each leg. (Ransom 2015)

Knee: Hamstring Curls & Knees to Chest – Take right leg and bend, bringing to chest or as high as possible. Squeeze leg with both arms extended and bring toward the body. Hold for 5 seconds and repeat 10 times. Repeat similarly to the left leg.

Lumbar: Lunge with Body Twist – Lunge with right leg forward, left leg back. Right knee should be over the ankle and left leg straight, toes on the ground. Place right hand on the inside of the right leg with the left arm extended into the air. Twist body with head facing to the left. Hold for 10 seconds and switch arms. Repeat 10 times, with each right and left hand touching the ground as one repetition.

Ankle: Ankle Bounce - Stand facing a wall, 1 to 2 feet away from the wall. Lean forward so the hands touch the wall. While placing weight on feet, rather than on hands, elevate the heels 1 or 2 inches off of the floor. Lower back to the ground after heels have been elevated. Repeat ankle bounces five to 10 times. (Thompson 20##)

Functional Movement Screen

1) Deep Squat – Participant will be asked to hold a dowel rod directly above the head to keep hands and arms in place, and squat as low as possible with good form. Ideally, the upper torso will be parallel to the shins, thighs will be below horizontal, and the knees and dowel will be aligned over the feet. In faulty movement patterns, the heels might be off the ground, the dowel might fall forward, the squat might be too high, or there's twisting, leaning or other asymmetries (Liu 2009).

2) In-Line Lunge - Used to screen ankle and knee stability, as well as abductor or adductor weakness. Once the administrator positions the participant's feet, she will do a basic lunge while holding the dowel behind her back, one hand near the neck, one hand near the lower back. Feet are pointed straight forward and in line with each other, until the back knee hits the floor. Return to starting position (Liu 2009)

3) Active Straight Leg Raise – Used to assess hamstring flexibility. While lying on back, arms at sides, participant will be asked to raise one leg as high as it can go without bending the knee, while leaving the other leg on the floor (Liu 2009).

4) Hurdle Step – Used to screen hips, knees, and ankles. Step over a hurdle that's a little below knee height. While holding the dowel across the shoulders, step over with one leg. Touch the heel down on the other side. Return to starting position (Liu 2009).

MEREDITH
COLLEGE

A comparison of an acute bout of static or dynamic stretching on a measure of functional movement

Informed Consent

Principal Investigator(s): Maryann Sibrizzi

Edward H. Robinson IV, Ph.D.

Investigational Site(s): Meredith College

Human Performance Lab

Introduction: Researchers at the Meredith College study many topics. To do this we need the help of people who agree to take part in a research study. You are being invited to take part in a research study that will include 20 women at Meredith College. You have been asked to take part in this research study because you are an active young adult who routinely participates in recreationally training. You must be between 18 and 35 years of age to be included in this research study.

The principle investigators conducting the research are Maryann Sibrizzi and Dr. Edward Robinson (Department of Nutrition, Health, and Human Performance).

What you should know about a research study:

- Someone will explain this research study to you.
- A research study is something you volunteer for.

- Whether or not you take part is up to you.
- You should take part in this study only because you want to.
- You can choose not to take part in the research study.
- You can agree to take part now and later change your mind.
- Whatever you decide it will not be held against you.
- Feel free to ask all the questions you want before you decide.

1. **Purpose of the research study:** Stretching is a commonplace practice before or after a bout of exercise. The purpose of this study is to determine the effects of a single bout of either static or dynamic stretching on the range of motion in the joints of the lower extremities (knee, ankle) during an assessment that tests functional movement.

Inclusion and Exclusion Criteria

Inclusion criteria:

- Recreationally trained women measured through self-reporting of exercise.
- Free of any physical limitations as determined by the Confidential Medical and Activity History questionnaire and/or PAR-Q
- Between the ages of 18 and 35

Exclusion criteria:

- Inability to perform physical exercise, as determined by the Confidential Medical and Activity History questionnaire and/or PAR-Q

- Any chronic illness that causes continuous medical care and would be affected by stretching

Testing location and time requirements:

All testing will be conducted in the Human Performance Lab (HPL) in the Weatherspoon Annex building at Meredith College. All measures and tests are conducted for research purposes only. The results will not be used to diagnose any illness or disease, and will not provide any meaningful information to your physician.

Time requirements: We expect that you will be in this research study for approximately 2 weeks and will consist of 6 visits to the HPL. The first visit will last approximately 30 minutes, the second and third visits about 20 minutes, and the final 3 visits will last approximately 30 minutes each.

What you will be asked to do in the study:

Upon being admitted to the study you will be assigned a subject number. This number will be used on all testing forms and will be kept separate from your medical history and PAR-Q.

Preliminary Visits (3):

Visit 1: You will be asked to read and sign this consent form before any study-related procedures are performed. During this first visit, the following will be done:

- Complete the Physical Activity Readiness Questionnaire (PAR-Q)
- Complete the self-reported medical and activity history questionnaire
- Your age, race and gender will be collected

- Your body measurements (height, weight) will be measured

Visits 2&3: The second visit will take place at least 24 hours following visit 1. On this visit, you will be instructed on and asked to practice the protocols (static/dynamic stretching and functional movement screen—see below for description) involved in the study.

Visits 4-6: These visits will take place no sooner than 24hrs following visit 3. On these visits you will be asked to complete 1 of three protocols assigned in random order:

- **Control Visit** – You will be asked to remain seated for a period of 5 minutes after which time you will complete the functional movement screen
- The Functional Movement Screen will consist of per\forming the following movements:
    1) Deep Squat – Participant will be asked to hold a dowel rod directly above the head to keep hands and arms in place, and squat as low as possible with good form. Ideally, the upper torso will be parallel to the shins, thighs will be below horizontal, and the knees and dowel will be aligned over the feet. In faulty movement patterns, the heels might be off the ground, the dowel might fall forward, the squat might be too high, or there's twisting, leaning or other asymmetries (Liu 2009).
    2) In-Line Lunge - Used to screen ankle and knee stability, as well as abductor or adductor weakness. Once the administrator positions the participant's feet, she will do a basic lunge while holding the dowel behind her back, one hand near the neck, one hand near the lower back. Feet are pointed straight forward and in line

with each other, until the back knee hits the floor. Return to starting position (Liu 2009)

3) Active Straight Leg Raise – Used to assess hamstring flexibility. While lying on back, arms at sides, participant will be asked to raise one leg as high as it can go without bending the knee, while leaving the other leg on the floor (Liu 2009).
4) Hurdle Step – Used to screen hips, knees, and ankles. Step over a hurdle that's a little below knee height. While holding the dowel across the shoulders, step over with one leg. Touch the heel down on the other side. Return to starting position (Liu 2009).

- **Static Stretch Visit** – you will be asked to perform the following static stretches prior to performing the Functional Movement Screen:

1) Ankle: Wall Stretch – Right leg forward (slightly bent) with left foot back and fully extended. Place both hands on the wall and apply pressure with hands. Push left leg back and right leg forward. Hold for 30 seconds. Repeat the same with the legs switched.
2) Hamstring: Standing Wall Stretch – With the body facing the wall, place both hands on the wall. Put the left leg forward and right leg back. Left foot should be resting on its heel and leg is fully extended. Right leg should be bent and leaning forward. To feel stretch, lean back while still having hands on the wall. Hold for 30 seconds and switch legs for other side.
3) Lumbar: Sitting Spine Stretch – Buttocks on the floor with legs straight out. The body should make an L shape. Cross the left leg over the right leg. Left leg is bent and close to the chest. Left foot should be flat on the floor. Place the right arm and

elbow on the outside of the left leg. Push to the opposite (right direction) and head should face to the left. Hold for 30 seconds. Repeat same scenario with opposite side.

4) Knee: Quad Stretch – With the left hand on the wall, grab the right ankle with the right hand and reach back, with heel touching the buttocks (if possible). Hold for 30 seconds. Switch to other side and hold for 30 seconds.

- **Dynamic Stretch Visit --** you will be asked to perform the following dynamic stretches prior to performing the Functional Movement Screen:

1) Hamstring: Dipping Birds – Step forward with the right foot, bend forward at the waist, and reach left hand to the right foot without bending the knee. Return to standing position, then step forward with the left foot, bend forward at the waist, and reach right hand to the left foot without bending the knee. Do 10 reps for each leg. (Ransom 2015)
2) Knee: Hamstring Curls & Knees to Chest – Take right leg and bend, bringing to chest or as high as possible. Squeeze leg with both arms extended and bring toward the body. Hold for 5 seconds and repeat 10 times. Repeat similarly to the left leg.
3) Lumbar: Lunge with Body Twist – Lunge with right leg forward, left leg back. Right knee should be over the ankle and left leg straight, toes on the ground. Place right hand on the inside of the right leg with the left arm extended into the air. Twist body with head facing to the left. Hold for 10 seconds and switch arms. Repeat 10 times, with each right and left hand touching the ground as one repetition.

4) Ankle: Ankle Bounce - Stand facing a wall, 1 to 2 feet away from the wall. Lean forward so the hands touch the wall. While placing weight on feet, rather than on hands, elevate the heels 1 or 2 inches off of the floor. Lower back to the ground after heels have been elevated. Repeat ankle bounces five to 10 times. (Thompson 20##)

Risks:

The risks involved with this study are minimal, but may include musculoskeletal injuries occurring during the stretching protocol. These injuries include muscle strains and pulls. However, the stretching and functional movement portion of the study is similar to movements performed during average training sessions that all recreationally trained individuals have previously performed during exercise.

You should report any discomforts or injuries to the principle investigator Edward Robinson, 919-760-2319, ehrobinson@meredith.edu.

Benefits

There are no direct benefits to participants.

Compensation or payment:

There is no compensation associated with participation in this study.

Confidentiality: Participant's privacy will be protected at all times. Participants will be provided locker room access to change into their workout clothes if needed. All phlebotomy will be conducted in a private room. Participants will remain dressed in exercise clothes (shorts, t-shirt, socks and shoes) at all times. Video recording will be conducted to use in the analysis of range of motion, however, recording of participants will only take place from the

umbilicus and below to ensure the anonymity of the participants. Recordings of participants will be labeled via subject number and will be maintained and analyzed on a password-protected computer.

The results of this study will be published as a group as part of a scientific publication. No individual results will be published or shared with any person or party. All information attained from the medical and activity questionnaires or performance tests will be held in strict confidence. Individual results will remain confidential and only be relayed to the participant upon request. All medical and activity questionnaires, as well as data collection sheets will be kept in a locked cabinet during and following the study. All information will be destroyed five years from the end of the study and not used for other research purposes. Participant folders will be marked with an I.D. number to protect against a breach of confidentiality, and the ID number will be removed upon disposal.

Study contact for questions about the study or to report a problem: If you have questions, concerns, or complaints, or think the research has hurt you, please contact Dr. Ned Robinson 919-760-2319 or by email at ehrobinson@meredith.edu.

IRB contact about your rights in the study or to report a complaint: Research at the Meredith College involving human participants is carried out under the oversight of the Institutional Review Board (IRB). This research has been reviewed and approved by the IRB. For information about the rights of people who take part in research, please contact: Institutional Review Board, Meredith College, Office of Academic Programs, 104 Johnson Hall, 919-760-8514. You may also talk to them for any of the following:

- Your questions, concerns, or complaints are not being answered by the research team.

- You cannot reach the research team.
- You want to talk to someone besides the research team.
- You want to get information or provide input about this research.

Withdrawing from the study:

You have the right to discontinue participation without penalty, regardless of the status of the study. Your participation in the study may also be terminated at any time by the researchers in charge of the project. This could be based upon your refusal to follow study instructions or follow the study protocol. Depending upon when you withdraw, you may be able to receive compensation for the time that you did participate. Please refer back to the "Compensation or Payment" section on the top of this page.

DO NOT SIGN THIS FORM AFTER THE IRB EXPIRATION DATE BELOW

Name of participant

Signature of participant

Date

Signature of person obtaining consent

Date

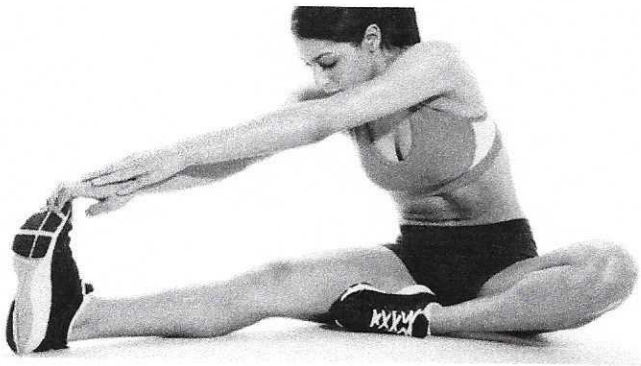
Printed name of person obtaining consent

Volunteers Needed for Research Study

Want to learn how flexible you are?

We need participants for a research study:

"A comparison of an acute bout of static or dynamic stretching on a measure of functional movement"



Description of Project: We are investigating the effect of whether static stretching or dynamic stretching increases flexibility more so than the other by ways of functional movement and other types of measurement.

Who is Eligible? Meredith College women between the ages of 18-35

What will you be asked to do? Complete 2 sets of stretches and assess flexibility of numerous lower body joints by the functional movement screen and sit-and-reach test. To learn more, contact the principle investigator of the study, Maryann Sibrizzi, at sibrizzi@email.meredith.edu.

This research is conducted under the direction of Dr. Ned Robinson, Exercise and Sports Science Department, and has been reviewed and approved by the Meredith College Institutional Review Board.

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