

The acute effects of static and dynamic stretching
on maximal bench press performance

by

Cara Goldberg

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Kinesiology Department

STATE UNIVERSITY OF NEW YORK COLLEGE at CORTLAND

Approved:

Date

Thesis Advisor

Date

Committee Member

Date

Committee Member

Date

Director, Graduate Studies

ABSTRACT

The purpose of this study was to investigate the short term effects of static and dynamic flexibility regimens on maximal bench press power in active adults. Twenty-four male and twenty four female subjects were pretested on their estimated 1RM bench press, which served as their own control. The males and females were equally split up into dynamic and static flexibility groups. Each group performed their designated set of stretches and immediately were retested for their bench press 1RM. A 2 (group) x 2 (gender) x 2 (test) mixed ANOVA was used with repeating measures on the last factor. The alpha level was set at .05. Results showed that there were no significant differences between stretching protocols nor between gender. Based on this study, one may conclude that when performing maximal bench press exercises, it does not matter what type of stretching is performed immediately preceding the exercise. However, based on previous research, when power activities are performed, it may be beneficial to execute dynamic stretching protocols prior to performance.

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CHAPTER 1

INTRODUCTION

Flexibility or joint range of motion is regarded as one pertinent component of physical fitness. It is a common belief among coaches and physical educators that increased muscle and joint flexibility can decrease the incidence of injury. These injury prevention characteristics reside in the idea that a short term reduction in muscle stiffness, coupled with an increased range of motion is associated with less resistant force at rest. Therefore, there is less likelihood for damage when the muscle is elongated during acute exercise (Young, Ballarat & Behm, 2002). Aside from decreased injury risk, stretching has also been shown to promote better performance during athletic endeavors (Kokkonen, Nelson & Cornwell, 1998). In theory, decreases in muscular stiffness would reduce the amount of force required to move the limb through a wide range of motion, which may in turn cause an increase in performance (Cramer, Housh, Coburn, Beck & Johnson, 2006). Recent studies however, have shown that basic static stretching performed by athletes immediately prior to athletic events may actually have detrimental effects on performance components such as power, strength and jumping ability. (Marek et al., 2005, Young et al., 2002; Kokkenen, 2001; Gelen, Saygin, Karacabey & Kilinc, 2008, Vetter, 2007). Additionally, athletes who stretch have shown no decrease in injury risks, nor have they shown a decrease in muscular soreness over those athletes who do not stretch as previously believed (Rubini, Costar & Gomez, 2007). However, one must take into account that several of these experiments have had subjects statically stretching for between 100 seconds and 30 minutes. This would be unrealistic for most athletes, except for the likes of gymnasts or dancers. According to the National Strength and

Conditioning Association, the ideal amount of time to hold a static stretch is 30 seconds, while the American College of Sports Medicine recommends stretching for 10-30 seconds for a total of three or four repetitions (Unick, Kieffer, Cheesman & Feeney, 2005). Bandeira, Mello and Periera, (2003) did not observe decreases in strength performance in ballet dancers when 15 second bouts of static stretches were used. However, when the time was increased to 60 seconds, a decrease in hip flexor strength was observed. Yet, this is only one experiment and the results yielded from other experiments could still hold true when dealing with a more realistic stretching timeline, but on a smaller scale. In addition, one experiment involving static and proprioceptive neuromuscular facilitation found no effect on vertical jump performance (Unick et al., 2005). Further experimentation is still needed.

Investigations of a more dynamic type of stretching during the warm up routine have recently been completed. Although several variations of the dynamic warm up exist, results have shown both positive results (McMillian, Moore, Hatler & Taylor, 2006; Yamaguchi & Ishi, 2005) and/or no change in performance following this type of stretching during the warm up (Faigenbaum, Bellucci, Bernieri, Bakker & Hoorens, 2005; Papadopoulos, Siatris & Kellis, 2005). The effect of stretching seems to depend on a myriad of factors such as: the type of stretch being performed, the length of time the stretch is held, the muscle group being stretched and the amount of elapsed time between the stretching and the target event. These external variables make it difficult to confidently state what the effects of stretching are on strength and power.

Both trainers and therapists need be aware of the implications, benefits and risks of static and dynamic stretching and their appropriate inclusion or exclusion in a

comprehensive exercise or rehabilitation program. For example, one specific factor to be considered is when patients are conducting strength tests for reentry into their designated physical activity. If strength really is negatively affected by pre performance static stretching, therapists may want to encourage a different form of warm up before such assessments. Additionally, coaches should be aware of any detrimental effects of pre performance stretching for their athletes as to better instruct them of the proper methods to prepare their bodies for the activity at hand.

Thus far, given the research previously performed, dynamic stretching appears to be the better option. However, much of the past research has combined both men and women into the same categories, making it difficult to decipher specific findings between genders. It is quite possible that given men and women's physiological differences, their ideal treatment options may also differ. It is possible that each stretching program affects the genders differently. As trainers and clinicians, we may not only have to treat each muscle differently, but we may have to take into account the needs of each gender as well. According to Youdas, Krause, Hollman, Harmsen and Laskowski (2005) women have a significantly greater range of motion than males, which may be attributed to the fact that on average, men perform more rigorous physical work. This work can result in greater joint micro trauma, which in turn may impede range of motion at the joint (Youdas et al., 2005). Active muscle stiffness, however is essential for the maintenance of joint stability (Granata, Wilson & Padua, 2001). One would imagine that range of motion has a direct effect on functional movement, which would lead to a decrease in strength performance.

Previous research has focused mainly on the effects of stretching on jumping and on lower leg strength performance (leg and hip extension) and there have not been many studies which focus on the effect of stretching on upper body strength performance. Fry, McLellan, Weiss and Rosato (2003) studied the effect of static stretching on bench press performance. They found that static stretching immediately preceding bench press performance significantly impaired mean power and mean velocity in 40 high school aged kids performing a 1Repetition Maximum. This is the only experiment documented to date focusing on upper body strength and how it is affected by previous stretching. Perhaps different athletes should ideally warm up differently, depending on the major muscle groups being used during performance.

The bench press motion involves simultaneous multiple muscle activation, namely of the triceps, pectoralis, serratus anterior and the anterior deltoids. The motion of a bench press is one which is mimicked in sports skills in football such as blocking, in shot-putting, and in the chest pass in basketball. Several other movements use at least one of the aforementioned muscles and when developed, can increase overall athletic performance.

Purpose

The purposes of this study were to:

- a. Determine the immediate effects of dynamic and static stretching warm ups on an estimated one repetition maximum (1RM) bench press.
- b. Look at the differences in performance between men and women in the aforementioned programs

The independent variables in this study were the different stretching routines- namely, static and dynamic. The dependent variable was the effect that these stretching routines had on the subject's strength, which was measured by estimating a 1RM in pounds based on a lift at approximately 80% of each subject's 1RM on the bench press. Gender was also an independent variable.

Hypotheses

The following hypotheses were tested:

1. The dynamic flexibility group will have the greatest gains in bench press strength from pre to posttest. The static stretching group will have experience strength detriments.
2. Females having performed the static stretching will experience greater decrements to their 1RM bench press as compared to their male counterparts.

Operational Definitions

1. One repetition maximum (1RM)- The maximum amount of weight a person can lift successfully one time only. It is often used to quantify levels of strength, track training progress or to identify areas of strength imbalance. In this study, the 1RM was estimated based on the subject's ability to lift a smaller weight load.
2. Static Stretch- Stretching to the point of discomfort and holding the stretch for a given amount of time, specifically 30 seconds for this particular study.
3. Dynamic Stretch- A stretch which uses active muscular effort, momentum and movement to create the stretch. For example, arm circles, arm swings and other

stretches involving movement. Specific stretches for this study are listed in chapter 3.

4. Strength- The ability to exert maximal force of contraction of a muscle.
5. Power- The rate of performing work. $\text{Power} = \text{Speed} \times \text{Strength}$

Assumptions

Some basic assumptions of the proposed research include the following:

1. Participants gave their best efforts during the 1RM bench press testing.
2. Participants maintained proper form throughout the duration of the exercise. (see figure 1)
3. Participants followed the rule of no upper body weight training outside of the study until after the completion of the second session.

Limitations

Some basic limitations of the study include the following:

1. The number of subjects who volunteered to participate in the study was limited.
2. Because dynamic stretching is fairly new, there was not a standard, well accepted stretch for the triceps muscle group. Therefore, the stretch listed below was created by the researcher.
3. Other limitations are variables that were not controlled for including race, height and weight.
4. Exercises were the same for all subjects, but may have produced different levels of fatigue in the upper body musculature depending on a myriad of factors.

Delimitations

Some basic delimitations of the research include the following:

1. Subjects chosen were confined to a certain body composition. (<30% for females and <20% for males respectively)
2. Subjects were confined to a certain activity level, which included a minimum of one day a week of weight training using similar muscles to the ones actively being used during the bench press. People who are brand new to exercise at the start of the study would have a much higher learning curve and improvement rate compared to others whom had been performing these or similar exercises in the past.
3. The 1RM was an estimate, not an exact determination.
4. The ages of the subjects was confined to 24-50 years old. The reasoning behind such a large age range is that although strength naturally declines around age 40, if muscles continue to be used consistently, their decline will be a great deal slower than in a sedentary individual. For example, an active 45 year old that lifts weights consistently will be a great deal stronger than someone in their 20's that does not- regardless of their age.

CHAPTER 2

LITERATURE REVIEW

One purpose of this research was to determine the effects of dynamic and static stretching on a maximum 1RM bench press. The other purpose was to classify the results by gender, as to better understand the physiological differences between men and women and how these differences apply to stretching treatments before activity. The following review presents results of studies which focused on the effects of static, PNF and dynamic stretching on different strength and power activities. These activities range from jumping, leg extension, leg flexion, bench pressing and more. Also included are some physiological differences between men and women and how they react to certain types of exercise.

Dynamic flexibility warm ups vary in specific exercises but tend to feature progressive, continuous movement. Callisthenic movements involving small amounts of strength are paired with running drills that include forward, backward and side to side motion. It often involves purposeful contraction of the antagonist muscle to move the intended body part. For example, to stretch the hamstrings, the subject would contract the hip flexors intentionally with the knee extended and swing their leg up anteriorly, to stretch the muscles of the posterior leg (Yamaguchi & Ishi, 2005). This same movement would be repeated a predetermined number of times. Another example would be the “butt kick,” which involves a running motion in which the subject contracts their hamstrings intentionally and flexes his or her knee joint so that the heel of the foot touches the buttock, therefore stretching the quadriceps femoris. Exercise scientists have found that dynamic warm up (DWU) has helped to increase oxygen uptake, increase body

temperature, increase heart rate, increase responsiveness of the nerves and muscles, lower lactate concentration, raise blood pH and to improve joint position sense (McMillian, Moore, Hatler & Taylor, 2006). Even with the power and strength aspect set aside, one can see the many potential benefits of dynamic stretching.

Static stretching is often performed prior to exercise in an attempt to improve performance and decrease the risk of injury through increased mobility of joints and muscles. It involves systematically stretching each muscle in the body while sitting or standing in one position. Each stretch is usually held for between 20-30 seconds. Static stretches may be performed actively by the individual or passively, with another person or immovable object assisting in the stretch. Stretches are usually held until the point of slight discomfort. Each stretch is usually repeated a predetermined number of times with specific “rest times” built in, depending on the specific program or experiment.

For the purposes of this paper, “strength” activities include those that involve maximum force produced in a static voluntary contraction or the maximum weight lifted in a 1RM test (Young & Behm, 2002). Power activities are considered to be movements requiring significant amounts of both speed coupled with force, such as a vertical jump (2002).

Active muscle stiffness is proportional to the myoelectric activation and force generated by the muscle (Granata, Wilson & Padua, 2002). This stiffness is essential for joint stability, but can also lead to decrements in range of motion. Males naturally have an increased level of stiffness.

Static Stretching

The most common of the previously stated stretches and the most widely accepted is the static stretch. Many athletic coaches include static stretching in both the warm up and the cool down of their warm up routines. It poses the least threat for injury and it is most convenient because the individual can perform static stretches by themselves in almost any type of environment.

Wallman, Mercer and McWhorter (2005) studied static stretching of the gastrocnemius on vertical jump performance. However, their method of analysis was different than simply an objective measure and recording of performed jumps. They studied muscle activation through the use of electromyography (EMG) during vertical jump performance both after a static stretching program as well as a “no stretch” program. They found that jump height was 5.6% lower after subjects completed a stretching program of 3 X 30 seconds on an incline board. Muscular strength is one of the most important factors affecting performance in the vertical jump. Therefore, if stretching has the acute effect of reducing strength, it would be expected that it would also negatively affect jump height. Interestingly enough, the EMG reading was 17.9% higher during the post stretch jumps, as compared to the pre stretch jumps. Vertical jump decrements after static stretching have been shown several times in the past, (Wallman, Mercer & McWhorter, 2005) The question that remains pertaining to the sharp increase in muscle activation is explored later in this chapter.

Marek et al., (2005) also found detrimental affects with static stretching. However, they studied static stretching's effects on strength, power output and muscle activation. Each subject performed a total of four stretching exercises (three assisted and

one non-assisted) for the quadriceps muscles. Four repetitions for each stretch were held for 30 seconds. Peak torque was found to decrease 2.8% and mean power decreased 3.2% at both slow and fast velocities immediately following the conclusion of the stretching exercises. Measurements were determined through the use of EMG and MMG (mechanomyography). These measurement techniques are discussed in more detail later in this chapter.

Yamaguchi and Ishii (2005) found that the subjects who had greater leg extension power before static stretching tended to show a greater reduction in power after the static stretching program. Therefore, coaches and trainers may have to be even more cautious when issuing static stretching programs to better trained athletes.

To further cloud the static stretching hypothesis, Cramer, Housh, Coburn, Beck and Johnson (2006), studied effects of static stretching on maximal torque production in eccentric muscle actions of the leg extensors. Thirteen women performed maximal voluntary leg extensions before and three to five minutes after a static stretching program. They found that the acute effects of static stretching did not affect eccentric leg extension in any of the women. Therefore, the detriment caused by static stretching may be mode specific, affecting only isometric and concentric strength (Cramer et al., 2006). The lack of change in eccentric actions may have been due to the unique motor control strategies used to employ torque production during eccentric muscle actions. If this pattern holds true, it should be further explored in other musculature and in different eccentric movements. Additionally, only females were used in this study. Future experiments would need to be performed on males due to the differences in joint laxity and muscle

composition between men and women, which are often accounted for by disparities in levels of hormones circulating throughout the body.

Much of the research pertaining to reduced strength after static stretching has been performed on the major muscles of the leg such as the quadriceps and hamstrings. However, Fowles, Sale and MacDougall (2000) found similar results after acute stretching in the plantar flexor muscles of the lower leg. Each stretch was held for two minutes and 15 seconds. It is difficult to draw conclusions based on these results because this time is well over the recommended stretch time (30 seconds) for athletes to perform stretches prior to athletic events. Measures of maximum voluntary contraction (MVC) were compared pre, post and at 5, 15, 30, 45 and 60 minutes after stretching. Results showed that compared to pre-stretch, MVC decreased 28, 21, 13, 12, 10 and 9% respectively. These data may still be important because they validate the idea that the initial strength and power decrement is much worse immediately following static stretching and slowly improves, but is still evident an hour later. Although the magnitude of the changes may decrease at shorter stretch intervals, the general patterns may hold true.

Contrastingly, Yamaguchi and Ishi (2005), failed to show any decrements in strength and power of the leg extensors related to static stretching. In their program, the quadriceps, hamstrings, hip flexors, gluteals and plantar flexors were stretched for 30 seconds with 20 seconds break in between. Results showed that static stretching for 30 seconds yielded no change in leg extension power compared to the group whose subjects performed no warm up program whatsoever. Strength tests were performed immediately following the stretching protocol. These results may be different than past research

relating to static stretching, due to the more realistic parameters of 30 seconds of stretching as opposed to between 100 seconds and 30 minutes (2005).

Finally, it is worth noting that because muscular strength and muscular endurance are linked, it is possible that the inhibitory influence that prior static stretching has on strength can also be extrapolated to the reduction of muscle endurance as well. Nelson, Kokkonen and Arnall (2005), set up two different experimental groups, each lifting either 40% or 60% of total body weight during a knee flexion exercise. The static stretching protocol included two different exercises for the hamstring muscles. Each stretch was held for 30 seconds in sets of four with 15 seconds of rest in between. One exercise was performed with the assistance of a tester and the other was performed individually. Subjects waited ten minutes before being retested for strength changes. The effect that stretching had on muscular endurance varied between the two groups. The 60% body weight group had an endurance decrement of 24%, while the 40% group had only a 9% decrement. Therefore, it may be assumed that the heavier the load lifted during the endurance activity, the larger the strength decrement. It was also hypothesized that muscle strength decrements are directly related to the intensity of the stretch. The greatest impact of this study lies in the idea that to improve muscle endurance, one must progressively overload until the point of fatigue is no longer produced by the final repetition with the same weight. Stretching prior to lifting could induce a premature feeling of fatigue and could delay the individual from progressing to a higher work load or more importantly for muscular endurance, from completing as many repetitions.

Dynamic Stretching

The effects of dynamic stretching seem to yield more positive results. During this type of stretching, some muscles are contracted actively and rhythmically to stretch the target muscles, therefore, core temperature is raised and post-activation potentiation occurs, both which have been shown to increase muscular performance (Yamaguchi & Ishii, 2005). Yamaguchi and Ichii compared the effects of static stretching for 30 seconds and dynamic stretching on leg extension power. They found that leg extension power after dynamic stretching of the quadriceps, hip flexors, gluteal muscles, hamstrings and plantar flexors was significantly greater than after non-stretching or static stretching.

The United States Army (McMillian, Moore, Hatler & Taylor, 2006) recently developed a dynamic warm up for individuals and military units. The researchers also conducted an experiment comparing the results of three power and agility tests after the implementation of their new dynamic warm up and they compared these results to their traditionally used static stretching warm up. A control group was also utilized. The first test was called the five-step jump test similar to a lengthened version of a triple jump. This is often recognized as a representation of lower body power and stability. The second test was called a T-drill, which was a combination of sprinting, sliding and running backwards. Since this drill doesn't focus sufficiently on strength or power, but more on agility, the results from this particular test will not be reviewed. The third test was a medicine ball underhand throw for distance and was chosen as a measure of total body explosive power. Repeated measures analysis showed that the dynamic warm up was associated with better scores on all three tests. The group that completed no warm up and the group that completed static stretching scored similarly, with the static group

scoring slightly higher on the 5-jump test. However, overall, their average scores ranged from 0.2% -0.7 % lower than the group who trained dynamically.

Papadopoulos, Siatras and Kellis (2005) also found better results with dynamic stretching. They tested the acute effects of both static and dynamic stretching and found that the dynamic stretching protocol left knee extensor and flexor strength unaltered, while the static stretching routine produced decrements in strength.

Faigenbaum, Bellucci, Bernieri, Bakker and Hoorens (2005) found similar results with children ages 10-12 years old. They took sixty children through three different warm up protocols. The first involved static stretching, the second involved dynamic stretching and the third involved dynamic stretching plus three drop jumps from plyometric boxes. The vertical jump and shuttle run performance dropped significantly following static stretching, while flexibility measures were no different from one stretching regimen to another. Unick et al., (2005) did not find significant decrements during vertical jump performance. However, their subjects only stretched for 15 seconds at a time, which is at the lower end of the recommended guidelines.

Vetter (2007) found that sprinting and jumping were affected differently by the same warm up protocol. Six different warm up routines, (two including static and two including dynamic stretching) were tested for their effects on both sprinting and jumping performance. One might assume that if a certain protocol negatively affected one power activity, that it would affect another in the same manner. That was not the case in this research. Jump performances were affected negatively by the two warm ups involving static stretches while the sprint performance was not affected. Warm ups involving dynamic stretches actually helped improve all performances. Also worth noting is that

there were no significant differences between men and women on either sprint or jump trials, which may begin to answer the question pertaining to genders being effected differently by different stretching routines.

Young and Elliot (2001) studied the effects of PNF and static stretching on maximum voluntary contractions and explosive force production during jump performance. Subjects warmed up with a five minute jog at a comfortable speed and then performed their assigned stretching routines. The PNF stretches took the form of contract-relax, involving a maximal isometric contraction against resistance from a tester for five seconds, followed by a relaxation by the volunteer while they were passively stretched by the stretcher. This was repeated three times for each muscle groups including the calves, quads and gluteals. The jumping tests included a squat jump considered to use purely concentric contractions and a drop jump, which uses eccentric forces. Results revealed that the statically stretched subjects were the only subjects to show a significant decrement (3.2%) in height/time and in the drop jump test only. One thing to take into consideration is that unlike several of the other experiments mentioned, a five minute warm up preceded the stretching regimens. It is possible that the magnitude of the reductions was diluted by a positive effect of the warm up (Young & Elliot, 2001). As mentioned in Young and Behm's (2002) review of static stretching being used as a warm up before strength and power activities, it is possible that the aerobic or low-intensity exercise and/or practice components of a warm-up may offset any potential negative effects of stretching. In a study by Knudson et al., (2000), only 55% of subjects experienced a decrease in vertical jump activity following a bout of static stretching. The other 45% experienced no change or an increase in vertical jump performance. However,

before statically stretching, each subject performed three minutes of cycling and three practice vertical jumps. Realistically, athletes don't usually stretch in isolation of some sort of warm up activity prior to their athletic events. Exercise scientists have known for decades that performing a stretching program without first warming up the muscles, could lead to pulls and tear in the musculature. If this is in fact true, this warm up regimen would be ideal because the benefits of injury reduction would still be present, while the benefits of the sub-maximal cardiovascular warm up may mimic those of a dynamic stretching component. Sub-maximal cardiovascular exercise before static stretching may be something worth considering and further exploring before making statements pertaining to the detriments of static stretching on power and strength activities.

Mechanisms of Stretch Induced Performance Decrement

Several mechanisms have been cited as factors in the decrement in strength and power performance following participation in a static stretching program. The most prevalent factors seem to be that of a neurological or a mechanical premise.

Neurological changes include the reduction in neuromuscular activity, which may encompass a decrease in motor unit activation, decreased firing frequency or altered reflex sensitivity, all of which could be caused by a reduction in the amount of excitatory inputs (Nelson, Kokkonon & Arnall, 2005). All of these possibilities reduce the magnitude of force transmission from the muscle to the skeletal system (Young & Behm, 2000). Several other researchers concur with this neurological hypothesis, but have failed to measure neural activity and have drawn these conclusions based on speculation

only. This specific mechanism was mentioned not only for several of the power and strength experiments, but also as the primary mechanism for muscular endurance.

The length- tension hypothesis classified under the mechanical standpoint states that increased compliance of the tendon produces a moment when muscle force is taking up slack rather than contributing to the gross movement itself (McMillian et al., 2006). Papadopoulos et al. reports that a relaxed musculotendinous system needs a sufficient amount of time before the produced force is conveyed to the related bones. Kokkonen et al., (1998) agrees that a stiffer musculature would produce force at both a longer sarcomere length and a slower shortening velocity, thereby placing the contractile component at a more optimal point in terms of force production. Guissard, Duchateau and Hainaut (1988) also agree that these decrements exist, but that they disappear as quickly as 30 seconds after the stretching, which in turn would not affect most performance activities. However, other researchers have found this refractory time to range anywhere from 4-10 minutes. Fowles, Sales and McDougall (2000) found the decrease in motor unit activation to last as long as one hour. This length tension theory has also been discussed by Merek et al., (2005) who described the primary mechanisms underlying stretching induced decreases in force production as being related to a decrease in musculotendinous stiffness which may alter the length tension relationship of the muscle fibers. Fowles et al., (2000) believe that stretches maintained at the same joint angle for less than 45 seconds may result in a reduced muscular stiffness. Additionally, after 15 minutes of recovery from this intense stretching, most of the decreases in force can be attributed to mechanical properties of the musculotendinous unit, rather than to neural factors. More specifically, the stretching may have altered the deformation of the

tissues so that the maximal force capabilities of the unit were limited. Rubini et al. (2007) agreed and stated that stretching may produce a decrease in viscosity of the tendinous structures, which allow the muscle fibers to slide with less resistance to movement. However, along with this increased viscosity, comes an increase in compliance, which may limit more cross bridge coupling, thus decreasing the capability of the muscle to produce force. Lastly, McHugh, Magnusson and Gleim (1992) describe this phenomenon as “stress relaxation,” which is described as muscle offering less resistance to passive stretching and increasing its capability of distending when muscular compliance increases. This loss of compliance may also limit the production of crossbridge coupling, thus a loss of tension when the muscle is stretched, causing a decrease in muscular performance (Rubini, 2007).

Another interesting notion proposed by Nelson et al., (2005) is that increased fatigue can alter Ca^{++} kinetics. Research with rat soleus muscles showed that during static stretching, there was an increase in Ca^{++} from the extracellular space. This influx was related to a 63% decrease in twitch tension and the slowing of Ca^{++} release from the sarcoplasmic reticulum, which is what ultimately causes a muscle to contract. However, rat physiology is different than human physiology. Similarly, it has been proposed that alterations of the connective tissue such as muscle damage from stretching may have contributed to force production loss in animals such as the chicken. Researchers found that creatine kinase enzyme activity increased by 250% after acute stretching in chickens, but only by 62% after passive hamstring stretching in humans. These numbers may be significant because creatine kinase enzyme activity has been used as a marker for exercise- induced muscle damage (Fowles, Sales and MacDougall, 2000).

Another mechanism that could account for the increase in fatigue after stretching, which has only been supported by a few researchers, (Nelson et al., 2005) stated that stretching can temporarily decrease blood flow to the muscles. Force reductions have been proven during periods of ischemia, which have been attributed to a lower oxygen count and impaired removal of metabolic wastes. If these waste concentrations are close to critical level, muscle contractions can be gravely impaired (2005). However, not many researchers have found that stretching decreases blood flow in the first place.

One final theory was proposed by Wallman et al. (2005). If the subjects stretched past the point of discomfort, they could have elicited pain receptors, which would have inhibited neural pathways responsible for muscle activation, thus limiting the amount of force able to be produced (2005). Lastly, the decrease in vertical jumping ability could be due to a decrease in ankle stability and the increase in muscle activation could be a protective mechanism as to assist in shielding the ligamentous structures and decrease the athlete's chances of injury (2005).

A mechanism regarding PNF stretching exclusively was suggested by Moore and Hutton (1980) who stated that a lingering discharge resulted from the contraction phase of a PNF stretch, as apposed to the idea that an excess relaxation follows the contraction phase. If so, this "residue" could counteract the effects of a reduced stiffness, which may explain the lack of significant effects found in the study conducted by Young and Elliot in 2001.

Another theory proposed by Wallman et al., (2005) was if the subjects stretched past the point of discomfort, they could have elicited pain receptors, which would have

inhibited neural pathways responsible for muscle activation, thus limiting the amount of force able to be produced (2005).

One hypothesis pertaining to the increase in strength following dynamic exercise is that hypertrophy of the muscle may be attributed to flexibility training. This phenomenon has been researched and found consistently in humans and in animals when the subjects stretched for 2-3 weeks straight (Rubin et al., 2007). Therefore, if the subjects had been stretching on a consistent basis prior to the experiment, they may have already begun the hypertrophy in the specific muscle, therefore making the strength results after dynamic stretching results seem exaggerated.

Regarding the EMG increase post stretching, several theories have been proposed. One which was suggested by Wallman et al., (2005) was that the muscle properties compensated for the possible increased compliance and decreased efficiency, which caused them to use a greater amount of energy by recruiting more motor units. Nelson, Kokkonen and Arnoll agree, stating that the decrease in excitatory inputs is what is being compensated for when new motor units are recruited. However, other research cited by Wallman et al., (2005) has shown a decrease in EMG activity following static stretching, which could be caused by the stretching having placed some of the motor units in a fatigue-like state, that in turn would lead to a decrement in performance.

Gender Differences

Differences have been found between men and women in joint range of motion, as well as muscle flexibility and length. These differences may readily affect the way each gender reacts to specific types of stretching. Some of the previous research on

gender differences may clue us in on how males and females may react to the proposed research.

To begin, Unick et al., (2007) found that initial flexibility scores were not significant in determining whether an individual's performance scores were affected by stretching. Therefore, if previous physiological characteristics do not effect performance, would differences in gender create a disparity? Walker, Miles and Ford (1984) examined the active mobility of extremities in both males and females by testing 28 different movements. Of the movements they tested, 14 were found to be statistically different between the genders. Women had a greater motion than men in eight of the nine upper body movements and three of the five lower body movements. It appears that the effects of gender on joint ROM and muscle length are joint and muscle specific (Youdas et al., 2005). Unick et al. (2005) agree with this theory, stating that the stiffness in the tendon structures of men are much greater and that indeed the viscoelastic properties of the muscle may differ between the genders.

Granata, Wilson and Padua (2002) also found that differences exist in active joint stiffness during active knee flexion and extension. Males were found to have a higher stiffness and inertia for all weight groups for both hamstrings and quadriceps muscles even at higher activation levels. Levels varied anywhere from 25-164 Nm/rad greater for the males. Reasons for these differences will be discussed later in subsequent parts of the research.

It seems difficult to draw any concrete conclusions based on previous research. Results have varied based on how long the stretch was performed, ability of the athlete, body part being tested, time interval between the stretch and the strength test and more.

Dynamic stretching seems to have a slight lead over static stretching, but for one to be sure, protocols and variables between the two must remain completely consistent.

Additionally, it is clear that men and women are different physiologically, but how this affects stretching and 1RM results is unknown.

CHAPTER 3

METHODS

The purpose of this research was to determine if static and dynamic stretching acutely affect both men and women during strength and power activities. In this particular study, 1RM bench press results were examined after dynamic static stretching programs. Differences in physiology between the genders were also considered when looking at the potential variations in results between both males and females. This chapter describes the participants, methods, procedures and equipment of the study.

Participants

A total of 42 active men and women ages 25-50 years old were studied. Younger subjects were excluded due to the fact that puberty may still play a role in strength gains in many young males- in some cases until the age of 20. Although this may seem like a wide variety of ages, in terms of strength, disuse of the muscle is more often the cause for changes in strength, rather than the age of the individual. If the muscles are continually used, they tend not to atrophy nearly as quickly as the average older adult. In order to assess whether subjects should have agreed to be part of this study, they were asked to read and sign a consent form (See appendix A) that explained the inherent risks of weight training and stretching. Signed forms were collected before the start of the initial study. All participants met a certain level of fitness. Subjects were currently participating in muscular strength and/or endurance work of each of the major muscle groups for a minimum of one day a week. Subjects were also active in some sort of cardiovascular program at the time of the study. These criteria were determined by the use of a

descriptive survey, given to the prospective subjects prior to acceptance into the study (See appendix B).

Subjects chosen as participants also met a lean body mass criteria. The maximum allowed percentage of body fat was 30% for females and 21% for males. These criteria placed the selected participants in the “healthy category” for each gender. The average of three consecutive readings were taken and recorded.

Individuals who met the fitness and body composition standards were randomly assigned to one of two groups. Each group was then divided by gender to form four groups with approximately eleven people occupying each group. The first group was the dynamic flexibility female group (DF). The second group was labeled the dynamic flexibility male group. (DM). The third group is the static flexibility female group (SF). The fourth group was known as the static flexibility male group (SM).

Equipment

Body fat standards were measured by the use of the hand held Omron- HBF 306C fat loss monitor, that measures body fat through bioelectrical impedance. This tool provides accurate measures of body fat within a 4% bias (Durenburg et al., 2002). Illness, failure to fast four hours before the test, incorrect programming, edema, dehydration and certain body types increase the percentages of error. These factors were controlled by calculating an average of three readings and by having the testing administered by a competent tester.

A 45 lb or 15 lb bar and circular weight plates were used by each subject to perform the bench press, as well as a flat bench. An Alnima WR30M stop watch was utilized to time the lapse between the flexibility routine and the 1RM test. One limitation

in the methodological procedure is that there was only one instructor to monitor sometimes multiple participants at once. Due to this limitation, a “buddy system” was employed on days with more than one subject. This was only the case for a total of three subjects in one group- the rest were tested individually. Careful instructions were given beforehand, and because the researcher was also present and performing the same procedure, experimenter error will be limited.

Procedures

Before the start of the experiment, a pretest was given to 10 of the 42 subjects to determine whether the methodological procedures of the estimated 1RM testing were consistent and the test was meaningful. This also helped to determine how many trials it took for 1RM numbers to become consistent so that the learning effect of the test had sufficiently leveled off. 1RM's on the bench press were determined based on the Wathan Formula (see Table 1) that was applied to the maximal number of repetitions subjects were able to complete at a chosen weight. Because safety is often an issue when athletes are going “all out” this is a better alternative to the traditional 1RM.

A warm up of 10 repetitions of a set using a curl bar only, (15 Lbs) or bench press bar (45 Lbs), depending on the subject's experience with bench pressing were completed. Each subject chose an estimated weight in which they thought they could lift between 6-8 repetitions based on previous experience lifting. If the subject was unsure, a more conservative weight was chosen. On the warm up set, each participant chose a grip on the bar that felt natural to them. A chalk mark was placed on the edge of the 5th digit on each hand so that the grip remained consistent for each subject on their subsequent lift. Additionally, a tape measure was used to measure the distance in between the 5th digits of

both hands so that during the second session, grip widths remained consistent. The number of repetitions and the weight lifted was recorded by the investigator and converted to a 1RM using the Wathan prediction equation (LeSuer et al., 1997). A converted 1RM was used to avoid the risk of injury which often occurs when heavier weights are used and form begins to be compromised. This equation was chosen, because it is one of the only formulas that has been shown to accurately predict a 1 RM for bench press performance.

Table 1. Wathan Equation for predicting a 1RM

$$1 \text{ RM} = \frac{100 * (\text{weight lifted})}{48.8 + 53.8e^{[-.075 * \text{repetitions}]}}$$

where, e is the mathematical symbol for the number whose natural logarithm is 1, e is approximately equal to 2.7181

Note. Equation reprinted from LeSuer, D.A., McCormick, J.H., Mayhew, J.L., Wasserstein, R.L., & Arnold, M.D. (1997). The accuracy of prediction equations for estimating 1RM performance in the bench press, squat and deadlift. *Journal of Strength and Conditioning Research*, 11, (4), 211-213.

Proper form includes having the back, hips and gluteals remaining on the bench and the bar touching the center of the chest at the bottom of every repetition (see Figure 1) Rest periods took place during the adjustments of the weight plates and totaled three minutes between each attempt. Three to five minute rest periods have been shown to fully restore creatine- phosphate and ATP stores during maximal and near maximal resistance activity. (Parsons, N.D, para 5). Subjects will then report back for the second session four days later. All were recorded on an individual data collection sheet (appendix C).



Figure 1. Proper bench press form

During the second session, subjects performed their given flexibility routine, which was randomly assigned by the researcher. No more than two participants tested at the same time due to the availability of benches, bars and volunteers. Rest time between the flexibility routine and the 1RM was exactly three minutes in between the stretch and the lift. This rest time was chosen as to mimic a flexibility routine preceding an actual athletic event. Once the new estimated 1RM was calculated, it was recorded and the % value of increase or decrease was calculated.

The dynamic flexibility warm up included two sets of 30 seconds for each side of the following exercises with 15 seconds rest built in for each set.

- a. Triceps Overhead Extension- Subject put one arm behind their head like they were going to scratch their back, then they forcefully straightened their elbow up above their head, before letting gravity pull it back down. This was repeated 10 times on each side. *approximately 30 repetitions per 30 sec/each arm.
- b. Arm circles with the shoulder adducted (stretching the biceps, pectorals and anterior deltoid)*approximately 22 revolutions per 30 seconds.

- c. Arm swings forward and back with palms facing down, arms crossing over one another in front of the body. (Stretching the chest, shoulders and back)*approximately 16 revolutions front and back per 30 seconds.
- d. Side Reaches- Subject bent to one side while holding their opposite arm overhead, quickly reversed directions and stretched to the other side. This exercise was done in a controlled continuous fashion for a total of 30 seconds on each side of the body (stretching the intercostals, upper back, serratus anterior and obliques)
*approximately 28 total repetitions (14 per side) per every 30 seconds.

(Specific pace was controlled through the use of a metronome)

The static flexibility program included:

- a. Overhead Triceps Stretch (see Figure 2)- Subject put one arm overhead. They then positioned their forearm as close as possible to their upper arm and grasped their elbow overhead with the other hand. They then pulled their elbow back and toward the head. The stretch was held then repeated with the other arm.



Figure 2. Triceps overhead stretch

- b. Pectoralis major stretch (see Figure 3)- With one arm extended, subject positioned one hand on a fixed structure shoulder height. They then turned their body away from the positioned arm. The stretch was held and repeated with the opposite arm. (Also stretches anterior deltoids)



Figure 3. Pectoralis major stretch

- c. Anterior Deltoid, pectoralis and biceps stretch (see Figure 4)- Subject clasped hands behind their back while keeping their body in an upright position. They then held their arms up as high as tolerated and held the stretch.



Figure 4. Anterior deltoid, pectoralis and biceps stretch

- d. Static Side Reach- Subject laterally flexed the trunk to one side and reached the opposite arm diagonally to the ceiling. (Stretching the intercostals, upper back, serratus anterior and obliques)

Each static stretch was held for a total of 30 seconds and repeated twice for each arm with 15 seconds of rest in between each repetition.



Figure 5. Lateral side stretch

Statistical Analysis

A 2 (group) x 2 (gender)x 2 (test) was utilized with a mixed ANOVA with the repeated measures on the last factor. It was tested at a .05 level of significance. For examining the reliability of the methodological procedures, SPSS for Windows was used to determine an intraclass reliability coefficient. The analysis was done using SPSS for Windows version 15. Reliability was verified after the first 10 subjects' data were collected.

CHAPTER 4

RESULTS AND DISCUSSION

The purpose of this study was to determine the acute effects of static and dynamic stretching routines on maximal strength performance in the bench press. Differences in results based on gender were also explored. After determining a base-line 1RM estimate bench press score, participants were brought back for a second session in which they performed either a static or dynamic stretching program. After completion of the program, acute effects on strength were tested by completing a second 1RM estimate. These estimated scores were converted into a 1RM score using the Wathan Equation.

Results

To examine reliability of finding an accurate baseline 1RM estimate, an intraclass reliability coefficient was determined for the first 10 subjects by retesting their baseline number. This coefficient was a .97 which reflects an accurate methodology.

There were a total of 42 subjects, 12 in the SF group, 8 in the DF group, 10 in the SM group and 12 in the DF group. Ages ranged from 25-50 years. The values for age and body fat means and standard deviations are listed in Table 2.

Table 2. Means and standard deviation values of demographic information of all subjects

	<u>Females</u>		<u>Males</u>	
	Static	Dynamic	Static	Dynamic
N	12	8	10	12
Age (yrs)	36.5(9.6)	40.5(9.2)	35.0(7.6)	29.4(5.0)
Body Fat (%)	24.2(3.7)	24.8(3.4)	16.0(4.0)	15.7(3.3)

The mean pretest bench press score for static females was 95.0 lb with a standard deviation of 23.1 lb. The mean posttest bench press for the static female group was 95.7 lb with a standard deviation of 23.7 lb. The mean percent change in bench press scores from pretest to posttest for the female static group was .94%. Five female participants from the static stretching group increased their estimated 1RM scores while six decreased their scores and one remained the same. The mean percent change in female dynamic stretching bench press scores for the dynamic group was 4.59%. Five participants from the female dynamic group increased their bench press from pre to posttest while two decreased and one remained unchanged.

The mean pretest bench press for the static male group was 231.2 lb with a standard deviation of 49.2 lb. The mean posttest bench press for the static male group was 232.4 lb with a standard deviation of 51.9 lb. The mean percent change in bench press scores from pre to posttest for the static male group was .47%. Three participants from the male static group increased their bench press from pre to posttest while five decreased their scores and two remained unchanged. The mean pretest bench press for the dynamic male group was 223.5 lb with a standard deviation of 48.7 lb. The mean posttest bench press for the male dynamic group was 226 lb with a standard deviation of 50 lb. The mean percent change in bench press scores from pre to posttest was 1.2%. Six of the participants increased their scores, four of them decreased and two remained unchanged. Table 3 presents a summary of these results.

Table 3. Bench press values (in lb) for males and females of each group.

Gender	Group	N	Pretest		Posttest	
			Mean	(SD)	Mean	(SD)
Females	Static	12	95.0	(23.1)	95.7	(23.7)
	Dynamic	8	75.8	13.0)	78.4	(8.9)
Males	Static	10	231.2	(49.2)	232.7	(51.9)
	Dynamic	12	223.4	(164.4)	226.0	(49.7)

The mean percent changes in weight lifted are illustrated in Figure 6. While the largest percent change appeared in the dynamic female group, variability was too large to produce significant results.

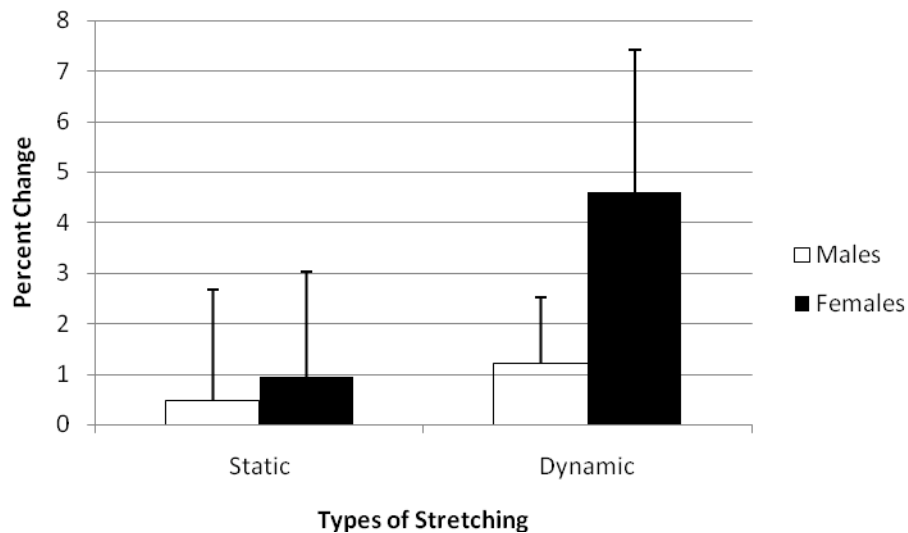


Figure 6. Mean percent change in weight lifted for both genders in each stretching protocol (standard error bars included).

A 2 (group) x 2 (gender) x 2 (test) mixed ANOVA was used with repeating measures on the last factor in order to analyze the changes in performance in bench press between genders, as well as stretching groups. The alpha level was set at .05. The main

effect of test in the different stretching groups (measure 1) was not significant $F(1,38)=1.287, p=.264$, partial $n^2=.033$. The 2-way interaction effect of group*test was not significant $F(1,38)=.281, p=.599$, partial $n^2=.007$. The 2-way interaction effect of test*gender was also not significant: $F(1,38)=.003, p=.956$, partial $n^2=.0005$. The 3-way interaction effect test*group*gender was not significant: $F(1,38)=.005, p=.945$, partial $n^2=.0005$.

The main effect of the test between genders was significant: $F(1,38)=140.9, p=.0005, n^2=.788$. The main effect of the group*gender was not significant: $F(1,38)=635.883, p=.644$, partial $n^2=.006$. These results show that there were no significant differences between the two stretching groups, nor was there a difference between genders, based on the two stretching groups. The interaction analysis shows that there was no significant combined effect of the test and group, or the group and gender.

Discussion

These results demonstrate that the performance of either a dynamic or a static stretching routine immediately preceding a 1RM estimate have similar effects on bench press performance in both males and females. Although no significant results were found, it may be interesting to note that there was a slight increase in estimated marginal means for the groups that performed the dynamic stretching program. The males and females both increased an average of about 2.5 lb in their posttest lift. The subjects who performed the static stretching routine improved on average just less than one lb. This may suggest that when it comes to upper body maximal strength, it matters less what kind of stretching routine is performed, and more that the athlete feels comfortable and

properly warmed up before their sub-maximal lift. These outcomes also may be the result of some procedural deficiencies, which will be discussed later in this section.

The results of this study may help to confirm the idea that the type of stretching performed prior to performance may only make a difference preceding power activities. Although very little research has been performed which looks at stretching's effect on upper body strength, much of the previous work has found similar results for strength exercises of the lower extremities. For example, researchers that discovered significant decreases in performance after static stretching include; Wallman, Marek, Papadopoulos, Cramer, Vetter and Fowles. Interestingly enough, these researchers were testing vertical jump, muscle activation and power output, torque, torque, sprint and countermovement jump, and maximal voluntary contraction respectively- all of which involve speed or power variables. (Torque= force x radius) One exception is Yamaguchi who found no significant difference in leg extension power after statically stretching. Based on these similarities, one may pose the question, "is static stretching dampening the nervous system prior to power exercises?" In regards to strength, this connection may not be as certain. For example, Bandeira didn't find decreases in strength in ballerinas after 15 second bouts of stretching, but did find decrease after 60 second bouts. The results of our study may be reconfirming the fact that before strength training exercises, mode of stretch may not make as big of a difference- especially if static stretching is kept under 20 seconds per muscle group. This evolving hypothesis also matches results found in previous research pertaining to dynamic stretching. Papadopoulos, Siatras and Kellis (2005) found that leg extensor and flexor strength was unaltered by dynamic stretching. McMillian, Moore, Hatler and Taylor (2006), who conducted a study with the United

States Army, found that dynamic stretching increased an upper body medicine ball toss, agility drill, as well as a three part jumping drill. It is important to notice, that the medicine ball toss is one of the few upper body exercises having been tested, but it is still considered a power activity. Additionally, Yamaguchi and Ishii, (2005) also found better results in leg extension power after a full lower body dynamic stretching program, as compared to a static program. Although in our study, no significant results pertaining to dynamic stretching were found, there was a slight trend in our research which showed the dynamic group making small improvements in posttest performance.

It may also be interesting to note certain dialogue expressed throughout the experiment. Three of the more trained subjects (all three male) who were more experienced with heavy power lifting expressed positive reactions after performing the dynamic stretching routine. Four of the less trained subjects (two male and two female) expressed feelings of fatigue after performing the dynamic exercises. Could it be that the stronger the individual, the more positive the dynamic stretches may be? Could the vigorous movements be too much for the individuals who may only be lightly weight training once or twice a week? This differentiation may be something worth exploring.

Other variables in the experiment with large ranges include both age and body fat percentages. For example, the DF group had an average age of 40.5 years while the DM group had an average age of only 29.4 years. Initially, the researcher planned on narrowing these factors but found that by doing so, she would have been compromising the number of participants, therefore altering reliability. It is quite possible that older skeletal muscle takes longer amounts of time to recover from a strenuous sub maximal test, which would have given the younger participants an advantage during their posttest.

When looking at body fat, it is safe to assume that a male with 8% body fat and one with 20% have completely different work out regimes, which could also make it hard to put them on the same gradient when judging their performances.

CHAPTER 5

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Summary

The purpose of this study was to determine the immediate effects of dynamic and static stretching warm ups on an estimated one repetition maximum (1RM) bench press. Also explored were the differences in performance between men and women in the aforementioned programs. The hypotheses were that the dynamic flexibility group would have the greatest gains in bench press strength from pre to posttest. The static stretching group would experience strength detriment. Females having performed the static stretching would experience greater decrements to their 1RM bench press as compared to their male counterparts. The participants were 42 active male and female adults divided randomly into four groups: a dynamic stretching male group, dynamic stretching female group, static stretching male group and static stretching female group. All four groups performed a 1RM pretest bench press and following a four day rest period and subsequent flexibility program, retested their estimated 1RM's on the fourth day. Statistical analysis showed no significant differences between the dynamic and static groups with regards to increasing bench press scores. Nor was there a difference found between males and females who performed each stretching protocol.

Conclusion

The results of this study do not provide enough support for the disuse of dynamic or static stretching prior to maximal bench press performance. Additionally, they do not support differentiated stretching treatments between genders prior to a maximal bench

press performance. However, static stretching prior to exercises involving speed or power may negatively affect the athlete's performance.

Recommendations

One drawback of this study and of previous studies is the inclusion of healthy, fairly active young adults only with no past history of bone or muscle damage to the particular muscles being stretched. Future research should focus on different subsets of populations to see if these results would still hold true. Making generalizations, especially for practical application can be detrimental to performance and recovery.

Mechanomyographic amplitude (MMG) which was used in Marek et al's study (2005) is a newer instrument that measures lateral oscillations of active skeletal muscle fibers. These oscillations are generated by gross lateral movement of the muscle at the start of a contraction. MMG amplitude is inversely related to the stiffness of an active muscle. This technique when coupled with EMG, may shed more light on stretching induced strength deficits. Future research should include MMG amplitude as a measurement tool. As previously stated, a majority of the research has been performed on the limbs of the lower body. More research should be conducted focusing on upper body and core strength which is often an extremely pertinent factor in athletic performance. Much of the research focuses on acute stretching immediately preceding athletic events. Other experiments could look at the effects of chronic stretching, and if any of these strength decrement mechanisms carry over to performance when the static stretching is performed days before the event.

One other drawback of this research may have been the methodological procedures. Although reliability was proven by rechecking a subset of 10 subjects for

their baselines, it is possible that it may take more than one pre test to confirm an accurate estimated 1RM bench press score. Therefore, the second reading may have not accurately reflected an actual increase or decrease of strength due to the flexibility protocol. Additionally, with only two testing sessions, it is very difficult to control for individual circumstances between the two days. Although an individual may have not “worked out” per say in the days in between, it is possible that they had to move something heavy as part of their daily lives. Or, more likely, nutritional, sleep and emotional states were probably not of equal standing during both sessions. Unfortunately, these are variables that are very difficult to control.

One additional note is that the term “dynamic stretching” needs to be more tightly defined. Programs should have some sort of standard or limit to their components. It doesn’t seem accurate to include moves such as lunges and sprints as part of a “dynamic stretching” program. These components as compared to leg swings are of a completely different caliber. Because dynamic warm ups are fairly new in the world of exercise and sport, there seem to be some movements that may fall into overlapping categories between “dynamic warm up,” cardiovascular exercise, strength training and even ballistic stretching, which has historically been shunned by exercise physiologists.

For example, McMillian et al., (2006) included a progressive program of movements in his study of US army cadets including exercises such as pushups, supermans, lunges and shuttle sprints. As one can see, there may need to be some sort of method of standardization for the practice dynamic stretching so that the moves don’t fall into several different categories.

Although no statistically significant results were found between stretching regimens prior to maximal bench press performance, this finding in of itself may lend us some insight relating to our original question. Although it does not seem to matter which stretching regimes are utilized prior to exercises using strength only, static stretches may have a negative impact on exercises that utilize power- or in any instance where speed of the movement plays a factor. These findings may be useful to athletes, clinicians and rehabilitation clinics. Novel findings pertaining to this topic could revolutionize the way athletes are trained and how training programs may have to differ between genders. However, before any final declarations are made, there is still much to be learned and more studies to be performed, taking into account these recommendations for future research.

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Appendix A

Adult Consent Form State University of New York at Cortland

The research you have been asked to participate in is being conducted by Cara Goldberg of the Exercise Science Department at SUNY Cortland, as part of a graduate thesis. In order to be a participant in the study described below, this informed consent form must read, signed and dated.

Purpose and Procedures of This Research Study

The purpose of this study is to determine the acute effects of static and dynamic stretching routines on maximal strength performance in the bench press. Differences in results based on gender will also be explored. You will come to the Jamesville-DeWitt High School weight room (or another predetermined location) a total of two times. The first time will include body composition testing by the use of a non-invasive procedure known as bioelectrical impedance as well as a pretest determining your estimated 1RM bench press score. The second session will include either a dynamic or static stretching program, as well as an immediate retest of your 1- RM bench press score. Additionally, prior to the first session, a short questionnaire will be completed, summarizing your current fitness activities in three of the domains of fitness.

Before you agree to participate, you should know the following:

A. Freedom to withdrawal

You are free to withdraw your consent and discontinue this study at anytime. Withdrawal will not result in penalty of any kind.

B. Protection of Participants' Responses

To protect confidentiality, numbers will be used to identify all data collected from exercise testing and only the primary researcher will see your name and contact information. All data collected and information containing names of participants will be filed and secured in the Exercise Science Department at SUNY Cortland for three years and after this time will be destroyed.

C. Length of Participation

Each exercise session should take no longer than 30 minutes. The two sessions however, need to be conducted exactly four days apart. Testing dates will take place starting in late August and will continue through the end of November. Please keep in mind that you will be asked to refrain from any upper body exercises exactly four days before the first session and in the time in-between the first and second sessions.

D. Full Disclosure

It may be necessary to keep some information regarding the experiment withheld from participants. No fitness assessment information will be given to the participants until two weeks after the second session of testing.

E. Expected Risks

Although you should not experience any pain or injury from participating in this study, some risks are possible. These possible risks may include soreness, muscle pulls or tears and other muscular discomforts and temporary rise in blood pressure. However, if specific instructions are followed, the possibility for these occurrences is minimal.

F. Benefits Expected

Participation in this study may be beneficial to you because you will receive free body composition testing and explanation of your results. It may also educate you on the proper form and benefits of certain stretching exercises, as well as the bench press. Additionally, this study will benefit society as it will lead to a better understanding of different stretching regiments and how they affect strength training.

G. Contact Information

If you have any questions concerning this study or your participation in it before or after consent, you may contact Cara Goldberg 315-395-7379 or the research advisor, Dr. McGinnis 607-753-4909. If you have any questions about research or the rights of you as a participant, you can contact Amy Henderson- Harr, IRG Designee, Office of Sponsored programs, SUNY Cortland 607-753-2511.

I _____ (print name) have read the description of the project, for which consent is requested, understand my rights, and I hereby consent to participate in this study.

Signed _____ Date _____

Appendix B

Pretest General Information Sheet

To the participant:

Please fill in the information as accurately as possible. All information will be kept confidential. Contact information may only be used by the researcher and only for this project. If you have any questions about anything related to this study, please contact the researcher.

Participant name _____

Age _____ years

Gender (M/F) _____

1.
 - a. Do you participate in cardiovascular exercise of moderate to high intensity at least once a week?
 - b. If so, please list the activities and the amount of time in which they are performed.
 - c. How long have you been following this program?

2.
 - a. Do you participate in weight training exercises?
 - b. If so, how often and for which muscle groups?
 - c. How long have you been following this or a similar program?

3. Do you stretch? How often? How long do you hold/perform each stretch?
Which body parts do you stretch?

4. What is your experience with bench pressing? (Time, frequency, intensity, etc)

Appendix C
Data Collection Sheet

Participant's Number _____ Age _____ Gender (M/F) _____

Date Session 1 _____ Date Session 2 _____

Time _____ AM/PM

Lab: Temp _____ Degrees C

Body Fat Reading #1 _____

Body Fat Reading #2 _____

Body Fat Reading #3 _____

Body Fat Percentage (Average) _____

Pretest

Weight lifted _____

Repetitions _____

Estimated 1RM Score _____

Designated Stretching Assignment- Static/Dynamic

Posttest

Weight Lifted _____

Repetitions _____

Estimated 1RM Score _____

% increase/decrease _____

Appendix D

Case Summaries^a

n	Testing Group	Gender	Age in Years	Percent Body Fat	Pretest 1 RM	Posttest 1 RM
1	Static	Female	47	29.2	66.5	66.5
2	Static	Female	32	22.3	95.8	102.3
3	Static	Female	36	24.2	110.5	102.1
4	Static	Female	26	24.2	130.7	139.9
5	Static	Female	27	19.4	111	104.9
6	Static	Female	27	26.2	71	83
7	Static	Female	37	26.1	100	95.8
8	Static	Female	40	19.2	131	131
9	Static	Female	44	28	79	74
10	Static	Female	54	28.9	89	90
11	Static	Female	44	24.6	93	99
12	Static	Female	24	18.5	62	59.9
13	Dynamic	Female	43	17.8	70.8	74.4
14	Dynamic	Female	29	24.3	50.7	59
15	Dynamic	Female	49	27.9	80	78.9
16	Dynamic	Female	49	27.4	76	78
17	Dynamic	Female	41	27.2	94	87
18	Dynamic	Female	26	26.8	82	82
19	Dynamic	Female	50	22.3	85	87
20	Dynamic	Female	37	24.5	68	81
21	Static	Male	40	13.2	190.3	215.6
22	Static	Male	38	13.7	168	167
23	Static	Male	40	13.2	256	239
24	Static	Male	49	20.2	191	175
25	Static	Male	39	14.2	341	341
26	Static	Male	34	19.9	228	239
27	Static	Male	25	16.3	242	242
28	Static	Male	32	21.2	262	287
29	Static	Male	26	9	230	221
30	Static	Male	27	19.4	204	197
31	Dynamic	Male	40	15.8	242.8	241.9
32	Dynamic	Male	26	11.1	125.7	125.3
33	Dynamic	Male	27	17.7	211	197
34	Dynamic	Male	25	11.8	163	170
35	Dynamic	Male	26	13.1	262	274
36	Dynamic	Male	27	15.7	262	254
37	Dynamic	Male	25	20.3	265	274
38	Dynamic	Male	34	14.4	249	248
39	Dynamic	Male	36	22.4	287	292
40	Dynamic	Male	33	17.7	175	192
41	Dynamic	Male	28	14.6	203	196
42	Dynamic	Male	26	14	236	248
Total	42	42	42	42	42	42