The Effects of Static Stretching on Muscular Hypertrophy During a Resistance Training Program

A Nine Week Study

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Abstract

Studies have shown that static stretching right before physical activity can negatively affect performance. In regards to weight lifting, it has been shown that static stretching immediately prior to lifting can decrease the maximum amount of weight that can be lifted. This study was created in order to determine if static stretching immediately prior to weight lifting over the course of nine weeks would result in smaller gains in muscle size compared to those who did not static stretch immediately prior to lifting over the course of nine weeks.
The Effects of Static Stretching on Muscular Hypertrophy During a Resistance Training Program

**Introduction**

A warm-up is very important before engaging in athletic activity, whether that be swimming, cycling, or lifting weights. Many peoples’ warm-ups include some form of stretching. Go to any park or gym throughout the world and one will undoubtedly find multiple people stretching immediately prior to engaging in physical activity. One may find runners stretching their hamstrings before a big run, kids stretching their shoulders before playing t-ball, and college guys stretching out their backs before playing a game of pickup flag football. Stretching is the common theme here, and the mode in which most people engage in, whether knowingly or not, is static stretching.

There are four main modes of stretching: static, dynamic, ballistic, and proprioceptive neuromuscular facilitation (PNF). Static stretching is the most common type of stretching, and involves stretching the muscles to the point of slight discomfort, and then holding that position for 10 to 30 seconds (Jenkins, 2005). Dynamic stretching involves rapid, powerful movements simulating the movement that is about to be performed. Ballistic stretching involves bouncing, and proprioceptive neuromuscular facilitation involves some series of stretching, contracting, and then stretching again. Research has recently been done regarding the different modes of stretching, the benefits and cons of each, and when each type is appropriate. Of particular interest is the mode of static stretching, as that is the mode that immediately comes to mind when most people think about stretching (Bushman, 2011). Go to any athletic event, whether that be a
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basketball game, triathlon, or swim meet, and one will undoubtedly see many participants engaging in static stretching immediately prior to their event with the hopes that it will cause them to perform both safer and better. However, recent studies show that static stretching immediately prior to athletic events seems to decrease performance, especially in activities that are high-intensity, and high-power oriented, such as weightlifting, high jump, and power lifting. Studies show that static stretching immediately prior to these activities actually decreases performance (Behm & Kibele, 2007; Brandenburg, 2006; Costa, dos Santos, Prestes, da Silva, & Knackfuss, 2009; Curry, Chengkalath, Crouch, Romance, & Manns, 2009; Jenkins, 2005; Kokkonen, Nelson, & Cornwell, 1998; Marek, Cramer, Fincher, Massey, Dangelmaier, & Purkayastha, 2005; Nelson & Kokkonen, 2001; Samuel, Holcomb, Guadagnoli, Rubley, & Wallmann, 2008; Viale, Nana-Ibrahim, & Martin, 2007; Yamaguchi & Ishii, 2005).

Static stretching has been shown to decrease leg extension power (Yamaguchi & Ishii, 2005), maximal isometric strength (Brandenburg, 2006; Viale et al., 2007), 1RM performance for both knee flexion and extension (Jenkins, 2005; Kokkonen et al., 1998), 1RM bench press (Costa et al., 2009), jump height (Behm & Kibele, 2007), and measures of balance, reaction time, and movement time (Winke, Jones, Berger, & Yates, 2010). After a static stretching bout, subjects in McHugh and Nesse’s study actually lost up to 11% of their strength for isometric knee flexion torque (McHugh & Johnson, 2006). Costa showed an average 8.75% decrease in bench press 1RM following an acute bout of static stretching (Brandenburg, 2006). Other studies have shown that decreases in strength can be anywhere between 2.2% and 9.9% following an acute bout of static stretching (Rubini,
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Costa, & Gomes, 2007). Studies also show that the decreases in performance actually last up to two hours after the stretch was performed. (Behm & Kibele, 2007).

There are many different theories regarding why this decrease in performance actually takes place. The most widespread theory involves the musculotendinous unit. The musculotendinous unit is comprised of a muscle and the tendons that attach it to bone. However, upon closer inspection of the muscle itself, it can be seen that the muscle is actually extremely complex. A muscle is comprised of millions of muscle fibers, which are even further divided into smaller strands known as myofibrils. A myofibril is made up of adjoining sections known as sarcomeres. A sarcomere is the basic contractile unit of muscle as well as the basic functional unit of a myofibril (Wilmore, Costill, & Kenney, 2008).

A sarcomere is made up of both thin and thick filaments. The thin filaments are known as actin, while the thick filaments are referred to as myosin (Wilmore, Costill, & Kenney, 2008). When a muscle contracts, the sequence goes all the way down to the myofibril’s sarcomeres. When an action potential from the neuron is transmitted to the muscle fiber, it causes an influx of calcium ions into the muscle cell. This calcium binds to receptor sites known as troponin on a rope like structure called the tropomyosin which is wrapped around the actin filament. When the troponin is activated, it causes the tropomyosin to twist around the actin filament so that the actin filament’s binding sites are no longer covered. When this happens structures on the myosin filament known as myosin heads, reach up and across to the actin filament’s binding sites. The myosin heads
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pull the actin filaments closer to the myosin filament’s source, and continue to move it
closer due to a series of rowing like movement exhibited by the myosin heads as they
release from their current binding site on the actin filament and reach for the next one that
is further down the filament. This whole process, known as the sliding-filament theory of
muscular contraction is what causes muscles to contract (Baechle & Earle, 2008;
Wilmore, Costill, & Kenney, 2008).

The stiffer the musculotendinous unit, the more force it is able to generate. Static
stretching immediately prior to exercise is thought to temporarily lead to both a softening
and lengthening of the musculotendinous unit. This softening and lengthening process
results in a significant amount of slack, or looseness, being produced in the unit, resulting
in the myosin heads having a larger distance that they need to cover on the actin filament
within the sarcomere. As a result, there is a diminished maximal amount of force that can
be generated by that particular musculotendinous unit due to the greater amount of
inherent force that must be generated to pick up the musculotendinous units’ slack within
the sarcomeres of the muscle (McHugh & Johnson, 2006; O’Conner, Crowe, & Spinks, 2006;
Samuel et al., 2008; Yamaguchi & Ishii, 2005). The lengthened musculotendinous unit not
only has to contract its normal amount now, but it also has to contract the extra distance
that it has been lengthened. This contraction process would automatically take a longer
period of time in an elongated unit compared to a normal one, and may be the reason that
static stretching leads to decreases in muscular performance (Fowles, Sale, &
MacDougall, 2000). A lengthened muscle due to static stretching could also result in
problems at the microscopic scale, as there could be an impaired cross-bridge overlap
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which would diminish force output (Behm & Kibele, 2007). The myosin heads would not
be able to grab hold of the actin molecules and pull as effectively as they could if the
sarcomeres had not been lengthened and stretched out. A lengthened muscle could result
in a detrimental alteration in the joint kinematics that are needed to produce a specific
force at the joint. However, the theory of the increase in slack throughout the muscle
would be unable to explain why there is a reduced peak contraction force after static
stretching, despite its ability to explain the reduced twitch force (Fowles, Sale, &
MacDougall, 2000).

Neural deficits are another theory for the decrease in performance after static
stretching (Yamaguchi & Ishii, 2005). It is thought that there may be a decrease in activity
at the neuromuscular level following a bout of static stretching leading to longer reaction
times, and diminished force production (Nelson & Kokkonen, 2001). This may be due to a
decrease in the sensitivity of the alpha motor neurons which involve the moving muscle.
Alpha motor neurons transmit signals known as action potentials to the targeted muscle.
These action potentials are what enable the muscle to contract. If these alpha motor
neurons are not as sensitive as they usually are, a greater stimulus will be required in
order for a action potential, and therefore movement, to be produced. This equates to a
longer time to produce a less powerful movement. Static stretching has been shown to
lead to a decrease in motor unit activation as well as muscular activity after an acute bout
of stretching immediately prior to activity (Rubini, Costa, & Gomes, 2007).

Muscle spindles have been thought to play a role as well. Muscle spindles are
sensory receptors within the belly of a muscle that monitor muscle length, and therefore
serve as a protection mechanism. If the muscle stretches to a point where damage to the muscle is likely, the muscle spindle will send an impulse to the brain, which will cause the lengthening muscle to contract, and therefore prevent excess stretching, and therefore damage, on the muscle. Repeated bouts of static stretching have been shown to reduce the sensitivity of the muscle spindles of a given muscle (Avela, Kyrolainen, & Komi, 1999).

The Golgi tendon organs have been thought to play a role in the static stretching phenomenon as well. Golgi tendon organs are essentially the opposite of muscle spindles. However, they are also protective organs. Golgi tendon organs monitor the tension within the muscle, or how strong of a contraction it is undergoing. If there is too much tension within the muscle due to muscular contraction the Golgi tendon organs will send an impulse to the brain which will cause the contracting muscle to relax as well as cause the antagonist muscle, or the muscle which opposes the contracting muscle, to contract. This protects the muscle by keeping it from contracting to tight to the point of damage (Behm, Button, & Butt, 2001). Static stretching is thought to increase the activation rate of the Golgi tendon organs. If this were the case, then that would mean that the Golgi tendon organs would be causing the muscles that are needed for exercise to relax, as well as increase the activity of the antagonist muscles inhibiting movement. The athlete would not be able to perform at their highest level because in a sense their own muscles are fighting against them. The muscles needed would not be giving a full contraction, and the ones that are not needed would be contracting. Having to fight these two combined sources would be a significant source of athletic impairment.
All of these above impairments caused by static stretching seem to be a built-in protective device for our muscles, tendons, and joints throughout the body. They help to protect these structures from excessive stress, help to protect peripheral neuromuscular structures from complete exhaustion, and monitor the motor units to ensure that the impulses sent from the brain to the muscles do not recruit more muscle cells than are needed (Avela, Kyrolainen, & Komi, 1999).

If static stretching immediately prior to activities that require large amounts of strength and power actually decreases performance, how would that affect the end goals of a weight lifting program, particularly for athletes that are trying to gain muscle mass? Hypothetically, it seems to make sense that if a person participated in a static stretching routine immediately prior to weight lifting, performance would be diminished. Both that person’s peak power output and strength would be decreased. This would cause a person to not be able to lift as heavy of a weight, or to perform as many repetitions for each exercise as this person could have if static stretching had not been performed immediately prior to lifting. If this same person static stretched a specific muscle immediately prior to a lifting exercise, targeting the same muscle that the weight lifting exercise was targeting, throughout the workout, then by the end of the workout this person would not have lifted as much weight as this person could have without having static stretched prior to each exercise. Static stretching prior to a resistance training routine would result in diminished workouts. Over time these diminished workout routines would add up, which would hypothetically mean that the person who engages in static stretching immediately prior to weight lifting, and therefore has diminished
muscular strength, would not see as large of gains in muscular hypertrophy as the person who did not engage in static stretching immediately prior to lifting, and therefore did not lift with diminished muscular strength. In other words, if two people engage in a resistance training program, and if one of them static stretches prior to lifting and the other does not, it should make sense that the one that does not static stretch prior to lifting will end up both stronger and with a larger increase in muscle size than the one that did static stretch prior to lifting.

Knowledge of what would happen in this scenario could be of great importance to those that are involved with athletics, particularly weight training. Personal trainers could use this information to help them to better prescribe exercises for clients, coaches could use it to help their team to perform at their highest potential, bodybuilders could use it to increase their chances of winning competitions, and athletes could use it as well if they are trying to gain muscle mass before their season begins.

**Methods**

**Subjects**

Twenty college males volunteered (19±1.26) to participate in the study. All were recreationally active, but none had been participating in a resistance training program steadily for the past six months as this would have skewed the results. This is due to the fact that trained weight lifters see smaller increases in muscle size compared to novice weight lifters just beginning a weight training program over the same period of time. The novice will see more dramatic increases in strength and size. An informed consent form was obtained for each subject, and all were cleared by taking the PAR-Q & YOU form.
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No subject who had been lifting weights steadily over the past six months, or who failed the PAR-Q & YOU was allowed to participate.

**Procedures**

All subjects were briefed regarding what to expect for the program and were instructed what to do. Before the resistance training program began, individual measurements were taken for weight, height, BMI, fat percentage, left and right bicep size, chest size, and left and right thigh size. The study lasted nine weeks, one week being spent away from the program, as spring break occurred during the program duration. Subjects were split into two groups, one which static stretched immediately prior to each exercise (the experimental), and one which did not static stretch immediately prior to each exercise (the control).

Subjects were instructed to go about their normal lives while participating in the program. They were instructed to maintain their current physical and nutritional habits, and to not make unnecessary changes to their diet or exercise routine over the course of the study. However, subjects were also instructed not to supplement with any form of protein powder, creatine, caffeine or any other ergogenic aid while participating in the program, as this would skew the results. Subjects were also asked to abstain from doing any other form of resistance training while going through this program, or from adding their own variety to the prescribed workout routine, such as performing very slow eccentric reactions, or from performing extra repetitions at the end of each set.

The weight lifting program required visiting the gym three times per week throughout the program, with the exception of the spring break week. The program
involved bench press, lat pullbacks, leg extensions, leg curls, bicep curls, tricep pull-downs, leg press, and pushups (all exercises are shown in Appendix A). Each exercise was performed for three sets of ten repetitions throughout the program, with the exception of the preparation week, and pushups. Preparation week involved one set of 15 repetitions for each exercise, with the exception of pushups, once again.

The static stretching group was given an additional list of stretches that they were to perform for each joint immediately prior to each exercise (all static stretches are shown in Appendix B). For example, if a subject were about to perform the bench press, he would first stretch his chest. If a subject was about to perform a leg extension, he would first stretch his quadriceps. Each stretch was to be performed one time for each side of the body immediately prior to the first set, and held for thirty seconds. The static stretches were only performed prior to the first set. They were not performed again in between each set.

The first week of the program was regarded as a preparation week. A lighter workout was performed consisting of lighter weights, and fewer repetitions of each exercise in order to help the subjects’ bodies to prepare for the coming program, to decrease initial soreness, and to help learn proper technique. Subjects performed one set of 15 repetitions at a weight that they could comfortably lift for the training week, with the exception of pushups, in which they performed one set of 25 repetitions. All subjects were instructed as to how to properly use each piece of equipment in the gym that they would be using throughout the program. At the end of the first week, the training week came to an end, and the program increased in intensity by increasing the amount of
weight lifted, decreasing the number of repetitions, and increasing the number of sets. Subjects were then required to perform three sets and ten repetitions of each exercise at a weight that got difficult around the eighth or ninth repetition, with the exception of pushups, which required three sets of 25 repetitions. Four weeks into the program, midpoint measurements were procured again. The study continued for the remaining five weeks, at which point the final measurements were once more obtained, and volunteers were told individually and secretly how much they had improved over the program. It is important to note that over the course of the study four volunteers dropped out of the study due to time constraints.

Statistical Analysis. A 2-way (control vs. experimental) repeated measures analysis of variance (ANOVA) was used for analysis. The level of significance was set at $p \leq 0.05$. Means and standard deviations were also computed for each separate aspect of the program for both control and experimental values.

Results

Table 1

<table>
<thead>
<tr>
<th>Measurements Taken Throughout Program</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td>First Measurement</td>
</tr>
<tr>
<td>-------------------</td>
</tr>
<tr>
<td>Weight (C)</td>
</tr>
<tr>
<td>Weight (E)</td>
</tr>
<tr>
<td>Height (C)</td>
</tr>
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Table 1 Continued
Measurements Taken Throughout Program

<table>
<thead>
<tr>
<th></th>
<th>First Measurement</th>
<th>Second Measurement</th>
<th>Third Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Height (E)</strong></td>
<td>179.49±8.78cm</td>
<td>179.49±8.78cm</td>
<td>179.49±8.78cm</td>
</tr>
<tr>
<td><strong>BMI (C)</strong></td>
<td>24.80±6.01</td>
<td>25.04±5.77</td>
<td>25.00±5.59</td>
</tr>
<tr>
<td><strong>BMI (E)</strong></td>
<td>21.68±4.05</td>
<td>21.88±3.91</td>
<td>22.03±4.03</td>
</tr>
<tr>
<td><strong>Fat % (C)</strong></td>
<td>16.04±10.04%</td>
<td>16.00±9.75%</td>
<td>17.09±9.23%</td>
</tr>
<tr>
<td><strong>Fat % (E)</strong></td>
<td>11.25±6.55%</td>
<td>11.63±6.08%</td>
<td>11.22±6.62%</td>
</tr>
<tr>
<td><strong>R. Bicep (C)</strong></td>
<td>33.02±3.67cm</td>
<td>33.75±3.45cm</td>
<td>34.11±3.91cm</td>
</tr>
<tr>
<td><strong>R. Bicep (E)</strong></td>
<td>31.89±3.63cm</td>
<td>32.39±3.69cm</td>
<td>32.81±3.66cm</td>
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<tr>
<td><strong>L. Bicep (C)</strong></td>
<td>32.03±3.51cm</td>
<td>32.66±3.47cm</td>
<td>33.39±3.68cm</td>
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<tr>
<td><strong>L. Bicep (E)</strong></td>
<td>31.40±3.16cm</td>
<td>31.89±3.42cm</td>
<td>32.03±3.29cm</td>
</tr>
<tr>
<td><strong>Chest (C)</strong></td>
<td>99.88±11.13cm</td>
<td>100.15±9.77cm</td>
<td>101.24±10.21cm</td>
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<tr>
<td><strong>Chest (E)</strong></td>
<td>96.45±8.74cm</td>
<td>96.45±8.63cm</td>
<td>98.07±8.83cm</td>
</tr>
<tr>
<td><strong>R. Thigh (C)</strong></td>
<td>54.16±8.79cm</td>
<td>55.26±8.86cm</td>
<td>55.34±7.61cm</td>
</tr>
</tbody>
</table>
Table 1 Continued

Measurements Taken Throughout Program

<table>
<thead>
<tr>
<th></th>
<th>First Measurement</th>
<th>Second Measurement</th>
<th>Third Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>R. Thigh (E)</td>
<td>50.73±5.12cm</td>
<td>50.45±4.96cm</td>
<td>52.85±5.82cm</td>
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<tr>
<td>L. Thigh (C)</td>
<td>53.70±7.81cm</td>
<td>55.43±8.62cm</td>
<td>55.16±7.72cm</td>
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<tr>
<td>L. Thigh (E)</td>
<td>51.08±5.85cm</td>
<td>50.87±5.80cm</td>
<td>52.56±5.50cm</td>
</tr>
</tbody>
</table>

The average (±SD) for each different measurement of the study is presented in Table 1. There was no significant difference between any of the different aspects of the study between the control and the experimental group. Weight (p=.227), height (p=.957), BMI (p=.227), fat percentage (p=.299), right bicep (p=.502), left bicep (p=.597), chest (p=.479), right thigh (p=.310), and left thigh (p=.357) were all statistically insignificant. Percent increases for each different variable of the study are shown in Table 2 below.

Table 2

Percent Increase for Both Groups

<table>
<thead>
<tr>
<th>Percent Increase</th>
<th>Control</th>
<th>Experiment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight</td>
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<td>.015</td>
</tr>
<tr>
<td>Height</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>BMI</td>
<td>.008</td>
<td>.016</td>
</tr>
</tbody>
</table>
The below tables show the gains or decreases in BMI, weight, height, fat percentage, and muscular size over the course of the program from the beginning to end.
TABLE 4

Height Changes Throughout Program

![Height Graph](image1)

TABLE 5

BMI Changes Throughout Program

![BMI Graph](image2)
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Table 6
Fat Percentage Change Throughout Program

Table 7
Right Bicep Change Throughout Program
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Table 8
Left Bicep Change Throughout Program

Table 9
Chest Change Throughout Program
Table 9
Right Thigh Changes Throughout Program

Table 10
Left Thigh Changes Throughout Program
Discussion

There were no significant differences in muscle growth between the static stretching group, and the group that did not static stretch. The results of this study go to show that there is no correlation between static stretching immediately prior to lifting during a resistance training program, and diminished gains in muscle size over a period of nine weeks compared to a control group that did not participate in static stretching immediately prior to lifting during a resistance training program.

At first, the results of this study seem to contradict the majority of studies that have been published which show that static stretching does indeed impair muscle strength and power when performed immediately prior to an athletic activity requiring these attributes (Behm & Kibele, 2007; Brandenburg, 2006; Costa et al., 2009; Curry et al., 2009; Jenkins, 2005; Kokkonen et al., 1998; Marek et al., 2005; Nelson & Kokkonen, 2001; Samuel et al., 2008; Viale et al., 2007; Yamaguchi & Ishii, 2005). However, it must be remembered that this study was designed not to measure the affects of static stretching on strength loss, but rather to see how it effects muscular hypertrophy during a resistance training program. The validity of the studies which show that static stretching prior to competition is detrimental to performance has been questioned as well (Brandenburg, 2006; O’Conner et al, 2006; 25; Yamaguchi & Ishii, 2005). Almost all of the studies that show that static stretching is detrimental to performance require the subject to perform anywhere from 10 minutes (Curry et al., 2009) to a full hour of static stretching prior to testing (Kokkonen et al., 1998; Viale et al., 2007; Wong, Chaouachi, Lau, & Behm, 2011). This does not accurately portray the pre-competition routine of the average athlete. A series of studies performed
on North American athletes showed that most athletes only hold a stretch for an average of 12 seconds, and that when held for this short of a period of time there is no significant impairment in athletic performance (Wong et al., 2011). If this is the case, then it seems that the other studies out there do not truly apply to the average athlete. In response to this finding, studies have been performed which show that static stretching for periods less than 30 seconds does not detrimentally effect athletic performance (O’Conner et al, 2006; Samuel et al., 2008; Winke et al., 2010; Wong et al., 2011; Yamaguchi & Ishii, 2005). In fact, O’Conner et al. (2006) showed that static stretching can actually improve performance during cycling as long as the stretching bout is kept shorter than 20 minutes, and the stretching bout is done as close to competition as possible. However, cycling is a much different activity than weight lifting.

If this is indeed the case, then there is a possible reason for the lack of significant difference between the static stretching and non-stretching group in this study. The subjects in this study only stretched for a period of 30 seconds before each lift. Static stretching for such a short time period obviously does not have an overall effect on performance. However, if the clients had engaged in a stretching program before lifting that lasted \( \geq 20 \) minutes such as many of the previously listed studies, then it is very possible that the static stretching group would not have seen as large of gains in muscle size as the non-stretching group, as the static stretching group would not have had the strength required to lift as heavy weights as the non-static stretching group.

In hindsight, there are a few improvements that could have been made to this study. Obviously, a larger sample size would give a more definitive answer to the
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hypothesis rather than this study. More volunteers would lead to an even more definitive answer, and would be much more accurate of the human population as a whole. Also, the length of the program might have been a factor as well. A longer study might yield more accurate results. The one week of spring break in the middle of the program was also an obstacle to the study, but could not really be avoided, and probably did not alter the results. However, future studies with the subject of static stretching should avoid the one week hiatus from lifting that this study did.

The results of this study would suggest that static stretching immediately prior to weight lifting, as long as the duration is less than 30 seconds, does not affect muscle growth. However, similar studies need to be done in this area in order to further confirm this before it is accepted as fact. A study with that lasted longer time duration needs to be performed as well in order to see if there is indeed an effect, but that this effect occurs slowly over a longer period of time, rather than over a shorter time frame, such as nine weeks. Though static stretching does not seem to affect muscular growth while engaging in a resistance training program, this study does bring to mind whether different modes of stretching might, particularly dynamic stretching.

Dynamic stretching immediately prior to competition has been shown to improve performance (Curry et al., 2009; Vardiman, Carrand, & Gallagher, 2010). In fact, if the athlete does choose to static stretch for longer than 30 seconds, it has been shown that performing dynamic stretching immediately after static stretching can eliminate any potential factors that will impede performance (Wong et al., 2011). This brings to mind the question as to whether dynamic stretching immediately prior to resistance training will
improve performance over time resulting in larger gains in muscular strength and muscular hypertrophy over the course of a training program compared to a weightlifter who does not engage in dynamic stretching immediately prior to lifting. The other modes of stretchings’ (ballistic stretching and proprioceptive neuromuscular facilitation) roles on impacting muscular hypertrophy would be interesting to study as well.

In short, if an athlete still chooses to static stretch immediately before competition, dynamic stretching immediately after, limiting holding stretches to less than 30 seconds, and limiting the stretching warm-up to \( \leq 5 \) minutes are the keys to being able to continue to engage in static stretching prior to the weight lifting while keeping the decreases in performance to a minimum (Curry et al., 2009; O’Conner et al., 2006; Vardiman et al., 2010; Wong et al., 2011).

In the course of researching for this study, articles were also found suggesting that static stretching may actually increase muscular hypertrophy to a small amount even without a resistance training program (Kokkonen, Nelson, Tarawhiti, Buckingham, & Winchester, 2010; Rubini et al., 2007). These studies suggest that by static stretching on days when an athlete is not resistance training will cause that athlete to see both gains in muscular hypertrophy as well as strength. This raises the question as to whether or not the reason that there were no significant differences between the static stretching and non-static stretching groups in this study were due to the increases in muscular size as a result of static stretching. Was the performance of the static stretching group actually impaired, but the effects of static stretching that cause muscular hypertrophy actually cause the experimental groups’ muscles to still grow, allowing them to achieve the same increase in
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muscular size as the control, or non-static stretching group. In other words, did the increases in muscular size due to static stretching make up for any strength deficits in the experimental group? However, the studies that showed that static stretching resulted in increases in muscle size required the subjects to study for periods of at least approximately 30 minutes (Kokkonen et al., 2010; Rubini et al., 2007). This study most certainly did not have volunteers stretching for anywhere near the time of 30 minutes, and whether this factor had any effect on the gains in muscle size among the static stretching group must be questioned. Although an athlete will experience an acute diminish in performance, including muscular strength, following static stretching for a time period greater than 30 minutes, a chronic static stretching program may increase muscular strength and size (Rubini et al., 2007). Clearly, more research needs to be done in this area before a definitive answer can be reached regarding this question.

What is the purpose then of static stretching? Clearly, static stretching can diminish performance when the stretching bout is longer than 20 minutes. However, most pre-event stretching routines do not last longer than 20 minutes and should not be expected to hurt the athlete’s performance in any way. However, dynamic stretching has been shown to actually improve one’s athletic performance, and therefore should be the method of stretching chosen before an athletic event or training session (Curry et al., 2009; Vardiman et al., 2010). What static stretching does is improve flexibility, both in a transient manner after an acute stretching session, and in a chronic manner, when performed with a consistent static stretching routine (Baechle & Earle, 2008; Marek et al., 2005; Powers & Dodd, 1997; Vardiman et al., 2010). This can be very important in some sports such as
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dancing, gymnastics, martial arts, or other activities that require a high degree of flexibility. There are possible links to decreased occurrence of injury following a chronic static stretching routine, but these reports are debated (Bushman, 2011; Marek et al., 2005).

Static stretching has also been shown to possibly increase muscular hypertrophy when performed on non-training days, and has been linked to possibly reducing the occurrence of delayed onset muscle soreness (DOMS) after an intense training session or event, though some studies debate this last statement (Costa et al., 2009; McHugh & Johnson, 2006; Powers & Dodd, 1997).

Practical Applications

The results of this study show that those who engage in static stretching immediately prior to any form of resistance training should not expect to see their performance diminished, as long as they keep their individual stretches under 30 seconds. However, static stretching longer than 30 seconds can result in decreased performance, and thus should be performed after the competition or workout in order to increase flexibility, and possibly gains in muscular hypertrophy.
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References


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Appendix A

Bench press  Lat pull down

Figure 1 Credit: Zachary Martin  Figure 2 Credit: Zachary Martin

Leg extension  Hamstring curl

Figure 3 Credit: Zachary Martin  Figure 4 Credit: Zachary Martin
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EZ bar bicep curl

Figure 5 Credit: Zachary Martin

Triceps push down

Figure 6 Credit: Zachary Martin

Leg press

Figure 7 Credit: Zachary Martin

Pushups

Figure 8 Credit: Zachary Martin
Appendix B

CHEST

Behind the back chest stretch

UPPER ARMS

Tricep stretch

THIGHS

Quad stretch

Biceps Stretch

Figure 9 Credit: Zachary Martin

Figure 10 Credit: Zachary Martin

Figure 11 Credit: Zachary Martin

Figure 12 Credit: Zachary Martin
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Hamstring stretch

Figure 13 Credit: Zachary Martin