

## Effects of Plantar Flexion Stretching on Flutter Kicking Time in Competitive Age Group Swimmers

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### Abstract

The purpose of this investigation was to emphasize the importance of plantar flexion (PF) stretching and its effect on flutter kicking time (FKT) in swimmers. There is a limited amount of research regarding the correlation between plantar flexion stretching and speed in competitive swimmers based on flutter kicking ability within a freestyle stroke. A pre-test and post-test were completed over four weeks for both the stretching and control groups. Two different stretches for PF were taught to competitive age group swimmers (13-17 years old). An independent T-test and a correlation coefficient were used for data analysis of PF range of motion (ROM) and FKT between the two groups. The study found a significant difference between stretching and control groups on the variable of swim time with the significance of this study set at  $p \leq .05$ . The stretching group was found to gain less PF ROM overall compared to the control group; however, the stretching group improved flutter kicking time (FKT) while the FKT of the control group decreased. Given the significant difference in FKT found between groups, this study suggests PF stretching correlates with faster swim times.

**Keywords:** swimming, stretching, flutter-kicking, ankle

### 1. Introduction

Ankle plantar flexion (PF) is thought to play a substantial role in swimming speed by allowing swimmers to propel their bodies forward more efficiently and effectively. A study by McCullough and colleagues found that ankle plantar flexion was a strong predictive measure of flutter kick time at 22.86 meters (m) in a group of competitive and non-competitive female swimmers. (McCullough, 2009) However, there is a limited amount of research regarding the correlation between a PF stretching regimen and flutter kicking time (FKT) in competitive swimmers. Flexibility is a key component of propelling the body through the water efficiently in competitive swimming. By having the most optimal amount of flexibility, it allows the swimmer to perform the swimming stroke more efficiently without having to spend unnecessary amounts of energy to overpower the resistance of ligaments and tendons around the joint. (Jorgic, 2009) Competitive swimmers at a Division I University exhibited hypermobility in shoulder abduction, external rotation and flexion. (Beach, 1992) Sufficient glenohumeral flexibility is necessary for a deeper pull, which allows stronger propulsion of the body over the upper extremity.

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It is also important for swimmers to have flexibility around the long body axis of the spine to rotate from side to side while alternating arms pulls and breaths. Rotation around the long body axis allows swimmers to grab more water underneath their bodies correctly, allowing the strong part of the arm pull to be directly under the swimmer's center of mass. (Counsilman, 1968) It also allows the side of the head to surface for a complete breath while the lower extremities continue to flutter kick. To acquire and maintain flexibility; many swimming programs implement a general stretching routine that includes glenohumeral and trunk stretching.

However, these programs fail to give strong focus to the ankle joint. Most swimmers, therefore, do not participate in a regular ankle stretching regimen and may lack optimal ankle flexibility. A study by Tošić used eleven tests to evaluate the flexibility of the hand, shoulder, leg and trunk and four tests to evaluate the swimming results of four different stroke styles; freestyle, breast, back and butterfly. (Tošić, 2011) A sample of 50 female swimmers between the ages of 11 and 14 with an average of three years training experience was used. The study assessed the relationship between flexibility and swimming results. The study concluded that flexibility was not a statistically significant predictor in swimming in all four strokes. The author concluded based on previous research that a positive correlation should exist between flexibility and success in swimming, and the development of flexibility as a motor skill had not received enough attention.

In the sport of swimming, it is important to have a good balance between upper and lower body function. Swimmers who solely use their upper extremities versus lower extremities would not be as effective as those who use both simultaneously. It is nearly impossible to keep up with the pace of competitors without correct, efficient coordination of the extremities. As stated by Sanders, "the (flutter) kick plays an important role in providing a stable "platform" for the whole stroke by facilitating body position to optimize propulsion and minimize resistance, and in assisting an economical body roll." (Sanders, 2007) The flutter kick improves the effectiveness and overall efficiency in the freestyle stroke by keeping the lower extremities elevated, which in turn keeps the whole body stable and improves buoyancy. (Sortwell, 2011)

The study was performed over four weeks. A pre-test was performed on the first day to establish a baseline followed by a post-test on the last day of the fourth week. A previous study by Bandy and colleagues tested the optimal time and frequency necessary to increase ROM of the hamstring muscle using a static stretch. (Bandy, 1997) The subjects in the treatment group stretched five days a week for six weeks. The stretching groups were divided into four different static stretching regimes; group one did three one-minute static stretches, group two did three 30-second static stretches, group three did one static stretch for one minute, and group four did one static stretch for 30 seconds. The researchers found no significant difference between the stretching groups, and all groups experienced an increase in hamstring flexibility. Based on this study, we employed three sets of one-minute stretches for all of PF stretches. The purpose of this study was to investigate the importance of PF stretching and its effect on speed in competitive age group swimmers. "Age group swimmer" refers to swimmers who are under the age of 18 years. It was hypothesized that there would be a significant difference between PF stretching and no stretching on FKT in competitive age group swimmers after four weeks.

## **2. Methods**

### **2.1 Participants**

The research study was an experimental design that used subjects from the Wichita Swim Club. At the start of data collection, the study included 19 swimmers between the ages of 13 and 17 years old. The swimmers were required to read and complete an assent form and have a guardian complete the consent form to be considered for the study. The subjects were randomly assigned to either group A or B which differentiated whether they would be in the stretching group or the control group. The control group was instructed not to do any ankle stretching during this study. This was a single-blind study because the testers, Wichita State University Doctor of Physical Therapy (WSU DPT) students, were unaware of who was in the stretching or control group. The coach was responsible for recording daily attendance, administering the stretching regimen, and initiating start-time for each trial.

## 2.2 Procedure

1. On day one, after the swim team warm-up was over, each of the swimmers who participated in the study drew either the letter A or B out of a cup to establish which group they would be in the stretching or the non-stretching. However, at this point the swimmers were unaware of which group would be doing the stretching regimen. After establishing which group the swimmer was in, an initial measurement of his/her PF and FKT over 50 yards was taken using the following methods:

a. A swimmer was asked to sit in a long-sitting position, plantar flex his/her feet as far as he/she was able, and hold that position.

b. A designated WSU DPT student measured the PF ROM of both ankles with the use of a goniometer. The fulcrum was placed over the lateral aspect of the lateral malleolus. The proximal arm was aligned with the lateral midline of the fibula. The distal arm was aligned parallel to the lateral aspect of the fifth metatarsal. The ankle plantar flexion measurement was taken by the same examiner each time. A study by Elveru et al concluded that clinical measurements of the subtalar joint neutral position, subtalar joint, and ankle passive range of motion can be moderately reliable if taken by the same therapists over a short period of time. (Elveru, 1988)

c. The swimmer proceeded to one of two lanes and was expected to perform 50 yards of flutter style kicking with a kickboard placed under his/her arms to keep the upper extremities stable and a snorkel breathing device to keep his/her head neutral in the water.

d. Four other designated WSU DPT students (two per lane) timed and recorded the swimmer's 50-yard time with a stop watch. The times from the two timers per lane were averaged.

2. Steps A-D was repeated with all remaining swimmers.

3. The swim coach was given a choice of picking between two blank envelopes marked "A" or "B". One envelope held a stretching regimen, while the other included only a piece of paper establishing that this group would be the control group. This was a single-blind study, so the choice of envelope was unknown to the WSU DPT student testers. After choosing an envelope, the swim coach was then instructed by the WSU DPT students in a stretching regimen that the selected swimmers would be required to perform independently at the Wichita Swim Club. The stretching regimen was as follows:

### A. Ankle Stretching #1 Instructions for Coaches (See Figure 1):

Have the swimmer sit on his/her heels with his/her toes flat. Using both hands for support behind him/her, have the swimmer lean back as far as he/she can tolerate. Stretch in this position for one minute, followed by 30 seconds of rest by having the swimmer lean forward putting his/her hands on his/her knees. Repeat this sequence two more times. Perform this routine each day following swim practice.



Figure 1: Ankle Stretching #1

### **B. Ankle Stretching #2 Instructions for Coaches (See Figure 2):**

Have the swimmer sit tall on the edge of a firm chair or bottom level bleacher. Have him/her point and then bring his/her right foot underneath the chair or bleacher. Apply a gentle downward pressure through the right foot until he/she feels a tolerable stretch on his/her ankle. Have the swimmer hold this stretch for one minute, followed by 30 seconds of rest by releasing the pressure and bringing the foot forward into normal sitting position. Repeat this sequence two more times on the right foot. Perform the same sequence with the left foot, and perform this routine each day following swim practice.



**Figure 2: Ankle Stretching #2**

4. Swimmers were required to perform stretches following each swim practice throughout the week for four weeks, monitored closely by the swim coaches.

5. After four weeks, steps A-D were repeated following swim practice with the same designated WSU DPT measurer and timers, and in the same order of swimmers to ensure accuracy. It was anticipated that some swimmers may experience some discomfort following the first few days of stretching due to tightness of certain muscles. It was suggested that the swimmers use ice following practice if this occurred.

### **3. Data Analysis**

After collecting and averaging ROM measurements of both left and right ankles, timed flutter kick trials, and time in/out of the water throughout the study from each swimmer, the data was analyzed comparing the control group to the stretching group by implementing an independent t-test and a correlation coefficient. A significant difference using an alpha level less than 0.05 was used to reject the null hypothesis.

### **4. Results**

Of the 19 swimmers participating in the study, four were excluded due to scheduling conflicts on the final testing day. The results indicated a significant difference between the stretching and non-stretching groups on the variable of swim time. Those who participated in the stretching regimen showed a smaller increase in PF ROM while increasing flutter kick time, compared to those in the control group who had a greater increase in ROM with a decrease in flutter kick time. Tables 1 and 2 represent the means and standard deviations for pre-test/post-test scores for both groups (stretching and control group) for ROM and time differences.

**Table 1: Differences in ankle PF ROM (bilateral average) before and after stretching versus no stretching (control group)**

ROM Differences			
Group	Mean (degrees)	N	Std. Deviation (degrees)
Stretching	3.8333	9	3.79967
Control	7.1667	6	5.31664
Total	5.1667	15	4.60460

**Table 2 Differences in swim time before and after stretching versus no stretching (control group)**

Time Difference			
Group	Mean (seconds)	N	Std. Deviation (seconds)
Stretching	-0.5378	9	1.17535
Control	1.0533	6	1.43659

**5. Discussion**

The results of this study demonstrated a significant difference between PF stretching and FKT among competitive age group swimmers. It was expected that PF stretching would not only increase FKT but would correlate with an increased PF ROM. However, those who participated in the stretching regimen showed a smaller increase in PF ROM with an increase in FKT, in comparison to those in the control group, who showed a greater increase in PF ROM with a decrease in FKT.

Several factors could have contributed to the unexpected results of this study. With such a small sample group, it is hard to determine if stretching truly affects speed alone or if other factors affected the results. This study did not take into account the swimmers other sporting activities or their ankle ROM in other planes. For instance, having greater calcaneal valgus or varus motion could have caused a difference in flutter kicking speed by changing the foot position as it moves through the water. Also, due to the absence of four subjects, some swimmers had to perform their post-test trial alone, which may have led to a decrease in FKT due to a lack of competitive drive. A few instrumental errors, including stopwatch malfunctions and the loss of a snorkel, during swim trials may have also contributed. At post-test, the coach was absent due to health complications; therefore, a WSU DPT student was required to initiate start times for each trial. During the pre-test, the coach initiated the swim trial with a two-whistle start. However, the WSU DPT student used verbal commands, which may have affected the participants’ reaction times.

Both groups showed improved PF ROM; however, those who performed the stretching regimen versus those who did not perform the stretching regimen had a significantly smaller increase in ROM. This may be due to measurement error of the measure. But this is unlikely as intra-rater reliability was excellent with a test-retest reliability of 0.954 with PF ROM measurements. The participants’ quality of stretching may have contributed to the unexpected results as previously stated. It is possible that the stretching group may have stretched inappropriately, which could have affected the muscle in a negative way. If overstretching occurred that caused pain in the corresponding muscle, the cause may have been the swimmer restricting the use of the painful ankle, causing the tendinous and ligamentous structures to shorten and lose flexibility. If participants failed to stretch with enough force to put tension on the ankle structures or didn’t perform the stretch long enough, then the optimal amount of ROM would not be gained. One study that implemented a 10-week running program found that at the end of the training program the runners had actually significantly decreased calf flexibility.(Moore, 2012)Perhaps the reasoning for decreased ROM the runners experienced over the 10-week training period is the same as the decrease in ROM the swimmers experienced.

In this study, a stretching regimen was implemented over a four-week time span to determine the benefits of long-term stretching on FKT in competitive-aged swimmers. Long-term stretching is stretching that takes place over the span of several weeks. Stretching over three or four weeks affects the overall stretch tolerance of a muscle, but it does not change the viscoelastic properties of the muscle. (Shrier, 2004) Athletic performance is improved due to stretch-induced hypertrophy, which results in an increase in force and contraction velocity. (McMillan, 2006) Further studies should consider using different time periods. These could be tested to see if, for example, performing a stretching regimen once is equally sufficient to increase performance as stretching several times per session. Age also may have been a factor. Since the age of the sample group was between 13 and 17 years, an improvement in FKT may have been due to subject maturation. If the swimming technique was not properly learned or practiced, the influence of flexibility and other motor skills on swimming efficacy is expected to be reduced and limited. (Jorgic, 2009)

Along with a variation of stretching protocol length, further research is needed to test different types of stretches and their influence on athletic performance. Other studies have concluded that static stretching before activities actually decreases athletic performance. (Shrier, 2004) Performing two different static stretching techniques for the quadriceps caused a significant decrease in maximal voluntary muscle contraction that lasted up to 120 minutes after the stretching was stopped. (Power, 2004) Another study found that an acute stretching regimen can inhibit the muscle strength endurance of the quadriceps and should not be performed before any activities requiring muscular endurance. (Nelson, 2005) Thus, comparing static stretching to other stretching techniques, such as dynamic stretching, can be performed to find their effects on athletic performance and ROM. Because the flutter kick only contributes to part of the total stroke speed in the freestyle stroke, additional studies should be performed to measure the effects of a PF stretching regimen on other swimming stroke speeds, such as the breaststroke in which the legs provide the majority of propulsive force and below average flexibility can limit the effectiveness of the kick.

## **6. Conclusion**

In conclusion, this study indicates that PF stretching is effective to a small degree to improve FKT compared to non-stretching. These results show that stretching may play a significant part in improving the swimming speed of competitive age group swimmers. This study found that both groups showed an increase in PF ROM, the control group had a greater gain. The swimmers in the control group showed a decrease in FKT while the swimmers in the stretching group had an increase in FKT. With such a small sample group it is hard to definitively state that greater PF ROM correlates with flutter kicking speed. This study specifically focused on competitive age group swimmers between the ages of 13 and 17 years. Further research is necessary to determine the correlation between a stretching regimen and its effect on speed within larger samples of competitive age group swimmers.

## 7. References

- McCullough, A. S., Kraemer, W. J., Volek, J. S., Solomon-Hill, G. F., Hatfield, D. L., Vingren, J. L., . . . Maresh, C. M. (2009). Factors Affecting Flutter Kicking Speed in Women Who Are Competitive and Recreational Swimmers. *Journal of Strength and Conditioning Research*, 23(7), 2130-2136.
- Jorgić, B., Aleksandrović, M., Okičić, T., & Madić, D. (2009) The influence of flexibility onto the swimming results in students of sport and physical education. *Sport Science*, 2(1), 91-94.
- Beach, M. L., Whitney, S. L., & Dickoff-Hoffman, S. A. (1992). Relationship of Shoulder Flexibility, Strength, and Endurance to Shoulder Pain in Competitive Swimmers. *Journal of Orthopaedic & Sports Physical Therapy*, 16(6), 262-268.
- Counsilman, J.E. (1968) Science of swimming. Englewood Cliffs, NJ: Prentice-Hall.
- Tošić, S. The influence of flexibility on swimming results. (2011) *Factauniversitatis - series: Physical Education and Sport*, 9(2), 193-202.
- Sanders, R. H. (2007). Kinematics, coordination, variability, and biological noise in the prone flutter kick at different levels of a "learn-to-swim" programme. *Journal of Sports Sciences*, 25(2), 213-227.
- Sortwell, A. (2011) The relationship between stroking parameters and leg movement quantity in 100 metre front crawl. *International Journal of Exercise Science*, 4(1), 22-29.
- Bandy, W.D., Irion J.M., & Briggler M. (1997) The effect of time and frequency of static stretching on flexibility of the hamstring muscles. *Physical Therapy*, 77(10), 1090-1096.
- Elveru R., Rothstein J., & Lamb R. (1988) Goniometric reliability in a clinical setting: subtalar and ankle joint measurements. *Physical Therapy*, 68, 672-677.
- Moore, I. S., Jones, A. M., & Dixon, S. J. (2012). Mechanisms for Improved Running Economy in Beginner Runners. *Medicine & Science in Sports & Exercise*, 44(9), 1756-1763.
- Shrier, I. (2004). Does Stretching Improve Performance? *Clinical Journal of Sport Medicine*, 14(5), 267-273.
- McMillian, D. J., Moore, J. H., Hatler, B. S., & Taylor, D. C. (2006). Dynamic vs. Static-Stretching Warm up: The Effect on Power and Agility Performance. *The Journal of Strength and Conditioning Research*, 20(3), 492-499.
- Shrier, I. (2004). Does Stretching Improve Performance? *Clinical Journal of Sport Medicine*, 14(5), 267-273.
- Power, K., Behm, D., Cahill, F., Carroll, M., & Young, W. (2004). An Acute Bout of Static Stretching: Effects on Force and Jumping Performance. *Medicine & Science in Sports & Exercise*, 36(8), 1389-1396.
- Nelson, A. G., Kokkonen, J., & Arnall, D. A. (2005). Acute Muscle Stretching Inhibits Muscle Strength Endurance Performance. *Journal of Strength and Conditioning Research*, 19(2), 338-343.