Why is her leg higher than mine: A study on flexibility in rhythmic gymnastics

Yuzuki Ito

Abstract

Flexibility plays a key role in the sport of rhythmic gymnastics. Specifically focusing on rhythmic gymnasts, hamstrings play a vital role as this muscle allows gymnasts to lift their legs or gain more flexibility [23]. The hamstring muscle consists of three muscle groups that connect the hip to the knee on the posterior of the thigh [25]. When aiming to increase flexibility, gymnasts often use one of the three methods to stretch their muscles. A common method is when an individual stays in a desired position of stretching for a period of their desired time [14]. This is called static stretching [14]. Another common type of stretching is dynamic stretching when an individual stretches while in motion to help warm up and loosen muscles [15]-[16]. Lastly, neural gliding is when the nerves are stretched [16]-[17]-[18]. A commonly used form of this is foam rolling. Previous studies have shown neural gliding to be just as effective as dynamic stretching but more effective than static stretching. Through these methods of stretching, we conducted a study using rhythmic gymnasts to determine which method was most beneficial to this population. We found that despite static stretching being the most common stretching method used by rhythmic gymnasts, neural gliding may be more useful for athletes to reach their goals.

Introduction

Rhythmic gymnastics is a sport composed mostly of females that combines dance, gymnastics, and ballet [24]. It originated in European countries around the 1800s that later spread throughout the world [24]. It involves the skills to use many different apparatuses including hoops, balls, ribbons, and clubs [24]. The use of these requires coordination but the sport also involves skills that root from strength and flexibility [24]. Each gymnast competes in a total of four, 90 second routines that use a different apparatus for each and takes a variety of skills within each routine [24].

Having adequate flexibility, especially in the legs, can be one way to attract interest from a coach or judge. This is because flexibility is required for performing many of the technical skills in rhythmic gymnastics [23]. If an individual does not have enough flexibility, limitations can arise to what they can undertake in the sport [23].

The hamstring muscles are specifically important to rhythmic gymnastics because of the abundance of skills requiring these muscles. For example, gymnasts use the hamstring muscles in everything from walking to the splits. The hamstring consists of three muscle groups: the semitendinosus, semimembranosus, and biceps femoris [23]. This is known as the hamstring muscle complex which connects the hip to the knee on the posterior of the thigh [25].

The semitendinosus muscle is a posterior component of the thigh, allowing movement and extension of the hip and also allowing flexion of the knee [2]. This muscle also allows for the rotation of the tibia, a bone that extends from the knee joint to the ankle joint, medially. The tibia holds a significant amount of body weight [1]-[3]. The semitendinosus originates from the ischial tuberosity which is a round bone at the bottom of the pelvis and inserts into the adductor tubercle of the femur [3]-[4].

The semimembranosus muscle, a second muscle found in the hamstring muscle complex, also allows for extension of the hip as well as flexion of the knee with the rotation of the tibia medially [1]-[2]-[3]. It is located on the posterior aspect of the thigh also originating from the ischial tuberosity and inserting into the tibia. The semimembranosus travels through the semitendinosus muscle. Tendons that are shared with the biceps femoris connect the semimembranosus muscle from the pelvis to the tibia [5].

The last component of the hamstring muscle complex is the biceps femoris. The purpose of this muscle is the same as the other two muscle components however the structure consists of both a short and long head. The long head originates from the top inner quadrant of the ischial tuberosity and the short head originates from the middle third of linea aspera, which is the longitudinal crest on the posterior surface of the femoral shaft [6]-[7]-[8]-[9].

In most forms of exercise, especially rhythmic gymnastics, stretching is important to help maintain the muscles, bones, and joints, while helping prevent injuries [10]. When stretching, muscle fibers contract starting from the sarcomere, a structure with layers of a myofibril. This myofibril consists of elongated threads that produce contraction located in the striated muscle cells [11]-[12]. After contracting, the overlap between thick filaments and thin filaments of structured muscle cell units increases and stretches to decrease the total area of overlap; this allows the muscle fibers to lengthen and stretch [11]-[13].

These three muscles make up the hamstring complex and play a crucial role in rhythmic gymnastics. Leg splits, a position where both legs are spread out in opposite directions in an attempt to create 180 degrees, are integral to the sport [26]. One way gymnasts can gain flexibility in this crucial skill is through stretching. Oversplits are when one leg is lifted higher than the other to stretch past 180 degrees, allowing for an increased stretch specifically in the hamstring muscle [26]. Without this hamstring flexibility, it can be difficult to succeed in rhythmic gymnastics.

There are three popular types of stretching methods, the most common in rhythmic gymnastics being static stretching [42]. The other two are dynamic stretching and neural gliding [43]. Static stretching is where an individual stays still in the desired position of stretch to the greatest possible elongation for at least 15 seconds [14]. The ultimate goal of static stretching is to target a specific muscle area to increase flexibility whilst feeling slight discomfort [14]-[27]. If stretching is done beyond pain tolerance and extreme discomfort is experienced, it can result in muscle tearings [27]. In rhythmic gymnastics, gymnasts often utilize sitting in the splits to target the hamstring muscle complex via static stretching [24].

A second method is dynamic stretching, where an individual stretches while in motion to help warm up and loosen muscles [15]-[16]. The movement is associated with the active muscle tensing while the joints are in a complete range of motion [15]. Because dynamic stretching is executed through movement, it is most popular amongst fitness athletes, including rhythmic gymnasts, as a way to warm up the body and muscles as well as prepare the body for inclined exercise; specifically speaking, rhythmic gymnasts use dynamic stretching to target the hamstring muscles [16]-[29].

Lastly, neural gliding, also known as flossing, is another popular stretching technique with the most well-known method being foam rolling [44]. Neural gliding consists of the tissues being twisted and moved without resistance [28]. The compression and movement of flossing on a joint or muscle alter the relationship of the fascia, the connective tissue that is wrapped in a thin casing and encloses all bones, organs, blood vessels, muscle, and nerve fiber, with the neuromusculoskeletal system. This allows for a free range of motion for the fascia [17]-[18]-[19].

Because of this, many rhythmic gymnasts are starting to incorporate neural gliding into their stretching habits to increase flexibility targeted at the hamstring muscle [30].

Background

Previous studies have looked at the effectiveness of these three different types of stretching. *The Journal of Strength and Conditioning Research* conducted an experiment on Division I quarterbacks to compare dynamic stretching and foam rolling to see which improved flexibility as well as their vertical jumping power better [20]. It was found that there was no significant difference in vertical jumping power or strength post-stretching. However, the hip flexion range of motion had a significant difference from baseline in both foam rolling and dynamic stretching. (No difference between the two types of stretching) [20]. This being said, the results may differ if they were to be conducted on rhythmic gymnasts since the experiment was only tested on male football athletes. The body fat percentage, height, and weight of Division I quarterbacks are highly unrealistic for rhythmic gymnasts who have a much lower mean for all three variables [31]-[32]-[33]-[34]-[35]. Not only this but the muscle strength and flexibility in rhythmic gymnasts differ from football players, especially male football players since rhythmic gymnastics is mostly women. Because of these differences, the results found in this study may differ from results that were to be tested on rhythmic gymnasts.

The Journal of Strength and Conditioning Research also experimented on male athletes of older age ranging from 19-47 years old to compare foam rolling, CRPNF (Contract-relax PNF stretching; a form of dynamic stretching), and a control group and see which would be most effective in improving flexibility in the hamstring muscle [21]. It was concluded that foam rolling and CRPNF stretching were found to be more effective than the control group and foam rolling increased the range of motion by 3.0 ± 2.1 cm (p = 0.001) and CRPNF by 4.0 ± 2.9 cm [21]. Though the claim of foam rolling being the most effective stretching method was proven the accuracy of the same results applying to rhythmic gymnasts may not be well since the study was conducted on male athletes who ranged from 19-47 years old with a height of 181.4 ± 7.0 cm. Since rhythmic gymnastics is predominantly women, the study only being conducted on male athletes could bring on different results. Additionally, the ideal retirement age for rhythmic gymnastics is around 22 years old; the height is also unrealistic due to rhythmic gymnasts' height averaging 163 cm [33, 36]. Keeping in mind that the study did not experiment on rhythmic gymnasts, the muscle strength and flexibility of rhythmic gymnasts also differ from recreationally active men [37]-[38]-[39]-[40].

Another study was done by *The Human Kinetics Journal* where 15 male and female college students tested foam rolling, static stretching, and dynamic stretching to see which method improved flexibility the most [22]. Through the research, it was concluded that foam rolling was found to be more effective compared to static and dynamic stretching, however, knee mobility (ability or rotation of motion) improved after foam rolling and dynamic stretching but not after static stretching [22]. Though foam rolling and dynamic stretching were proven to be effective over static stretching, it is important to keep in mind that the experiment was only conducted on college students; college students have a standard age mean whereas, in rhythmic gymnastics, the age varies in the sport of rhythmic gymnastics [36]. Another important differing variable would include the flexibility of non-athletic college students; it differs from the hamstring flexibility rhythmic gymnasts have [33]-[41].

Even though these studies gave insight into understanding which stretching method is most effective, it is not enough to distinguish the most effective stretching method for rhythmic

gymnasts. Therefore, we looked at which methods were most efficient for this sport. Although previous research has shown neural gliding to be the most effective, we hypothesize that static stretching will be most effective. This hypothesis is supported by the constant practice of static stretching in rhythmic gymnastics which has allowed many rhythmic gymnasts to show improvement in flexibility over time.

Methods

Participants: Participant 1 was a fifteen year-old, 155 cm rhythmic gymnast. Participant 2 was a sixteen year-old, 157 cm rhythmic gymnast. Each participant attended six 4-hour training sessions per week. Out of the 4 hours, 1 hour is spent on stretching.

Data collection: Three stretching methods were tested on the gymnast before their practice on the second, third, and fourth day of training of that week. The participant was instructed to lie on the ground, straighten their legs and lift each leg individually before and after the stretching was done (image 1). To attain accurate data, the participant was instructed to lay flat on their back, point their toe and use a measuring tape to measure the height from the ground to the tip of their toe in cm; laying 183 cm away from the camera set in the same spot for all pictures. This was done on both the right and left leg and for all three stretching methods that were conducted for three days, one stretching method per day. For each day, the gymnast conducted the stretching instructed for that day for 3 minutes total on each leg that was timed on a phone stopwatch.

***Static stretching*:** the gymnast sat in a 210 degree oversplit for two minutes, and then at the last minute, their hands were held up, allowing gravity to push them further into the split.
***Dynamic stretching*:** the gymnast sat in oversplits for 3 minutes. In the first minute, they flexed and pointed their front toe repeatedly until the minute was over. They flexed their back toe for the second minute and straightened and bent their back knee. For the last minute, they laid their chest on their front leg and flexed and pointed their toe again.
Neural gliding: the gymnast foam rolled their hamstring muscle for 3 minutes straight. Afterward, the gymnast lay on the ground so measurements and horizontal pictures could be taken.

Survey: Questions were asked to each participant after the stretching was completed. The following questions were asked:
“Do you feel more stretched? Do you feel your leg was higher? Which stretching do you feel was most effective in increasing flexibility? Which stretching was most comfortable?”

Results

In this study, we looked at how far both gymnasts legs would go whilst laying flat on their back after each stretching method was tested. As seen in table 1, there was an improvement of flexibility by 5 cm on the left leg and 4 cm on the right leg for static stretching for participant 1 (table 1, figure 1). For dynamic stretching, there was an improvement of 6 cm on both legs (table 1, figure 1). Neural gliding had the greatest difference of 7 cm on the left leg and 8 cm on the right leg (table 1, figure 1). The results of participant 2 were similar with neural gliding being

the most effective with an improvement of 7 cm on the left leg and 6 cm on the right (table 2, figure 1). Dynamic stretching came in second most effective with a difference of 4 cm on the left leg and 5 cm on the right leg followed by static stretching being the least effective with a 3 cm difference on the left leg and a 4 cm difference on the right leg (table 2, figure 1). However, given that there were only two participants in this study, statistical analysis was unable to be performed to fully conclude which form of stretching is most effective (figure 1). However, our hypothesis that static stretching would be the most effective form of stretching for rhythmic gymnasts trends towards being disproved, as neural gliding was seen as the most effective method of stretching in this study.

Image 1:

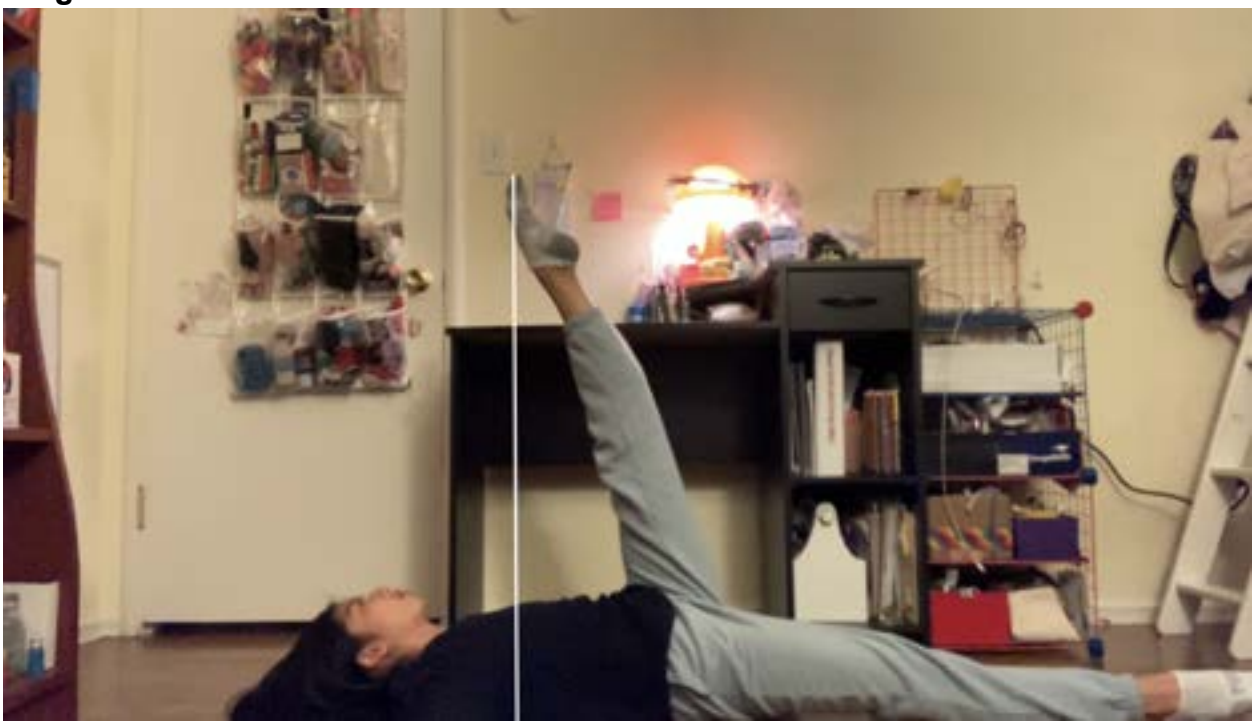

Image 1: *From the ground to the tip of the pointed toe was measured, as shown in the white line. The phone was set up on the ground 6 feet from the individual.*

Table 1: Left Leg Outcome

	age	Height (cm)	Static stretching (cm)	Dynamic stretching (cm)	Neural gliding (cm)
Participant 1	16	156 cm	3	4	7
Participant 2	15	153 cm	5	6	7

Table 1: *stretching values were calculated by measuring the distance from ground to toe post-stretch subtracted from the distance from ground to toe before stretching in cm.*

Table 2: Right Leg Outcome

	age	Height (cm)	Static stretching (cm)	Dynamic stretching (cm)	Neural gliding (cm)
Participant 1	16	156 cm	3	5	6
Participant 2	15	153 cm	4	6	8

Table 2: *stretching values were calculated by measuring the distance from ground to toe post-stretch subtracted from the distance from ground to toe before stretching in cm.*

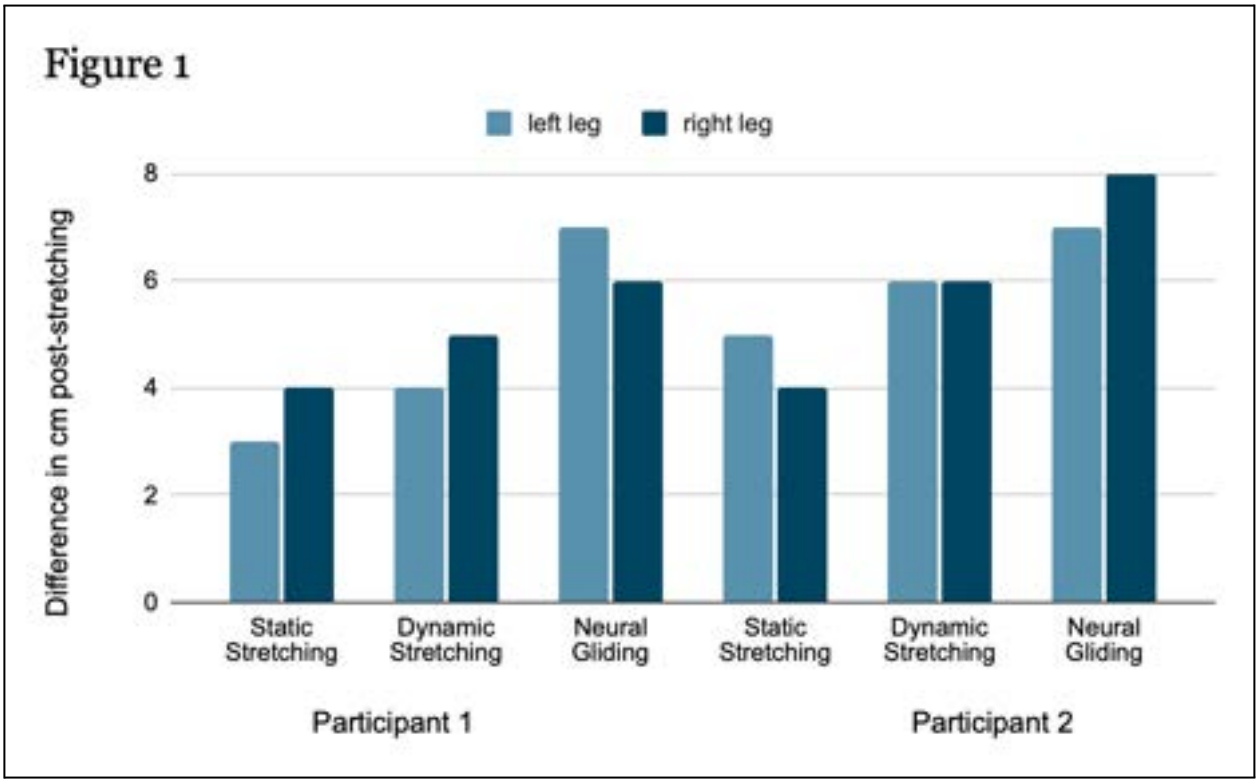

Figure 1: *The height difference in cm of the left and right legs of participants 1 and 2 after conducting static stretching, dynamic stretching, and neural gliding. The higher the number the higher the bar), and the greater the stretch.*

Survey results

After experimenting, the participants overall felt neural gliding was the most effective. They had both stated though neural gliding was the least painful, it felt the most beneficial as the leg was easier to lift when lying on the ground compared to dynamic and static stretching. On

the other hand, static stretching felt the least effective, and was said to be the most painful. Dynamic stretching was stated to hurt slightly, but not as bad as static stretching. The dominant leg for participant 1 was the right leg which was concluded to be easier to lift whereas the dormant leg for participant 2 was the left leg so that leg was easier to lift. At practice, static stretching is the most dominant practice of stretching but dynamic stretching and neural gliding have slowly been introduced into the warmup as well, allowing both participants to notice an increase in flexibility.

Discussion

Hamstring muscles play a key role in succeeding in the sport of rhythmic gymnastics [23]. The ability to strengthen and elongate the muscle is what allows gymnasts to safely and beautifully execute skills during their routine [45]. Knowing that hamstring flexibility is crucial in allowing a rhythmic gymnast to succeed due to the high flexibility demand in the sport, three common stretching methods were studied for efficiency: static stretching, dynamic stretching, and neural gliding [23].

Through previous studies, all three methods have shown to increase flexibility in the hamstring muscle, however, showed a trend of neural gliding being the most effective, dynamic stretching being the second most effective, and static stretching being the least effective [20]-[21]-[22]. Keeping in mind that no sources specifically focused on the effectiveness of these stretches for the hamstring muscles of rhythmic gymnasts, a study was conducted with these specific variables. Two rhythmic gymnasts of similar height were tested to see which of the three methods would be most effective. From the experiment, results showed that both rhythmic gymnasts had the most improvement in flexibility from neural gliding, thus proving the same results as previous studies.

Using this information, it is important for neural gliding to be more incorporated into the stretching routines of athletes rather than static stretching being the most dominantly practiced method as proven by the experiment results. If neural gliding was implemented into the daily stretching routines of rhythmic gymnasts, it could show drastic changes of improvement in flexibility meaning higher leg extensions or more leg split flexibility. Since flexibility plays an important role in the sport of rhythmic gymnastics, knowing that neural gliding is potentially the most effective form of stretching means more gymnasts should be incorporating neural gliding into their practices over static stretching, which is most common.

Since this study was conducted on only two rhythmic gymnasts, we need a larger pool of participants to conclude that neural gliding is statistically the most effective form of stretching. Additional limitations include not using participants with a wide range and variety of flexibility levels, heights, and ages. In other words, since the experiment was conducted only on high-level athletes who are older, the results may have differed if conducted on younger athletes who have less experience with the sport yet have an easier ability to become more flexible. Another limitation includes only conducting the stretching methods in one way, rather than multiple ways. For example, foam rolling was the only method conducted for neural gliding, whereas multiple exercises could have been executed such as different forms of sciatic nerve glides. Therefore, though static stretching is the most common stretching method throughout rhythmic gymnasts, our study helps show that neural gliding may be more useful for athletes to reach their goals.

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