Effects of Static, Dynamic, PNF Stretching on the Isokinetic Peak Torque

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Purpose: The aim of this study is to suggest the basic materials for proposing effective and efficient methods when stretching by measuring isokinetic muscular strength according to static, dynamic and PNF stretching.

Methods: This study was conducted on 45 healthy persons (male and female) in their twenties who are attending universities. The subjects are randomly divided into three (3) groups, and static stretching is applied in group 1, dynamic stretching is applied in group 2 and PNF stretching is applied in group 3. After carrying out static, dynamic and PNF stretching, peak torque was measured using isokinetic muscular strength measurement.

Results: According to the results, at 60°/sec and 180°/sec isokinetic peak torque of the knee joint according to types of stretching, the largest changes were shown in Group 2 extension and flexion, and the least changes were shown in Group 1. There were significant differences among the three groups ($p<0.05$), and the result of after-analysis by LSD showed that there were significant differences between Groups 1 and 2, and Groups 1 and 3 ($p<0.05$).

Conclusion: The intention of this study was to determine the peak torque using Cybex after applying three stretching methods to hamstring muscles, and the case of dynamic and PNF stretching was found to be more significant in both the 60°/sec and 180°/sec angular speeds than that of static stretching. Using the results of such studies, if dynamic and PNF stretching are applied together with warming-up before performing sports, the risk of suffering wounds would reduce and the exactness of sports would increase.

Keywords: Stretching, Peak torque, Angular velocity

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Ⅰ. Introduction

As a result of their busy and routine daily lives, most people in modern society experience weakened physical strength owing to lack of exercise. Therefore, to compensate for insufficient physical strength, most people participate in many group activities such as soccer, basketball, badminton, mountain cycling, etc., usually on the weekend. Most of these activities are dynamic, whereby ordinary people who exercise only on weekends, in contrast to professional players who specialize in exercising every day, are not fully ready for sudden sports, so that they are exposed to many risks, actually sustaining many wounds. It has been pointed out that hamstring strains are a recurrent major damage on sports fields due to a lack of flexibility, and are the cause of degradation.[1] Ordinary sports activities requiring excessive physical activities become major causes of personal injuries and diseases.[2] In addition, sports activities require strong power necessary for momentary muscular contraction in order to display minute motor skills and also need flexibility to expand a range of motion of joints. However, while enjoying sports requiring excessive physical activities, many people are limited in their exercise ability owing to lack of flexibility and become injured in the muscle, tendon and joint systems. Therefore, to prevent becoming wounded while exercising, it is essential to increase flexibility.[3] Increased flexibility prevents the expenditure of unnecessary energy during sports activities, and improves coordination ability by increasing the exactness and fluidity of exercise and muscular activities.

Therefore, stretching is a common method for increasing flexibility.[4]

Park stated that stretching not only increases flexibility but also blood circulation, and improves respiratory-circulation ability and environment adaptability[5], while Ce maintained that it contributes to the improvement of muscular ability by increasing heat occurrence and metabolic activities in the muscle.[6] Also it has been revealed that stretching is strongly related to various elements of physical strength such as instantaneous reactionary force, agility, muscle strength, balance, etc., and increases the ability to perform exercise.[7] When performing sports, in most cases, personal injuries occur within a range in excess of the normal joint motion, except for cases due to external injuries. Therefore, stretching to increase flexibility is essential. In general, the elements that limit the range of motion related to flexibility can be divided into:

(i) limitation according to the features of the muscle itself;

(ii) limitation according to the features of the nervous system;

(iii) limitation according to the structural function of joints; and

(iv) limitation according to subcutaneous tissue of the skin. These features can be converted into appropriate stretching techniques.

Stretching is a type of movement which increases the length of muscle, and methods such as static stretching, dynamic stretching and PNF stretching are being used.[8] Static stretching is maintained on a limited range of motion, dynamic stretching adds bounce to the limited range of motion, while PNF stretching uses proprioceptors. Feland et al.[9], Young, and Elliott[9] reported that the PNF method is effective among many stretching methods, while Fasen et al. reported that active or PNF stretching is more effective than passive stretching. However, Davis et al.[11] proposed that static stretching is a suitable method for effectively extending the hamstring muscle, while Gajdosik et al.[12] also stated that slow and static stretching increases the range of motion by effectively extending the hamstring muscle. Worrell et al. suggested that while stretching of the hamstring peak torque is possible, research and discussion is still ongoing on how to apply the most efficient method and on the correct duration and frequency of hamstring stretching.[13]

Indeed, there are many controversies about the stretching method that is most effective. While stretching is used as a means for warming up and warming down before performing sports activities,[14] only a few studies have been carried out on the effects of flexibility according to types of stretching and on suitable stretching for displaying the greatest power. Therefore, the aim of this study is to suggest the basic materials for proposing effective and efficient methods when stretching by measuring isokinetic muscular strength according to static, dynamic and PNF stretching.

II. Methods

1. Subjects

This study was conducted on 45 healthy persons (male/23 and female/22) in their twenties who are attending universities. Following an explanation of the study's goal and method, the students became voluntarily subjects of this study. The subjects are students who are not receiving any special medical opinion from a doctor, while those students who regularly exercise for flexibility or reinforcing muscular power of the legs, or have radiating pain at the time of SLR were excluded from this study. The subjects are randomly divided into three (3) groups, and static stretching is applied in group 1 (15 persons), dynamic stretching is applied in group 2 (15 persons) and PNF stretching is applied in group 3 (15 persons). The general characteristics of the subjects are shown in (Table 1).

Table 1. General characters of Subjects (N=45)

Groups	Sex (M/F)	Age (yr)	Height (cm)	Weight (kg)	Fat body (%)	Muscle mass (kg)
1(n=15)	7/8	23.4±1.8†	169.1±8.4	66.4±10.2	15.3±2.1	31.5±3.4
2(n=15)	8/7	22.9±2.3	172.3±8.1	69.1±8.6	17.8±3.4	30.7±3.8
3(n=15)	8/7	23.5±2.6	171.5±8.3	67.8±11.7	16.1±2.6	32.1±2.4
p*	0.86	0.41	0.52	0.18	0.84	0.44

* $P<0.05$
† Mean±SD

2. Experimental methods

The study of Hwang and Ji, using the methods of static, dynamic, and PNF stretching, was utilized.[15]

1) Static Stretching

Static stretching was conducted under the situation in which there is no pain, but inconvenience owing to severity is experienced for 30 seconds, and a rest of 10 seconds was repeated three times. For the stretching method, the subject sat on a mat, and the dominant part of his/her leg was stretched straight forward and his/her other leg faced the back, with the calf and the inside of the quadriceps contacting. His/her both hands were then placed toward the toes of the leg stretched forward and, after keeping it static for 30 seconds, the subject took a break for 10 seconds and 3 sets were conducted.

2) Dynamic Stretching

Dynamic stretching is to be carried out in the same posture as that of static stretching, but does not require maintenance of the static condition for 30 seconds. For this stretching, the subject repeated the motion in which his/her arms were stretched forward and returned to their original position and, after the subject took a break for 10 seconds, 3 sets were conducted.

3) PNF Stretching

PNF stretching is carried out in the same posture as that of static stretching, but when the subject is about to unfold his/her waist, the inspector induced an isometric contraction by giving as much resistance as the force that the subject had applied to the back, and, after the subject kept the contraction for 8 seconds, he/she relaxed for 2 seconds. This stretching was conducted for 30 seconds three times. Then, after taking a break for 10 seconds, 3 sets were carried out.

4) Isokinetic peak torque test

After carrying out static, dynamic and PNF stretching, peak torque was measured using isokinetic muscular strength measurement. In general, 60º/sec angular velocity is used to measure the strength of defect, while 180º/sec angular velocity in the muscle explosiveness and endurance wear is used because these represent two types of angular velocity.[16] The extension and flexion of the knee joint were measured at an angular speed of 60º/sec and 180º/sec. For measurement, after the subject applied a muscular load of Cybex by keeping himself/herself in a submaximal contraction condition before measurement by each angular speed three times, the inspector used the results of the inspection made in the maximum force five times for measuring the peak torque. In order to display the maximum ability when making a measurement, the inspector, after explaining in detail the measurement goal, ensured that the subject fully understood the inspection process.

3. Statistical analysis

One way ANOVA was used to analyze how to stretch according to changes in peak torque for each group test, and LSD was used for the after-analysis to determine the differences between groups for a post-hoc test. To compare isokinetic peak torque before and after stretching within each group, a Paired t-test was conducted. For statistical significance, $\alpha=0.05$ and statistical dealing, Window SPSS version 10.0 was used.

III. Results

1. Changes of the peak torque before and after exercise according to types of stretching between groups at 60° /sec.

The isokinetic peak torque of knee joint according to types of stretching showed the largest changes in Group 2 as 16.94 Nm at extension and 14.48 Nm at flexion, and showed the least changes in Group 1 as 1.93 Nm at extension and 1.91Nm at flexion. There were significant differences among the three groups ($p<0.05$) (Table 2), and as a result of after-analysis by LSD, there were significant differences between Groups 1 and 2, and Groups 1 and 3 ($p<0.05$).

2. Changes of the peak torque before and after exercise according to types of stretching between groups at 180° /sec.

The isokinetic peak torque of knee joint according to types of stretching showed the largest changes in Group 3 as 12.84 Nm at extension and 16.08 Nm at flexion, and showed the least changes in Group 1 as 1.36 Nm at extension and 1.88 Nm at flexion. There were significant differences among the groups ($p<0.05$) (Table 3), and as a result of after-analysis by LSD, there were significant differences between Groups 1 and 2, and

Table 2. Changes of the peak torque before and after exercise according to types of stretching between groups at 60°/sec and 180°/sec (N=45) (Unit: Nm)

Angular velocity	Movement	Group 1	Group 2	Group 3	p*
60°/sec	Extension	1.93±0.09†	16.94±0.25	15.53±0.58	0.02
	Flexion	1.91±0.02	14.48±0.50	13.11±0.12	0.01
180°/sec	Extension	1.36±0.18	12.58±0.36	12.84±0.40	0.02
	Flexion	1.88±0.05	15.98±1.37	16.08±0.35	0.02

* $P<0.05$
† Mean±SD

Groups 1 and 3 ($p<0.05$).

3. Changes of the peak torque before and after exercise according to types of stretching within each group

All the three groups significantly increased in extension and flexion of the knee joint at an angular speed of 60°/sec and 180°/sec, after stretching was carried out.

IV. Discussion

In respect of stretching, lack of flexibility becomes a hindrance to exercise and reduces athletic performance, which results in the possibility of injury in the muscle-tendon and joint systems. As a result, the flexibility of the body reduces and thus wounds are repeatedly inflicted during exercise.[17] Also, because flexibility, one of the indexes of aging, is related to efficiency of physical activities, appropriate flexibility is necessary to maintain an efficient daily life. For this reason, the increase of flexibility through stretching increases not only the range of motion but also the exactness of exercise and muscular activities, and improves coordination ability.[18,19] Many studies demonstrate a variety of effects of stretching. It is known that, in terms of stretching that considers only physical flexibility, static stretching has more effect than dynamic stretching,[20,23] but it is reported that static stretching does not promote stretch reflex, so does not increase the stress applied to relevant muscles.[12,24] According to Walker, the stress occurring in muscles during stretching exercise is twice as much as that of static stretching.[25] This study also showed the same results, indicating that static

Table 3. Changes of the peak torque before and after exercise according to types of stretching within each group (N=45) (Unit: Nm)

Group	Angular velocity	Movement	Before	After	p*
Group 1[2,3] (n=15)	60°/sec	Extension	199.31±16.43*	201.24±16.52	0.70
		Flexion	138.26±17.44	140.17±17.46	0.07
	180°/sec	Extension	129.86±14.34	131.22±14.16	0.31
		Flexion	107.26±12.47	129.14±12.52	0.03
Group 2[1] (n=15)	60°/sec	Extension	198.58±17.62	215.52±17.37	0.02
		Flexion	139.37±17.23	153.85±17.73	0.01
	180°/sec	Extension	128.76±16.25	141.34±16.61	0.01
		Flexion	106.28±14.04	122.26±15.41	0.02
Group 3[1] (n=15)	60°/sec	Extension	196.89±16.23	212.42±16.81	0.01
		Flexion	138.53±18.14	151.64±18.26	0.03
	180°/sec	Extension	127.51±15.44	140.35±15.84	0.03
		Flexion	105.48±13.08	121.56±13.43	0.01

* $P<0.05$
† Mean±SD
1, 2, 3: LSD multiple comparision

stretching was higher at both 60°/sec and 180°/sec in isokinetic peak torque inspection than static stretching. Moore and Hutton maintained that PNF stretching has a more efficient effect than static and dynamic stretching,[26] but it was found in this study that the value of the peak torque of static stretching and PNF stretching was similar. It is considered that the study of Moore and Hutton measured flexibility[26] while this study measured peak torque.

In this torque, static, dynamic and PNF stretching were applied to hamstring muscles and thus the isokinetic peak torque increased. This result accords with the results of the isokinetic changes in stretching conducted on Taekwondo players.[27]

Various studies report an increase of peak torque by stretching. Ce et al.[6] reported that stretching increased anaerobic power, while Marek et al. suggested that stretching increased peak torque.[28,29] The results of this study demonstrated that, in the peak torque inspection of PNF stretching, PNF stretching was significantly higher than static stretching. Such a result is considered to be due to the dynamic stretching induced stress reflex and the increased stress of muscles,[30] while in the case of PNF stretching, it is considered that the stretching, using the principles of autogenic inhibition, activated GTO and affected the stress of the muscles which increased the peak torque.

The intention of this study was to determine the peak torque using Cybex after applying three stretching methods to hamstring muscles. The cases of dynamic and PNF stretching were found to be more significant in both 60°sec and 180°/sec angular speeds than that of static stretching. Using the results of such studies, if dynamic and PNF stretching are applied together with warming-up before performing sports, the risk of suffering wounds would reduce and the exactness of sports would increase. In terms of the limitations of this study, the number of subjects per group was small, so it was difficult to generalize the result of the study. Also, the application of each stretching time did not indicate the maximum effects, but was measured by applying stretching in a specified time; it is therefore difficult to simply compare with any other study. In the future study, it would be necessary to compare each type of stretching after applying the time in order to indicate the maximum effects.

Author Contributions

Research design: Lim CH
Acquisition of data: Lim CH
Analysis and interpretation of data: Lim CH
Drafting of the manuscript: Lim CH
Administrative, technical, and material support: Lim CH
Research supervision: Lim CH

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