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Original Article

# Comparison of isokinetic muscle strength and muscle power by types of warm-up

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**Abstract.** [Purpose] The purpose of this study was to clarify the influence of static stretching at warm-up on the isokinetic muscle torque (at 60°/sec) and muscle power (at 180°/sec) of the flexor muscle and extensor muscle of the knee joint. [Subjects and Methods] The subjects of this study were 10 healthy students with no medically specific findings. The warm-up group and warm-up with stretching group performed their respective warm-up prior to the isokinetic muscle torque evaluation of the knee joint. One-way ANOVA was performed by randomized block design for each variable. [Results] The results were as follows: First, the flexor peak torque and extensor peak torque of the knee joint tended to decrease at 60°/sec in the warm-up with stretching group compared with the control group and warm-up group, but without statistical significance. Second, extensor power at 180°/sec was also not statistically significant. However, it was found that flexor power increased significantly in the warm-up with stretching group at 180°/sec compared with the control group and warm-up group in which stretching was not performed. [Conclusion] Therefore, it is considered that in healthy adults, warm-up including two sets of stretching for 20 seconds per muscle group does not decrease muscle strength and muscle power.
**Key words:** Stretching, Warm-up, Muscle power

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## INTRODUCTION

Stretching is helpful for injury prevention, flexibility of periarticular connective tissues, strengthening of exercise performance, and rehabilitation of the musculoskeletal system[1–7)]. The American College of Sports Medicine[8)] advises that stretching is effective in warm-up and cooldown before and after aerobic exercise, and that it should be included in rehabilitation exercise programs in terms of musculoskeletal injury prevention. In static stretching, the most commonly used among the different types of stretching, a static is maintained for 10–45 seconds up to the maximum range of motion (ROM) centered on the agonist muscle required during exercise. This practice increases body temperature, is effective for injury prevention, and is used by most athletes in the field[9)]. Conventionally, studies showing that static stretching improves exercise performance and flexibility and is effective for injury prevention are dominant[10)].

However, despite the fact that stretching is broadly used in such a way, putting together previous studies associated with this, it is considered that pre-exercise stretching temporarily decreases muscle strength, power, and sports performance[11–20)]. In this regard, Nelson et al.[16)] reported that pregame stretching inhibited the exertion of maximum muscle strength, vertical jumping ability, and muscle endurance. However, Perrier et al.[18)] reported that no significant difference in the Sargent jump was observed between their static stretching group and their control group.

Likewise, even if there is a possibility that static stretching might adversely affect exercise performance and athletic performance, it is recognized as a partial element of warm-up, and warm-up including static stretching is performed in most fields of recreational sports. Because of this, further studies on temporary effects of flexibility exercise in performance of activities related to physical strength are needed. Thus this study was conducted in order to verify the effect of pre-exercise static stretching on muscle strength and muscle power by evaluating the muscular function of the knee joint using an isokinetic machine by type of warm-up.

## SUBJECTS AND METHODS

The subjects of this study were 10 students who were attending S University in Seoul, Republic of Korea, had no medical problem, and consented to participate in the experiment after the purpose of the study was fully explained to them. Their physical characteristics are as shown in Table 1 below. This study was approved by the ethics committee

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**Table 1.** Characteristics of the subjects

| Gender | n | Age (yrs) | Height (cm) | Weight (kg) | Body fat (%) |
|---|---|---|---|---|---|
| Male | 10 | 22.0±3.4 | 175.6±5.5 | 70.5±9.0 | 18.0±7.2 |

of the Institutional Review Board of Sahmyook University.

To achieve the purpose of this study, subjects were asked to avoid drinking and smoking one day before the experiment, not to participate in excessive physical activity and nonroutine social activity, and to maintain normal sleeping hours in order to secure proper test data. On the day of the experiment, they were asked to consume a light meal, arrive at the measurement room by 09:00 a.m., and take a rest.

For comparison of muscle strength and muscle power according to the presence or absence of warm-up with stretching, the same subjects were classified into a control group that did not perform warm-up, a warm-up group that performed simple running and joint exercise, and a warm-up with stretching group. The control group directly underwent isokinetic muscle testing without warm-up, while the warm-up group started power walking at a strength of 40–60% of the predicted maximum heart rate, performed light running for 10 minutes, and then underwent isokinetic muscle testing. The warm-up with stretching group performed light running for 5 minutes, performed static stretching, and then underwent isokinetic muscle testing. The stretching program consisted of 12 types stretching of the global muscles of the whole body. Two repetitions of each stretching motion were performed, each taking 20 seconds, and the entire stretching program took 10 minutes to perform. All subjects rested for one minute after warming up and then underwent isokinetic muscle testing of the knee joint. The sequence of performance of each warm-up was individually randomized. In successive weeks, each group was tested according to the type of warm-up being utilized. This occurred over a period of three weeks, with the control group, warm-up group, and warm-up and stretching group allowed a week to rest in between tests.

A knee extension/flexion isokinetic dynamometer (Humac Norm Testing & Rehabilitation System; CSMI) was used for this study. First, the subjects were asked to have a seat on the Humac Norm stand, which was made to allow the hip joint to bend at 90 degrees, and then the anatomical axis of rotation of the knee joint was adjusted in accordance with the dynamometer axis of the dynamical system. The upper body, pelvis, and femoral region were fixed using a three-point safety belt and thigh strap, and the axis of the foot and dynamometer was fixed to the direct upper part of the medial ankle bone using a Velcro strap. The opposite lower extremity was fixed with a limb stabilization bar. To prevent the influence of the weight of the axis of motion of the tested lower leg and isokinetic machine on the torque of the knee joint, gravity effect torque was measured and entered in a computer, and range of motion (ROM) was limited to between 0° of extension and 90° of flexion. Then, the test procedure was explained to the subjects. They were asked to extend and flex the knee by exerting their maximum strength as soon as possible, to keep their trunk up against the back rest during the test, and to hold onto the handle of the machine with their hands. The subjects performed maximal test of 4-times repetition. Each maximal test was conducted with an angular speed of 60°/sec (velocity of 60°/sec) for measurement of isokinetic muscle strength and with an angular speed of 180°/sec (velocity of 180°/sec) for measurement of isokinetic muscle power. The exercise was conducted twice prior to testing so that adaptability to the test was improved for subjects and optimal results were achieved. Also, for motivation during testing of maximal isokinetic strength and isokinetic power, subjects were verbally encouraged, and were allowed to view their torque graphs during testing as a form of visual feedback.

In this study, for analysis of muscle strength and muscle power, measurements of the left and right knee joints were divided into each independent variable, and data processing was performed. For data analysis, the mean and standard error were calculated per variable using the SPSS for Windows, version 12.0, software. In addition, one-way ANOVA was performed using a randomized block design for analysis of differences in the isokinetic muscle strength and muscle power of the extensor muscle and flexor muscle of the knee joint between groups. When there was a significant difference between groups, the least significant difference post hoc test was used. The significance level for statistical verification was set to 0.05.

## RESULTS

In this study, prior to evaluation of muscle strength (60°/sec) and muscle power (180°/sec) of the knee joint, warm-up and warm-up with stretching were conducted. One-way ANOVA was performed by randomized block design for each variable, and the following results were obtained Table 2.

Comparative analysis of the differences in flexor peak torque among the control group (99.3 ± 4.2), warm-up group (96.4 ± 4.4), and warm-up with stretching group (95.6 ± 5.4) with an angular speed of 60°/sec showed no significant difference among the groups ($F = 0.26$, $p = 0.77$).

Comparative analysis of the differences in flexor peak power among the control group (75.3 ± 3.6), warm-up group (78.2 ± 3.5), and warm-up with stretching group (82.2 ± 3.6) at 180°/sec showed significant differences among the groups ($F = 4.63$, $p = 0.02$), and the post hoc test showed that the warm-up with stretching group had higher muscle power than the control group and warm-up group.

Comparative analysis of the difference in extensor peak torque between the control group (173.7 ± 7.0), warm-up group (172.4 ± 8.0), and warm-up group with stretching group (165.7 ± 10.3) at 60°/sec showed no significant difference among the groups ($F = 0.89$, $p = 0.42$).

Comparative analysis of the differences in extensor peak power among the control group (121.8 ± 4.8), warm-up group (125.6 ± 5.2), and warm-up group with stretching

**Table 2.** Maximal isokinetic muscle strength and muscle power of the knee joint

| Angular speed | | Control | Warm-up | Warm-up with stretching | Post hoc |
|---|---|---|---|---|---|
| | | Group | | | |
| Flexion | 60°/sec | 99.3 ± 4.2 | 96.4 ± 4.4 | 95.6 ± 5.4 | |
| | 180°/sec * | 75.3 ± 3.6 | 78.2 ± 3.5 | 82.2 ± 3.6 | 1,2<3 |
| Extension | 60°/sec | 173.7 ± 7.0 | 172.4 ± 8.0 | 165.7 ± 10.3 | |
| | 180°/sec | 121.8 ± 4.8 | 125.6 ± 5.2 | 124.4 ± 5.9 | |

Mean ± SE (Nm). 1=control; 2=warm-up; 3=warm-up with stretching. *$p<0.05$

group (124.4 ± 5.9) at 180°/sec showed that no significant difference among the groups (F = 1.19, p = 0.32).

## DISCUSSION

Stretching actively or passively extends the muscles, joints, and tendons. It enhances flexibility, reduces the possibility of injury, and contributes to the performance of advanced techniques. In particular, static stretching maintains a performed posture without bound, and studies on such stretching effects[5, 21–23] have reported that it can improve muscle strength. Young and Elliott[22] reported that flexibility training to prevent stiffness of upper limbs was improved exercise performance of the bench press, and Wilson et al.[21] and Worrell et al.[5] reported that peak torque increased in the hamstring muscle. However, many recent studies have expressed skepticism with regard to results indicating that stretching has a positive effect on improvement of exercise performance or injury prevention[11, 13, 14, 16–18, 24–27].

In a study targeting 22 university students, Nelson et al.[24] reported that after static stretching, knee flexor peak torque showed a significant decrease, approximately 7.5%, and knee extensor peak torque decreased by 5.6%, compared with the control group. Cramer et al.[11] and Marek et al.[13], who conducted stretching in women in their twenties and healthy university students, reported that it had a negative effect on isokinetic peak power. Causes for reduced muscle strength after stretching include decreased motor unit activation or neural factors, such as changes in reflex sensitivity, and mechanical factors including changes in muscular elasticity affected by the length-tension relationship[28]. In addition, Behm and Chaouachi[29] and Fowles et al.[28] reported that static stretching would decrease the autonomy of the reactive nerve of the muscle spindle and the sensitivity of the receptor, and that stretching continued for more than tens of seconds would extend muscles and decrease pressure on the joint, leading to impaired the requirement of Type II muscle at need to muscle power and speed expression. Cramer et al.[12], who measured peak torque and performed electromyography after acute stretching, found that force production and muscle activation decreased both in the stretched leg and unstretched leg, arguing that the reason why peak torque decreased in the unstretched leg was that the inhibitory mechanism of the central nervous system acted as a result of stretching of the opposite leg.

On the other hand, according to the study of Unick et al.[26], performance of the vertical jump test in female basketball players after static stretching and dynamic stretching, revealed that neither stretching types influenced jumping ability. Also, according to the study of Little and Williams[14], performance of static stretching and dynamic stretching in soccer players, showed that neither of the stretching types influenced jumping ability, but dynamic stretching improved high-speed performance.

In this study, changes in the flexor peak torque and extensor peak torque of the knee joint were compared after static stretching in relatively active university students. This study tended to decrease in the warm-up with stretching group at 60°/sec compared with the control group and warm-up group, but without statistical significance. In addition, extensor peak power at 180°/sec was not found to be statistically significant. However, flexor peak power at 180°/sec was shown to increase significantly in the warm-up with stretching group compared with the control and warm-up groups. Therefore, the results of this study show that performance of the two sets of pre-exercise stretching for 20 seconds by muscle group did not decrease isokinetic torque and muscle power during exercise.

It is considered that causes for differences in results after stretching include the specificity of the subjects and their exercise capacity in addition to methodological differences, that is, type, level, time, and frequency of stretching. Therefore, it is concluded that further studies are required to verify the type, time, and frequency of the most proper stretching method according to the level of exercise.

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