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Changes in Pain Following the Different Intensity of the Stretching and Types of Physical Stress

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Abstract

Background: Both the rapid concentric and eccentric contractions during exercise repeatedly impose excessive stress on muscle tissue. The hamstring muscles are very susceptible to injury due to the tensile stress. Various interventions are currently being undertaken to prevent strain injury before exercise. Stretching is the most common method and is known to have a positive effect on flexibility and muscle performance. However, relatively few studies have investigated the potential negative factors of stretching.

Objects: The purpose of this study was to examine changes in pain following the different intensity of the stretching and types of physical stress.

Methods: The subjects were divided into three groups based on the intensity of stretching: 100% (S100), 75% (S75), and 50% (S50) of the measured force at the point of discomfort in static stretching and 100% (P100), 75% (P75), and 50% (P50) of the maximum voluntary isometric contraction in Proprioceptive Neuromuscular Facilitation (PNF) stretching. The pain individual subjects perceived after stretching was measured via a Visual Analog Scale (VAS) and compared between the groups

Results: Despite the decrease in the intensity of static stretching, no decrease in VAS value was observed. In PNF stretching, a significant decrease was observed at P50 compared to P100. S100 was significantly higher than P75 and P50.

Conclusion: Previous studies have shown that PNF has a superior or the same effect on flexibility in comparison with static stretching. This effect was maintained even in moderate intensity. PNF stretching performed under moderate rather than high intensive static stretching, which causes pain and discomfort, might be recommended in clinical settings.

Key Words: Hamstring; Intensity; Pain; Stretching.

Introduction

During exercise, muscles receive continuous demands for rapid conversions between concentric and eccentric contractions. In particular, ball games, such as basketball or soccer, require rapid lower extremity movements and occasionally involve performing explosive sprints with simultaneous rotational motions. Such movements can repetitively cause heavy loads and stress on the muscles of the lower extremities, which can often result in sport injury (Jönhagen et al, 1994). Among the numerous muscles of the lower extremities, the hamstring muscles are two-joint muscles, except for the short head of the biceps femoris, that play an important role in stabilization of the hip and knee joints. It is well known that injury to the these muscles greatly hampers trunk stability (Safran et al, 1989; Hartig and Henderson, 1999). Because injury to the hamstring muscles requires long-term rehabilitation, various interventions are applied before starting exercise to prevent muscle damage and increase the flexibility of the muscle-tendon

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units (Agre, 1985; van Mechelen et al, 1993). One of the most popular methods is stretching exercise, which is suggested as an essential pre-workout routine for athletes as well as the general population. There are currently three main types of stretching exercise: static, proprioceptive neuromuscular facilitation (PNF), and dynamic stretching.

Stretching exercise has been noted to effectively increase flexibility, thereby preventing damage to the muscle tissues during exercise, and to positively influence muscle performance in the long term. Although many studies have been conducted to validate the positive effects of stretching, studies on the negative impacts of stretching are relatively scarce. The possible negative effects of stretching include short-term reduction in muscle performance and damage to the muscle tissues from repetitive stress (Kokkonen et al, 1998; Nelson et al, 2001, 2005; Nelson and Kokkonen, 2001). The decrease in muscle performance can be explained by the alteration in the length-tension relationship due to increase in the sarcomere length and crossbridge reduction due to higher muscle compliance that underlies performing short-term intense stretching (Rubini et al, 2007). Moreover, high-intensity stretching can induce excessive stress to the muscle tissue, which can cause microtears. Applying repetitive, high-intensity stretching can disrupt the fine balance between injury and healing mechanism, causing irreversible damage that can result in physiological deformation of the muscle tissue (Askling et al, 2002; Kim et al, 2007). Permanent increase in flexibility of the muscle-tendon units signifies that tissue alteration has been achieved at the plastic region, beyond the elastic region, where it can maintain the original state without tissue deformity following eccentric stretching (Knudson, 2006). In principle, the amount of force applied to the plastic region is substantial to induce alterations to the muscle tissue, such that many of the participants can perceive pain. The pain provoked by this maneuver can last several days depending on the degree of the applied force (Lim, 2018). Many studies have analyzed and compared the increase in flexibility and muscle performance across different methods of stretching, but only a limited number of comparison studies have been performed on the degree of occurrence and differences in pain perception (Church et al, 2001). Given that there is no significant difference in the increase in flexibility across different methods, it would be pertinent to start a discussion on the differences in performance in various stretching techniques in terms of the participants' standpoint rather than that of the examiners.

This study implemented static stretching, which required passive stretching by the participants, and PNF stretching, which involved active stretching. The degree of pain perceived by the participants immediately following stretching was measured. Furthermore, the intensity of stretching was quantified and differentially applied to groups in a stepwise manner, and the corresponding changes in the level of pain were additionally compared and analyzed.

Methods

Subjects

Eighty healthy young adults participated in the study (37 males and 43 females; mean age, 21.7±1.6 years; mean height, 167.5±8.8 ㎝, mean weight, 63.7±12.8 ㎏). Subjects with lower back, knee, or ankle injury were excluded, as well as those who experienced pain in those areas in the last 6 months. This study was approved by the Institutional Review Board of the Woosong University (1014549-161115-SB-34). Before conducting the experiment, all participants were provided with adequate explanation on the experimental process, the purpose of the study, and the procedure methods. Only those participants who provided informed consent were included in the study.

Procedures

Participants were randomly allocated into 6 groups

Table 1. Differences in pain perception following the different intensity of static and PNF stretching

Group	S100[a]	S75[b]	S50[c]	P100[d]	P75[e]	P50[f]
VAS[g]	6.33±1.67[h]	6.15±2.15	5.16±1.75	4.85±1.61*	2.73±2.18	2.28±2.09

[a]100% of the measured force at the point of discomfort in static stretching, [b]75% of the measured force at the point of discomfort in static stretching, [c]50% of the measured force at the point of discomfort in static stretching, [d]100% of the maximum voluntary isometric contraction in PNF stretching, [e]75% of the maximum voluntary isometric contraction in PNF stretching, [f]50% of the maximum voluntary isometric contraction in PNF stretching, *significant difference compared to P50, [g]visual analogue scale, [h]mean±standard deviation.

(3 groups performed static stretching, 3 groups performed PNF stretching). The participants in all groups laid down on an experimental bench and performed stretching of their dominant leg. While stretching, the pelvis and non-dominant leg were stabilized on the bench with a strap to limit their movements. First, static stretching was performed by straight-leg raise up to the point of feeling pain or discomfort. At this point, the intensity of the static stretching was measured by a portable dynamometer (MicroFET3, Hoggan Health Industries Co., UT, USA). Applying the same intensity measured from the maximum lower extremity extension was defined as S100, and 75% and 50% values from the maximum were designated as S75 and S50, respectively. Stretching was performed according to the corresponding intensity for each group. Static stretching was performed once for 30 seconds. PNF stretching was performed 5 times at the point of feeling resistance while performing the straight leg raise (1 cycle, 6 seconds), and between cycles, a 5-second rest was given. By measuring the value using the dynamometer at the maximum hip extension, the intensity of the PNF stretching was applied at 100% (P100), 75% (P75), and 50% (P50) to each group, respectively. The level of individual pain perception following stretching was recorded using the visual analogue scale (VAS).

Data Analysis

The mean differences in age, height, weight, and VAS scores were analyzed using one-way ANOVA. Statistical analyses were performed using IBM SPSS Statistics 23 (IBM Corp., Armonk, NY, USA), and the level of statistical significance was set at 0.05 for all data analyses. All results were expressed as mean±standard deviation.

Results

No statistical differences were found in the age, height, and weight of the participants across the groups. When examining the changes in the VAS scores in terms of different intensities applied in the same stretching group (Table 1), in static stretching, there was no significant difference in the VAS scores between S100 (6.33±1.67) and S50 (5.16±1.75) despite the decrease in intensity. However, in PNF stretching,

Table 2. Pairwise comparisons between static and PNF stretching groups

Group	S100[a]	S75[b]	S50[c]
P100[d]	-	-	-
P75[e]	p<.01	p<.01	p=.03
P50[f]	p<.01	p<.01	p=.01

[a]100% of the measured force at the point of discomfort in static stretching, [b]75% of the measured force at the point of discomfort in static stretching, [c]50% of the measured force at the point of discomfort in static stretching, [d]100% of the maximum voluntary isometric contraction in PNF stretching, [e]75% of the maximum voluntary isometric contraction in PNF stretching, [f]50% of the maximum voluntary isometric contraction in PNF stretching.

a significant decrease in the VAS scores was found between P100 (4.85±1.61) and P50 (2.28±2.09).

When analyzing the differences in the VAS scores, which were measured immediately following stretching (Table 2), between the static and PNF stretching groups, the static stretching groups in general demonstrated higher VAS scores at the same level of intensity. Only the highest intensity group (P100) showed no statistical difference when compared to all other intensities in the static stretching groups. In PNF stretching that occurred at 75% and 50% intensities, substantially lower VAS scores were observed than those of all static stretching groups.

Discussion

In this study, we compared the degree of perceived pain among participants in two types of stretching methods that are most prevalent in clinical practice for increasing muscle tissue flexibility. Moreover, by applying varying intensity of stretching, the corresponding differences in pain perception of the participants were additionally analyzed. In static stretching, eccentric stress is imposed on the tissue due to increase in passive range of motion of the joint, whereas in PNF stretching, the eccentric stress is caused by active muscle contraction.

The level of pain perception with different stretching techniques showed a slightly higher mean value in the static stretching groups than that in the PNF stretching groups at high intensity, but there was no statistical difference. At submaximal intensities, the S75 group showed a substantially higher pain level than that of the P75 group, and the S50 group also had a considerably higher value than that of the P50 group. The degree of pain following static stretching was generally greater than that measured in all PNF groups and, moreover, it showed a significantly higher value when the comparison was made between the S50 group, the lowest intensity group in static stretching, and the P75 group. In other words, the participants perceived a higher level of pain after performing static stretching, even with reduced level of intensity. To interpret the above, one needs to understand the difference in the mechanisms of pain derived from the two stretching methods. First, it is difficult for the participants to be actively involved while the examiner is performing the static stretching, which is a passive style of stretching. Performers of this technique normally induce quantitative elongation of the tissue based on the perceived resistance from the active and passive connective tissues. The degree of resistance felt against the tissue can be a more pertinent factor than the discomfort or pain perception of the participants (Sullivan et al, 1992; Hartig and Henderson, 1999; de Weijer et al, 2003; Behm and Kibele, 2007). In static stretching, extending the joint beyond the physiological limit occurs with additional tissue stretch towards the anatomical limit, which can amplify pain. Contrarily, PNF stretching requires selective isometric contraction of the shortened muscle at the point of pain or discomfort. Unlike static stretching, which directly stresses the muscle-tendon units, neurophysiological mechanisms act further to increase flexibility in PNF stretching. Isometric contraction while performing the hold-relax technique of PNF reduces the action of the muscle spindle (inhibiting flexibility from stretch reflex) and enhances that of the Golgi tendon organ (facilitating the increase in flexibility by autogenic inhibition), contributing to increase of the range of motion (Sheard and Paine, 2010). Additionally, added positive effects of increasing the muscle tissue flexibility can be obtained from inhibiting the tonic reflex activity (Moore and Hutton, 1980; Etnyre and Abraham, 1986; Guissard and Duchateau, 2004). The pain following PNF stretching can be greatly influenced by indirect factors, unlike that following static stretching, which achieves enhanced flexibility through inducing a great load of stress directly to the tissue.

Besides the difference between the stretching groups, differences in pain perception were found with changes in intensity within the same type of stretching. Initially, in static stretching, it was observed that the VAS scores in the S70 and S50 groups were mostly maintained at 97.2% and 81.6% of that of the S100 group, respectively. Regardless of the significant reduction in the stretching intensity, the decrease in the VAS scores was not large enough to reach statistical significance. In contrast, in PNF stretching, the P70 and P50 groups showed reduced values at 56.3% and 47.1% of that of the P100 group, respectively, showing a greater reduction in the VAS scores with diminished degree of intensity. The score of the P50 group was considerably different from that of the P100 group. In static stretching, applying 75% of the maximum intensity showed practically no reduction in pain perception, and applying 50% intensity demonstrated a partial reduction in the scores. However, in PNF stretching, a rapid drop in the VAS score was seen at 75% intensity, and only a small reduction was observed after 50% intensity. Detailed examination of the frequency of reporting pain by the participants revealed that all participants selected the VAS score greater than 1 with static stretching in S100 and S75, as well as S50, which was performed with the lowest level of intensity. In PNF stretching, except P100, a fair number of participants reported no pain at all. The VAS score of 0 (no pain) was recorded following stretching in 33.3% of the participants in P75 and 27.6% in P50. In terms of static stretching, the higher degrees of pain despite a decrease in intensity can mean that the point of triggering pain reaches earlier than the physiological point of resistance in the muscle tissue, and the stress load due to passive stretching of the muscle tissue can be linked to a gradual increase in pain. In earlier studies, PNF stretching showed the same effectiveness in increasing flexibility with a high intensity as well as with a low to moderate intensity (Feland and Marin, 2004; Sheard and Paine, 2010; Khodayari and Dehghani, 2012). Moreover, the neurophysiological features of PNF stretching that positively contribute to increase in flexibility is shown to be more effective in low to moderate intensity than in high intensity (Schmitt et al, 1999). Taken together, the previous studies examining the effects of stretching in increasing flexibility and the results of this study looking at the level of pain perception of the participants, performing PNF stretching with the highest intensity possible might be a better choice than static stretching in order to maintain the effects of enhancing flexibility while significantly reducing the pain perception of the participants.

This study has adopted the VAS scores to measure pain perception, which is the most widely used tool to quantify the level of pain in clinical practice. However, it has a limited use as a marker for detecting the changes of micro-damage and corresponding physiological changes to the muscle tissue. More objective and standardized experiments using biomarkers are required in the future.

Conclusion

In earlier studies looking at the effects of PNF stretching, when compared to static stretching, it has demonstrated similar, if not greater, effects on increasing the degree of flexibility, and showed similar efficacy not only with high, but also with moderate intensity. Static stretching, which provokes relatively more pain and discomfort to the participants, might be inappropriate to be utilized in the clinics for subjects with a higher pain sensitivity. It is recommended to adopt low to moderate intensity PNF stretching in clinical practice, because it demonstrates less limitations for general application.

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