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Original Article

Acute effects of static stretching and massage on flexibility and jumping performance

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Abstract

Objective: The purpose of this study was to evaluate the effects of static stretching and the application of massage on flexibility and jump performance. **Methods**: Thirty-five athletes studying Physical Education at University (mean age 23.6±1.3 years, mean height 177.8±6.3 cm and mean weight 72.2±6.7 kg) performed one of three different warm-up protocols on non-consecutive days. Protocols included static stretching [SS], combined static stretching and massage [SSM], and neither stretching nor massage [CONT]. The athletes performed flexibility, countermovement jump (CMJ) and squat jump (SJ) tests. **Results**: SS and SSM protocols demonstrated 12% ($p<0.05$) and 16% ($p<0.05$) respectively greater flexibility than the CONT protocol. SJ and CMJ performances were significantly decreased 10.4% ($p<0.05$) and 5.5% ($p<0.05$) respectively after the SS protocol. There was no significant difference between SSM and CONT protocol in terms of SJ and CMJ performance. **Conclusion**: This research indicates that whereas static stretching increases the flexibility it decreases the jumping performance of the athletes. On the other hand, the application of massage immediately following static stretching increases flexibility but does not reduce jumping performance. Considering the known negative acute effects of static stretching on performance, the application of massage is thought to be beneficial in alleviating such effects.

Keywords: Warm-Up, Stretching, Massage, Flexibility, Jumping

Introduction

Studies on improving sports performance mostly focus on long-term exercise programs and reaching peak performance targets using different exercise methods. To date, very few studies have addressed the acute preparation period before maximum performance, which is an important segment of an exercise program. Although some research suggests that[1-4] warm-up exercises do not affect performance, warm-up exercises before activities that require high energy output with the purpose of increasing body temperature and blood flow are thought to increase performance[5-8]. Particularly, warming-up, stretching and massage are conventional methods used to enhance performance and reduce the risk of muscle injury through biomechanical, nervous and physiological mechanisms[9-11].

Warm-up exercises generally begin with running at a modest aerobic level and the intensity is gradually increased. The athletes perform static stretching exercises after running. Stretching exercises are widely performed by the trainers and the athletes with the common belief that such exercises improve performance and reduce the risk of sustaining injury. However, recent research suggests that static stretching exercises before competitions and training reduce performance by decreasing speed, power and energy production[12-18]. The knowledge of the negative effects of static stretching exercises on sports performance has prompted sports scientists, trainers and athletes to seek an alternative approach.

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Massage is one of those alternative methods. Along with static stretching, massage is also widely used by the athletes. Massage is believed to enhance blood supply to the muscles and to increase muscle temperature[19], therefore improving performance[9]. In addition to the aforementioned effects, massage is also believed to reduce the risk of injuries by increasing flexibility and reducing rigidity[20-22].

A close relationship has been observed between muscle stiffness and muscle injury particularly in exercises that require high energy output, in addition to higher performance such as jumping and sprinting[23]. Massage is thought to be beneficial in reducing muscle stiffness through its mechanical effects.

The limited number of studies that have been performed to evaluate massage and its effects on sports performance have yielded variable results depending on the type of massage used, its duration and frequency. In a study evaluating 20-metre sprint times of male collegiate games players, an improvement in performance was observed after conventional warm-up and warm-up combined with massage, however, no improvement was observed after massage alone[24]. Likewise, a study on 14 sprinters did not report any influence on stride frequency after Swedish massage for 30 minutes before physical activity[25]. However, the highest stride frequency was observed immediately after massage. Moreover, stride frequency alone is not sufficient to evaluate sprint performance unless combined with the length of stride. Another study noted a decline in power after petrissage massage for 6-15 minutes[26]. The massage technique in this study was used to provide comfort and relaxation; therefore it is not surprising that an increase in power was not observed.

A very limited number of studies in the literature indicate that there is not yet sufficiently strong evidence to suggest favourable effects of massage before physical activity on sports performance. However, massage alone or in combination with or immediately after other warm-up exercises is presumed to have favourable effects on sports performance: the range of joint motion is increased (active and passive), muscle stiffness is decreased, blood flow is increased together with an increase in arterial pressure and muscle temperature is increased.

Trainers and athletes have not abandoned conventional static stretching exercises, although recent research suggests a decline in performance if such exercises are performed before physical activities that require high energy output. However, there is a tendency towards preferring more than solely one type of exercise before athletic performance. Although the isolated effects of massage, static stretching or active warm-up exercises have been determined, the precise effect of static stretching exercises performed immediately after massage has not yet been clarified. The present study aims to evaluate the effects of static stretching followed by massage before physical activity that requires high energy output.

Materials and methods

Ethics Approval: The Non-invasive Clinical Research Ethics Committee approved the study protocol. The participants were informed about the scope and procedures of the study. All individuals were provided with written informed consent before participating in the study.

Subjects

Thirty five physical education students (age 23.6±1.3 years, height 177.8±6.3 cm, weight 72.2±6.7 kg) voluntarily participated in the study. The subjects were asked to restrain themselves from taking caffeine on each testing day and to avoid food consumption in the two hours before testing.

Eligibility criteria for the study were as follows:

1. ≥18 years old
2. Male
3. Performing regular exercise ≥5 hours/week

Exclusion criteria were as follows:

1. Suffering from any systemic and/or chronic disease (diabetes mellitus, hypertension, heart disease)
2. Suffering from any visual, vestibular or cerebellar disease
3. Consuming caffeine on each testing day
4. History of recent musculoskeletal injury (upper and lower extremities) within the last three months
5. Suffering from any other contraindication to massage (fever, recent surgery, contagious disease)

Experimental design

Thirty-five physical education students were familiarised with all experimental tests before the baseline performance was determined. The study consisted of three experimental sessions. At each session, the subjects performed one of three different warm-up protocols: static stretching (SS) combined static stretching and massage (SSM) or neither stretching nor massage (CONT). Following a standardised five minute jogging warm-up, the subjects then completed the flexibility and jump performance tests. The performance tests consisted of flexibility, countermovement jump (CMJ), and squat jump (SJ). Three trials were performed for each test. For each variable, the highest value of the three attempts was used for analysis.

Procedures

Before data collection, all participants performed introductory exercises and attended trial sessions that included warm-up exercises, static stretching, massage, flexibility, CMJ and SJ tests two days prior to the first study procedure. Each protocol was initiated with a warm-up by jogging at slow pace for five minutes in the gym. Warm-up jogging was followed by walking for two minutes. Then, each participant randomly performed one of three experimental protocols on non-consecutive days. Two minutes after the completion of the relevant protocol (resting interval),

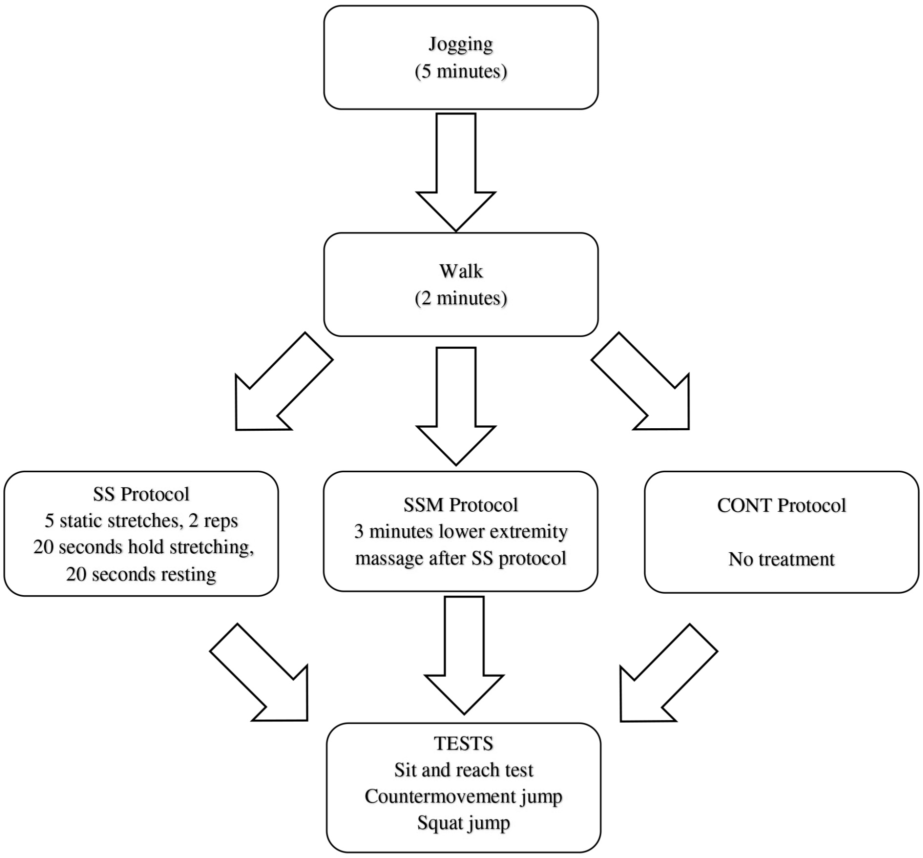

Figure 1. A summary of the experimental method.

flexibility, CMJ and SJ tests were performed in their respective order (Figure 1). All tests were administered by the same trainer and all massages were performed by the same professional sports masseur.

The SS protocol consisted of low-intensity aerobic running for five minutes combined with five static stretching exercises for the muscles of the lower extremities. Static stretching was performed by slightly stretching the muscle (active stretching) to the point of warm sensation (with slight discomfort) and holding that position for 20 seconds; two cycles of stretching were performed at 20 second intervals (1:1)[27-29]. The static stretching method was performed for the following muscle groups (calf, quadriceps, adductor, hamstring and hip rotator)[30].

The SSM protocol consisted of the SS protocol combined with massage to the lower extremities for three minutes. Conventional (Swedish) massage was performed to the lower extremities of the athletes for three minutes immediately after completion of the SS protocol. The musculature that was massaged was the same musculature that was stretched via the static stretching method in the previous protocol. Massage techniques included effleurage, friction, petrissage, percussion, and vibration.

The CONT protocol comprised of low-intensity aerobic jogging for five minutes. After the completion of jogging and two minutes of walking, flexibility, CMJ and SJ tests were administered without performing stretching or massage.

Flexibility Test

The flexibility of the lower extremities of the participants was evaluated by a sit and reach test. The participants were seated on a surface while the legs were extended forward, and the ankles were positioned at 90 degrees of flexion with the soles of the feet placed on a sit and reach apparatus (Takei Sci. Inst. Co., Ltd., DGTK-5403, JP). The participants were asked to keep their knees extended and place the right hand over the left, and slowly reach forward as far as they could by sliding their hands along the measuring board and holding for two seconds at the point of greatest reach. Reaches short of the toes were recorded as negative forward reach scores and reaches beyond the toes were recorded as positive forward reach scores in centimetres to the nearest 0.5 cm using the scale on the box. The measurement was repeated three times, and the highest value was recorded for analysis[31].

Jump Performance Tests

CMJ and SJ tests were employed in this study. The tests were performed using a timing mat (Newtest 2000, Oulu,

Table 1. Mean flexibility and jump scores of each research protocol.

	SS	SSM	CONT
Flexibility (cm)	9.3 ± 3.3[ab]	9.6 ± 3.1[ab]	8.3 ± 2.8[a]
Countermovement Jump (cm)	32.8 ± 5.9[ab]	35.4 ± 6.5[b]	36.6 ± 6.0[a]
Squat Jump (cm)	30.9 ± 3.9[ab]	33.1 ± 4.6[b]	32.7 ± 4.8[a]

SS, static stretching; SSM, static stretching and massage; CONT, control-without massage and static stretching. ([a]) Significant difference (p<0.05) between CONT and SS, SSM protocols. ([b]) Significant difference (p<0.05) between SS and SSM protocols.

Finland), which measures the time that the feet are off the mat. The hands were placed on the hips while performing the tests. In the SJ, knee-hip angle was set at 110 degrees which was measured using a universal goniometer. Three attempts were performed for each jump test (CMJ followed by SJ) and the best result was used in the analysis of the jump performance[31].

Statistical Analyses

Descriptive statistics (Mean±*SD*) were formulated for the variables age, height, body weight, flexibility, CMJ, and SJ. Data obtained for each of the three protocols were analysed using repeated measures analyses of variance (ANOVA). SS and SSM protocols composed the study group, while CONT protocol was designed as the control group. When a significant *F* value was achieved, post-hoc comparisons were achieved via a least significant difference (LSD) test to identify specific differences between trials. Statistical significance was set at *p*>0.05, and all analyses were carried out using the Statistical Package for the Social Sciences version 10.0 (SPSS, Inc. Chicago, IL).

Results

The SS protocol demonstrated 12% greater (p<0.05) flexibility than the CONT protocol. The SSM protocol also showed 16% greater (p<0.05) flexibility than the CONT protocol. The SSM protocol demonstrated 3.2% greater (p<0.05) flexibility than the SS protocol. Results of jumping scores showed that SJ and CMJ performances were significantly decreased 10.4% and 5.5% (p<0.05) after the SS protocol. Unlike the SS protocol, there was no significant difference between the SSM and CONT protocols in terms of SJ and CMJ performance. In addition, the SSM protocol demonstrated 7.1% and 7.9% greater (p<0.05) SJ and CMJ performances than the SS condition (Table 1).

Discussion

This research has been performed to evaluate the acute effects of static stretching and the application of massage on flexibility and jump performance. As previously reported by many authors, the results of this study also indicated that static stretching increases the flexibility but decreases the performance of the athletes. However, the marked result of this study is that massage immediately after static stretching increases flexibility, but shows no effect on jump performance.

This result suggests that static stretching exercises alone are not enough to prepare athletes for the activities that require high energy output (such as jumping). The current finding is in line with the results of the studies in the literature that evaluated the effects of static stretching on peak performance[12,32-38]. Physical activities that require high energy output such as jumping also require a high level of muscle contraction to achieve higher performance[36,37]. Static stretching exercises before such activities are known to reduce performance. A large number of studies demonstrate static stretch induced performance impairments[39]. The decrease in performance has been explained by the decrease in muscle elasticity in relation to the decrease in elastic energy potential during the eccentric phase of the muscle contraction[40].

Barlow et al investigated the effect of lower extremities massage in a 'sit and reach' test[41]. There was no significant difference between the massage and control groups. Similarly, Zainuddin et al. found no significant effect of massage on the range of motion and flexibility[42]. A recent meta-analysis of seven studies examined the effect of massage on flexibility and found that massage significantly increased flexibility scores by 7%[43]. Similar to previous studies, in our present study, static stretching, and massage after static stretching increased the flexibility by 16%. Our result is slightly higher than previous studies because of the combined effect of static stretching and massage[24,32,33].

Kargarfard et al. found favourable effects of massage on jump performance[44]. However, recent meta-analysis of the studies examining the effect of massage on jump performance found that massage had no overall effect on jump performance[43]. The most pronounced finding in the present study is that massage after static stretching did not decrease jump performance. Considering the known negative acute effects of static stretching, massage is thought to be beneficial in alleviating such effects. In contrast to the current findings, it is widely accepted in the literature that massage unfavourably affects performance in short-term activities that require high energy output[24,32,33,45,46]. However, there are no studies in the literature that employed massage to alleviate the negative effects of static stretching. The studies usually performed massage for approximately 15 minutes[24,32,33,47]. The decrease in short-term peak performance seems to be explicable considering the comforting and relaxing effects of short-term massage for 15 minutes. The present study employed short-term massage. The studies reported that massage increased muscle elasticity, and thus increased performance by stimulating the nervous system within the muscle tissue[36,37]. However, we could not find any previous study that could provide evidence to support this theory until today. The results of the present study support this theory. In addition to the deep relaxing effects of massage, we believe that the muscle elasticity is improved by friction and vibration, therefore no decrease in performance is observed following static stretching.

Fletcher (2010) compared nine minutes of massage with dynamic stretching after massage and dynamic stretching alone in order to evaluate the effects of massage on 20-metre sprint performance[24]. They reported a 2.74% decrease between massage and dynamic stretching, a 2.44% decrease between massage and dynamic stretching after massage, and no significant difference was reported between dynamic stretching and dynamic stretching after massage. The results suggested that massage unfavourably affected short-term peak performance; however, dynamic stretching after massage alleviated the negative effects of the massage. The author attributed the decrease in peak performance to the decrease in muscle stiffness in relation to massage. Arabaci (2008) administered 15 minutes of classic Swedish massage (MG), 15 minutes of stretching (SSG), and 15 minutes of resting (CONT) to three randomly selected groups of participants, and evaluated vertical jump, 30-metre sprint performance and flexibility[32]. The peak jump and sprint performances before and after the protocols showed a decrease in the MG and SSG groups, however, no change was observed in the CONT group. The MG and SSG groups showed an increase in flexibility measurements, whereas no change was observed in the CONT group. Similar to the study by Arabacı (2008), Arazi (2012) evaluated the interaction of vertical jump, 30-metre sprint, T test and flexibility with different warm-up methods[32,33]. The peak jump, sprint and agility performances showed a decrease in the MG and SSG groups; however, no change was observed in the CONT group. The MG and SSG groups showed an increase in flexibility measurements, whereas no change was observed in the CONT group.

Conclusion

In line with the studies in the literature, the results of the present study showed that static stretching after low-intensity aerobic exercises increased flexibility performance while decreasing jump performance. The 15-minute massage with the purpose of providing relaxation clearly unfavourably affected jump performance while increasing flexibility. The present study showed that static stretching followed by three minutes of massage might prevent a decrease in jump height. Limited studies performed to evaluate massage and their effects on sports performance have yielded variable results depending on the type of massage used, its duration and frequency; the diversity of results herald future studies to be conducted in this field. In conclusion, general aerobic warm-up followed by static stretching combined with massage can be recommended to increase flexibility as well as to preserve athletic performance before physical activities that require high energy output.

Ethical statement

This study meets the guidelines of the Declaration of Helsinki and after The Non-invasive Clinical Research Ethics Committee of Sakarya University was approved by the study protocol; all subjects provided written informed consent.

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