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Acute effects of proprioceptive neuromuscular facilitation stretching, massage and combine protocols on flexibility, vertical jump and hand grip strength performance in kickboxers

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Abstract

Background and Study Aim Strength, power and flexibility are among the features that provide advantage against the opponent in kick boxers. There are many factors that can affect the development of these parameters in a positive and negative way before the competition. These factors may differ according to the type and intensity of warm-up and stretching exercises, depending on psychological and physiological conditions. The aim of this study is to evaluate the effects of proprioceptive neuromuscular facilitation (PNF) stretching, massage, PNF+massage on flexibility, vertical jump and hand grip strength performance in kickboxers.

Material and Methods The sample group of the study consisted of 12 men (age: 18.50 ± 0.97 years, height: 161.60 ± 4.47 cm, body weight: 62.20 ± 9.07 kg, BMI: 23.77 ± 2.63), who did kick-box regularly for at least 3 years. This group performed 4 different stretching and warm up protocols on non-consecutive days. Warm up and stretching protocols were determined as follows: light jogging for only 5 minutes (NSM), PNF stretching (PNF), massage (M), PNF stretching+massage (PNF+M). After warm up and stretching protocols, participants completed vertical jump, flexibility and hand grip strength.

Results There was a significant improvement on flexibility performance in order from low to high respectively NSM, PNF, PNF+M, M. Moreover, there was a significant difference between NSM and PNF, NSM and M, NSM and PNF+M in flexibility ($p<.05$). There was a significant difference between PNF and PNF+M, M and PNF+M in favour of PNF+M in vertical jump ($p<.05$). There was a significant decrease in right- and left-hand grip strength for all protocols.

Conclusions As a result of the study, PNF and massage can be recommended to kickboxers before flexibility performance. However, PNF and massage are not recommended before activities that affect the lower extremity, such as strength and vertical jump.

Keywords: active warm up, combat sports, exercise, jogging, passive warm-up

Introduction

Kickbox, karate is a combat sport derived from thai box and west box and relies mainly on kick and punch for self-defense. A kick box match consists of 3 rounds and each round lasts 2 minutes. This sport requires not only speed, technical ability, but also high strength and endurance [1]. Also, maintaining optimal body mass is an important element of the training process and allows the competitor to choose the weight class in which he/she performs best. Kickbox is an individual sport that requires direct coach supervision and constantly follows a training process. Supervision of the coach allows the athlete to progress through training faster, which may result in a greater number of success. It is reported that a kickbox match works all muscle groups, requires coordination and activates both aerobic and anaerobic metabolism [2]. With a situation constantly changing during a competition, athletes may need to demonstrate a sharp level of proprioception, quick response time, both simple and complex, good hand-eye coordination, spatial orientation and responsiveness [3]. Preferred efforts during both match and training are based on maximum loads [4]. It is stated that the contribution of energy system to kick box is 70-80% anaerobic and 20-30% aerobic [5]. During a kickbox match, more than 50% of Adenosine Triphosphate (ATP) is provided by aerobic metabolism [6]. For this reason, it is very important for kickboxers to have a high level of aerobic and anaerobic capacity, to maintain high-intensity efforts and increase recovery between matches [7].

In particular, warm up, stretching and massage are traditional methods used to increase performance and reduce the risk of muscle injury through biomechanical, neural and physiological mechanisms [8, 9]. Warm-up exercises usually start with low-intensity aerobic jogging and increase in intensity over time. Athletes do proprioceptive neuromuscular facilitation (PNF) stretching exercises after running. PNF stretching exercises are

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divided into types within themselves. Contract relax antagonist contract (CGAC), one of the most widely used techniques, involves additional contraction of the agonist muscle during stretching before additional stretching of the target muscle. A number of individual studies show that PNF is more effective than static or dynamic stretching for improving range of motion (ROM) [10, 11]. Stretching exercises are performed by trainers and athletes in the belief that such exercises improve performance and can reduce the risks associated with injury. However, recent studies have shown that PNF stretching exercises before competitions and training do not affect vertical jump and explosive strength [12, 13]. It shows that it increases flexibility and hand grip strength [14, 15]. Knowing the different effects of PNF stretching exercises on sports performance has led sports scientists, coaches and athletes to find an alternative approach.

One of the alternative methods to PNF exercises is massage. Like PNF stretching, massage is one of the methods commonly used by athletes. It is reported that massage increases blood flow rate in the muscle, blood circulation in the skin, parasympathetic activity, relaxation hormone, tissue adhesion, muscle harmony, and joint range of motion. It has also been reported to reduce active and passive stiffness, pain, muscle tension and spasm, and neuromuscular excitability [16]. Massage is believed to relieve muscle tension, reduce muscle pain, improve flexibility and range of motion, increase muscle blood flow; and enhance clearance of substances such as blood lactate or creatine kinase [17]. A limited number of studies conducted to evaluate the effects of massage on sports performance have reported that it affects different parameters depending on the type, duration and frequency of massage used. When the literature is examined, different results have been reported on vertical jump [18, 19, 20], flexibility [21, 22] and hand grip strength [23]. A very limited number of studies in the literature indicate that there is not yet enough strong evidence to suggest the positive effects of physical massage on sports performance after massage. However, it is assumed that, alone or in combination with other warm-up exercises, massage has positive effects on sports performance: increased range of motion (active and passive), decreased muscle stiffness, increased blood flow, an increase in arterial pressure and muscle temperature [20].

Coaches and athletes may prefer PNF stretching exercises because of their preventive effects on injury-related micro-trauma, but research shows that there is no increase in performance if such exercises are performed before physical activities that require high energy output. However, they can see a positive effect in flexibility activities. Athletes tend to prefer more than one type of exercise before athletic performance. Although the effects of massage, PNF stretching or active warming exercises have been determined, the exact effect of massage performed immediately after PNF stretching has not yet been clarified. This study aims to evaluate the effect of PNF Stretching, Massage and PNF stretching followed by massage on flexibility, hand grip strength, vertical jump and anaerobic performance change.

Material and Methods

Participants

Twelve male volunteers, who regularly participated in kick-box training for at least 3 years and competed actively in international competitions, (mean age 18.50 ± 0.97 years, mean height: 161.60 ± 4.47 cm, mean body weight: 62.20 ± 9.07 kg, body mass index: 23.77 ± 2.63) participated in the study. Before starting the study, the volunteers were given detailed information about the content, purpose and methodological model of the study. Informed consent form was signed by the subjects who stated that they volunteered to participate in the study. Prior to the study, participants were asked to sleep for at least 8 hours before each testing session. In addition, they were asked to come full, provided that they ate at least two hours before the morning and evening sessions. All test and measurement applied in this study were approved by the Institute's Clinical Research Ethics Committee (Approval Number: 2021/2515).

Experimental Design of the Study

In the study, the anthropometric measurements of the participants were determined. Measurements were made in the Sports Hall of the Faculty of Sports Sciences. All volunteers who agreed to participate in the study were informed in detail about the content of the study before the test. Before the application started, the participants were given necessary information about the content, place and time of the study. Research consist of PNF stretching (30-40% heart rate (HR), 4 min jogging + 8 min seven contract relax antagonist contract (CRAC), massage (30-40% HR, 4 min running + 8 min lower extremity massage) and PNF stretching + massage (30-40% HR, 4 minutes running+4 minutes CRAC PNF stretching+4 minutes lower extremity massage) and NSM (only 30-40% HR, 12 minutes running) protocols. After each protocol vertical jump, hand grip strength and flexibility tests were performed (morning: 09:00-11:00), with at least 2 days between test sessions. This study continued approximately 12 days. All protocols continued consecutive days. In addition, the reason why these time periods of the day were chosen for the research is related to the fact that kickbox competitions started in the morning hours.

Stretching and Warm-up Protocols

NSM: The warm up rate was determined according to the 30-40% heart rate of each subject [24]. Subjects were light jogging for only 12 minutes under the control of the experts. In this way, both warm up intensity and warm up differences between participants in the training were eliminated. After 12 minutes light jogging, subjects' vertical jump, hand grip strength and flexibility tests were performed.

PNF: This protocol consisted on 4 min jogging + 8 min seven contract relax antagonist contract (CRAC). Stretching exercises as advanced seated hip adductor stretch, intermediate lying knee extensor stretch, hip external rotator and back extensor stretch, beginner seated hip external rotator stretch, advanced standing lower-trunk lateral flexor stretch, intermediate wrist flexor stretch, Shoulder and Elbow Flexor Stretch determined [25]. Stretching exercises were aimed at primary muscles in terms of affecting vertical jump, flexibility and hand grip strength (Table 1). Each stretch consisted of 5 seconds of passive initial stretching to a mild stretch or restriction point followed by 5 seconds of isometric contraction of the target muscle. The subject was then instructed to contract the opposite muscle group for an additional 5 seconds using a concentric contraction providing a new starting point. After 5 seconds, the procedure was repeated and 20 seconds was determined as the total duration of CRAC exercise in a single region. A certified athletic trainer was used as an assistant during total stretching exercise time in the study and data was recorded during CRAC PNF protocol. A pre-recorded tape is included to ensure consistency of CRAC PNF protocol. When the lead investigator was ready for the first stretching exercise, the assistant pressed the play button to start the shooting. This provided commands for the lead investigator that allowed for consistency of the duration of contraction and active movement during CRAC PNF and the time it took to switch to another muscle group.

M: This protocol consisted on 4 min running + 8 min lower extremity massage. In the traditional (Swedish) 8-minute massage of the lower extremities of kickboxers, the musculature massaged was the same muscles that were stretched with the CRAC PNF stretching exercises in the previous protocol. Massage techniques included effusion, friction, petrissage, percussion, and vibration.

PNF+M: This protocol consisted on 4 minutes running+4 minutes CRAC PNF stretching+4 minutes lower extremity massage.

Countermovement Jumps (CMJs)

Volunteer kickboxers were asked to perform three counter movement jumps (CMJs) on a strength platform (Newtest 2000, Oulu, Finland) with 1 minute rest in between. The starting and ending positions were made upright, standing at hip width, hands on hips. Movement of the hands was not allowed during the entire measurement so as not to affect the jump height. Upon command, the participant lowered their center of mass by bending their knees to a degree of their own choosing, and immediately jumped vertically as high as possible after reaching the lowest position [26, 27]. The highest jump height was used for the analysis. Anaerobic power (peak and average) of kickboxers was calculated using the Johnson & Bahamonde Formula [28], which allowed calculation of jump distance, body weight and height data.

Flexibility Test

The volunteer who performed the sit-reach test stood on the test bench with their ankles straight in 90-degree flexion, sitting on the floor with bare feet, and leaning forward with his body without bending the knees, they reached the farthest point on the table with their hands and remained there. After one trial, the volunteer's best score of three trials was recorded [29].

Hand grip strength (HGS)

During measurement, the participant stood upright, his arm was free at the side, and hand dynamometer was perpendicular to the ground and asked to be squeezed downwards. The volunteer squeezed the tool with all his might and the number on the screen was kg. recorded in type [30]. Hand grip strength values were measured three times, right and left, with the "TAKEI GRIP-D" brand hand dynamometer for the reliability of the test [31].

Statistical Analyses

Data analysis was performed by the SPSS software version 26.0 (SPSS, (SPSS, Inc., Chicago, IL, USA) program. Data were expressed as mean ± standard deviation (SD) in bar graphs. Repeated measures anova was used to analyze the differences of flexibility, vertical jump and hand grip strength according to four exercise protocols (NSM, PNF, M, PNF+M). Variances were found to be homogeneous for all protocols. Significance level was interpreted according to $p<.05$, $p<0.1$ and $p<.001$.

Results

In Figure 1, there was a significant increase in flexibility for NSM, PNF, M, PNF+M [$F_{(1.27)=}$ 8.92 p=.000, partial eta squared: .448]. Moreover, there was a significant difference between NSM and PNF, NSM and M, NSM and PNF+M ($p<.05$).

In Figure 2, there was a significant increase in vertical jump for NSM, PNF, M, PNF+M [$F_{(1.15)=}$ 7.883 p=.013, partial eta squared: .417]. Moreover, there was a significant difference between PNF and PNF+M, M and PNF+M in favour of PNF+M ($p<.05$).

In Figure 3, there was a significant decrease in right hand grip strength for NSM, PNF, M, PNF+M [$F_{(2,093)=}$6,743 p=.005, partial eta squared: .380]. Moreover, there was a significant difference between

Table 1. PNF stretching exercises and the major muscles used

PNF stretching exercises	The major muscles used
Shoulder and Elbow Flexor Stretch	Pectoralis major, pectoralis minor, anterior deltoid, coracobrachialis, biceps brachii, brachialis, brachioradialis
Hip external rotator and back extensor stretch	Gluteus maximus, gluteus medius, gluteus minimums, piriformis, gemellus superior, gemellus inferior, obturator externus, obturator internus, quadratus femoris, lower latissimus dorsi, erector spinae
Advanced seated hip adductor stretch	Gracilis, adductor magnus, adductor longus, adductor brevis, pectineus, middle sartorius, lower erector spinae, lower latissimus dorsi
Intermediate lying knee extensor stretch	Right vastus intermedius, right rectus femoris, right psoas major, middle and upper right sartorius
Beginner seated hip external rotator stretch	Gluteus maximus, gluteus medius, gluteus minimums, piriformis, gemellus superior, gemellus inferior, obturator externus, obturator internus, quadratus femoris
Advanced standing lower-trunk lateral flexor stretch	Rectus abdominis, left external oblique, left internal oblique
Intermediate wrist flexor stretches	Brachioradialis, flexor carpi radialis, flexor carpi ulnaris, flexor digitorum profundus, flexor digitorum superficialis, palmaris longus

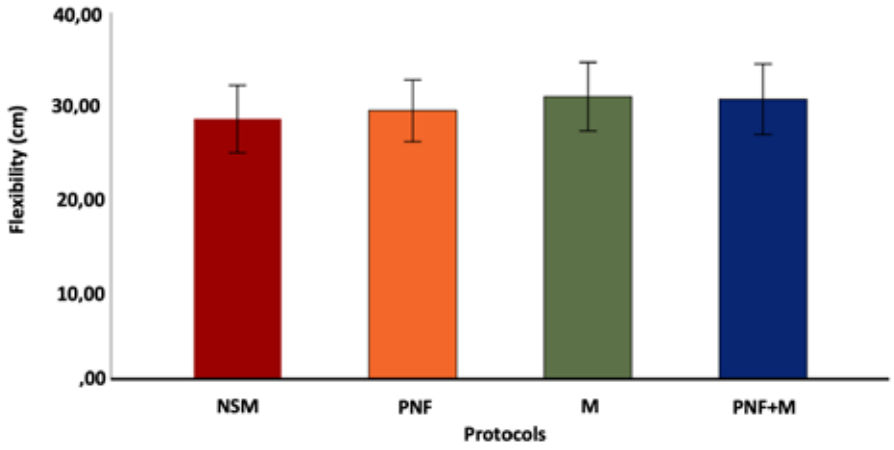

Figure 1. Flexibility performance of four warm up and stretching protocols

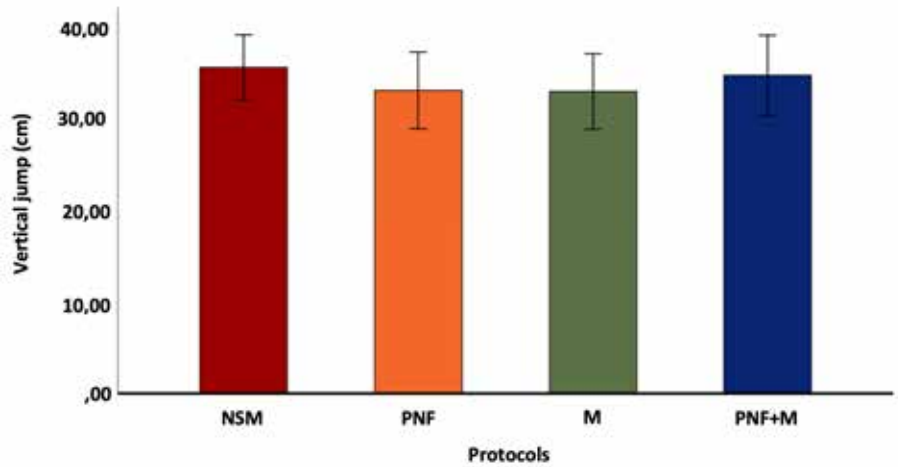

Figure 2. Vertical jump performance of four warm up and stretching protocols

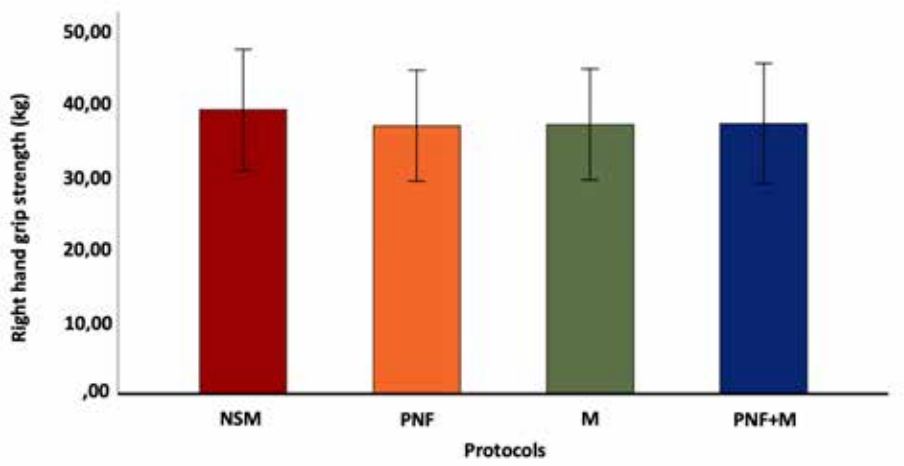

Figure 3. Right hand grip strength performance of four warm up and stretching protocols

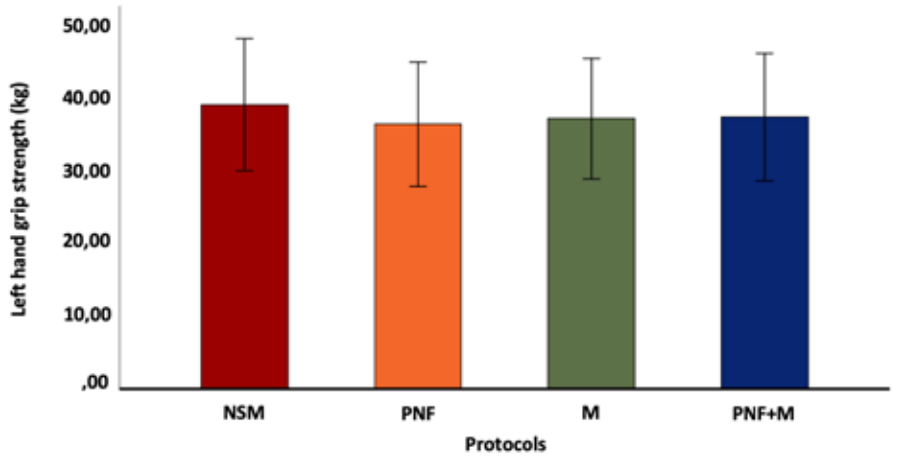

Figure 4. Left hand grip strength performance of four warm up and stretching protocols

NSM and PNF, NSM and M, NSM and PNF+M (p<.05).

In Figure 4, there was a significant decrease in left hand grip strength for NSM, PNF, M, PNF+M [$F_{(2,176)=}$3,497 p=.043, partial eta squared: .241]. Moreover, there was a significant difference between NSM and PNF (p<.05).

Discussion

For many years, athletes do warm-up and stretching exercises before physical activity or competition. The purpose of warm-up and stretching is to improve physiological, biomechanical and psychological performance of the athlete by increasing their body temperature and range of motion. However, coaches and athletes haven't yet determined which is the most appropriate warm-up or stretching protocol to increase performance improvement in sports such as kickboxing. Coaches and athletes often perform stretching exercises after general warm-up exercise. Studies examining the effects of stretching and massage sessions after general warm-up may add originality to the literature for kickboxers. The aim of our study was to evaluate the effects of different stretching and massage protocols on vertical jump, flexibility and hand grip strength in kickboxers. From our hypotheses, it was confirmed that PNF+M, M and PNF can reduce vertical jump performance. The hypothesis that stretching and massage protocols might produce different results versus flexibility was also confirmed.

To the best of the authors' knowledge, this is the first study with repeated measurements comparing the acute effects of NSM, PNF, M, and PNF+M protocols on performance in vertical jumps, sit and reach, and hand grip performance in kickboxers. The main results were the performance reductions in vertical jump tests after PNF+M and PNF, PNF+M and M protocols. In addition, decreases in right hand grip strength were found after NSM and PNF, NSM and M, NSM and PNF+M. The differences in flexibility between NSM and PNF, NSM and M, NSM and PNF+M. Furthermore, decreases in left hand grip strength were found after NSM and PNF protocols.

The results of the present study are partially consistent with previous studies that examined the use of massage in pre-event warm-up. For example, Arabaci [21] showed a significant worsening in the

vertical jump (VJ) and significant improvement in sit and reach test (SR) test. The results of stretching intervention were similar to those of the massage intervention. Hunter at al. [32] found a decline in mean force from pre to post-intervention for the massage condition. McKechnie et al. [33] found no significant change in the power measures following massage. Yildiz et al. [20] found that static stretching (SS) and combined static stretching and massage (SSM) protocols demonstrated 12% and 16% respectively greater flexibility than the control protocol. Countermovement jump (CMJ) and squat jump (SJ) performances were significantly decreased 10.4% and 5.5% respectively after the SS protocol. McKechine et al. [33] suggested that pre-event massage can increase the plantar flexors' flexibility. However, Barlow et al. [34] suggested that a single massage of the hamstring muscle group was not associated with any significant increase in sit and reach performance immediately after treatment in physically active young men. Capobianco et al. [22] found that self-massage prior to stretching improves flexibility in young and middle-aged adults. Koumantakis [35] indicate that muscle flexibility was positively influenced immediately after a single intervention of instrument assisted soft tissue mobilization (IASTM), vibration massage or light hand massage. There are some reasons why flexibility performance can increase after massage and decrease or no change vertical jump and hand grip strength performance. Massage can produce mechanical pressure, which is expected to increase muscle compliance resulting in increased range of joint motion, decreased passive stiffness and decreased active stiffness (biomechanical mechanisms). Mechanical pressure might help to increase blood flow by increasing the arteriolar pressure, as well as increasing muscle temperature from rubbing. Depending on the massage technique, mechanical pressure on the muscle is expected to increase or decrease neural excitability as measured by the Hoffman reflex (neurological mechanisms) [16].

Bradley et al. [36] claimed that PNF or static stretching should not be performed immediately prior to an explosive athletic movement. Moreover, there are lots of studies showed that PNF didn't have a significant effect on vertical jumping [37, 12]. This may be due to the muscles being stretched too far outside of their capacity, causing inhibition following the stretching [11]. PNF stretching should reduce muscle activation and possible inhibition of autogenic and reciprocal inhibition through some degree of reflexive disfacilitation with reduced muscle spindle receptor activity of the nuclear bag and nuclear chain [38]. Increased tolerance to stretch, decreased viscoelasticity, and to some extent decreased muscle-tendinous stiffness due to PNF exercises may contribute to the sustained increase in elastic ROM [39, 40].

Conclusions

As a limitation, this study did not include measurement instruments that could directly identify the neurophysiological mechanisms mentioned as being responsible for the reduction in physical performance after the different stretching methods and male kickboxers joined this study. Therefore, future studies should include evaluations that enable comparisons of the influence of mechanical and neural factors, or their association, on performance after PNF, M and PNF+M protocols.

Based on the results found in this study, PNF, M and PNF+M protocols do not promote positive effects on vertical jump and hand grip strength performance. However, PNF, M and PNF+M protocols should be viewed with caution, especially because of the higher intensities reached in these methods and the extensive possibility of negative effects on performance in activities involving vertical jumps. Thus, physical trainers in kickbox can include PNF, M and PNF+M protocol sessions similar to those in this study in their warm-up routines during training sessions, allowing kickboxers to increase their levels of flexibility without further negative effects on performance in vertical jump activities.

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Conflict of interest

The authors report no conflict of interest.

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