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The effects of the application of dynamic and PNF stretching on the explosive strength abilities of the lower limbs in warm-up in hockey and football athletes

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Abstract

Introduction. This article deals with the issue of the effects of stretching on the level of explosive strength abilities in the lower limbs in warm-up. We know from a large amount of scientific studies that dynamic stretching has a positive effect on most sport performances (especially power and speed sports) rather than static stretching. Dynamically stretched muscles produce more power primarily because of the increased activation of the motor units. Higher performance during fast dynamic exercise is related to higher activation of the central nervous system. Proprioceptive neuromuscular facilitation (PNF) seems to be an optimal method of stretching when trying to increase joint mobility in the joint-muscle unit, where muscle contraction is used, followed by a relaxation phase and the subsequent stretching of the muscle. Aim of Study. The aim of this study is to compare the impact of dynamic and PNF stretching on explosive strength abilities of the lower limbs in active hockey players (n = 19, weight 84.7 ± 6.4 kg, height 179.8 ± 3.1 cm) and football (soccer) players (n = 23, weight 77.6 ± 5.1 kg, height 175.5 ± 4.3 cm) ranging in age from 18 to 26. Material and Methods. The PNF method of Sölveborn was used, a method characterized by the physiological knowledge that a muscle significantly decreases its tone after isometric contraction is applied. This was compared in our research to the use of dynamic stretching during warm-up. We used the following motor exams for testing the explosive strength of the lower limbs – a standing long jump (rebound with feet together) and a vertical jump (Sargent test). Results. We can state from the results of the parametric t-test that on the chosen level of significance (p < 0.05) practically significant differences were noted in the application of dynamic and PNF stretching in the hockey players' vertical jump, and in addition to this, that the observed differences were substantively significant. For soccer players there are no statistically different results in the vertical jump test (p < 0.05) and that the participants have similar results after both dynamic and PNF stretching exercises. Conclusions. The impact of the acute application of dynamic stretching on explosive strength abilities in the lower limbs of hockey players was significantly more effective than the application of the PNF stretching technique in the vertical jump test performances. The experiment confirmed the short-term effect of the application of dynamic stretching on the explosive strength of the lower limbs of hockey players.

KEYWORDS: stretching methods, muscle stretching exercises, explosive strength.

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Introduction

Stretching means a set of specially performed exercises to achieve muscle elasticity and tone. It is understood as a system of methods used to increase the range of motion in the joints and it relates to the skeletal muscles and that part of the nervous system that controls them [17]. The purpose of stretching is to prepare an individual for imminent sports performance, to compensate for unilateral load, to reduce muscle tension and to create a feeling of physical relaxation, to actively regenerate after a performance (in the resting intervals between

exercises oxygenation of the tissues associated with the release of metabolites occurs), to loosen and stretch the tissues, and to increase flexibility.

The aim of the study is to compare the effect of dynamic and PNF stretching on explosive force in a selected group of hockey players and football (soccer) players.

The problematics and the inclusion of stretching techniques in the warm-up phase of the training unit are dealt with in a number of studies [1, 8, 13]. Available research shows the different effects of various forms of stretching in warm-up to subsequent sports performance. Most authors prefer the use of dynamic stretching to static stretching in the initial phase of the training unit [1, 8, 13]. It is reported that static stretching and PNF stretching (proprioceptive neuromuscular facilitation) show a drop in the strength of participants after their use during warm-up. Therefore, the present research is focused on the comparison of indicators related to the explosive strength of the lower limbs in the application of dynamic and PNF stretching during the warm-up performed in a selected group of athletes. The research is based on the findings that the PNF method according to Sölveborn uses physiological knowledge that the muscle significantly reduces its tone after isometric contraction [17]. The second method used in the warm up, the dynamic stretching, makes use of the production of greater force caused by the increased activation of motor units as a prerequisite.

Dynamic stretching is used in the initial part of the training unit because its advantage is the acute increase in the ability to produce strength in the activated muscle groups. It is therefore suitable as part of the warm-up, especially before strength and speed performances, but it has proved to be the least effective method for the development of joint mobility.

Slomka and Regelin [19] show the benefits of dynamic stretching. When nervous pathways responding to stretching tension are activated more strongly than during static stretching, speed related strength better remains inside the muscles than during static stretching, coordination inside the muscle improves, capillaries remain completely open during the exercise, and the blood supply of muscles continues to flow.

The principle of PNF techniques was developed in the 1940s by neurophysiologist Herman Kabat. Originally, PNF was used in medical movement rehabilitation, and to date some techniques are also used in sports medicine. PNF includes various techniques. Their comparison and evaluation are difficult because there are inconsistent resources on which the name and description of PNF techniques are based. In practice, it is possible to combine isotonic and isometric (concentric and eccentric) muscle activation in various combinations, including activation of both agonists and antagonists. PNF techniques use some of the proprioceptive spinal reflexes for easier stretching of the muscle.

PNF techniques according to Dostálová and Miklánková [6] present several variants: The first technique is stretching after agonist contraction. The agonist activates concentrically, the muscular tension increases for 7 to 10 seconds, followed by a release of 2 to 3 seconds, and then the stretch of the muscle for 10-15 seconds is conducted in association with exhalation. The second technique is the post isometric contraction of the agonist, which uses isometric muscle activation when the muscle tension increases against resistance, which is followed by release and passive stretching with the assistance of a partner and accompanied by exhalation. We use post isometric relaxation (PIR) techniques where the isometric tension is minimal with very gentle stretching or post isometric stretching (PIP) techniques where the isometric stress is relatively high and subsequent stretching is more prominent. The third technique employs reciprocal innervation by simultaneously activating an antagonist, i.e., a muscle working in the opposite direction, or an isometric activation of the antagonist for 5 to 7 seconds at the same time, followed by stretching of the agonist for 15 to 20 seconds.

Experts consider PNF methods to be the most effective [4, 12]. They are more suitable for more advanced exercisers because their implementation requires experience.

Material and Methods

Participants

For our research 42 people were deliberately selected and tested to evaluate the impact of dynamic and PNF stretching in the 18-26 year-old age range. Participants were active athletes. In total, 19 hockey players were measured with an average height of 179.8 ± 3 cm and an average weight of 84.7 ± 6.4 kg. In total, 23 football (soccer) players were measured with an average height of 175.5 ± 4.3 cm and an average weight of 77.6 ± 5.1 kg. Tested subjects were hockey players from the team HC Slovan: Ústečtí lvi in Ústí nad Labem and footballers from the team FK Neštěmice in Ústí nad Labem – both team were in the first league. All 42 participants were involved in both measurements. All 42 people consented to the testing. The reason for choosing people in these specific sports was that they require a high level of explosiveness, speed, and physical skills, which

could be influenced by the application of stretching. The number of training units per person was at least 4 times a week, from which we deduced that the people we selected had an average sport performance higher than the majority of the population. The tested subjects were aware of the possible risks, but also of the positive aspects associated with the use of the standing long jump and the vertical jump during testing.
The research was approved by the Ethics Committee of the Faculty of Education of UJEP in Ústí nad Labem under reference number 1/2017/1.

Procedures
For quantitative research, we chosen the test and measurement method. At first, the participants were familiarized with the research itself and the timetable. A timetable was discussed with the coaches and the research itself was explained to them. Measurements took place at weekly intervals between application of different types of stretching by the whole group under the supervision of a physiotherapist. The height and weight of all tested subjects was measured.
A total of two measurements were made. The first measurement took place at HC Slovan on the 9th of June, 2018 and on the 16th of June, 2018 at the winter stadium in Ústí nad Labem under the same conditions (humidity). The second measurement took place at the football club FK Neštěmice on the 8th of August, 2018 and the 15th of August, 2018 on the football field in Ústí nad Labem under identical conditions (clear skies, 20-25°C). The hockey players were measured in the morning and the footballers were measured in the afternoon. All the persons tested were acquainted with the reason and purpose of the measurement. Before each test the same procedure was performed with dynamic or PNF stretching. Dynamic stretching is done in such a way that the driving force of motion is the movement energy of the body. The individual attempts to perform conscious, controlled movements without holding the body in an extreme position, and without any swinging. The Sölveborn PNF method uses the knowledge of muscle tone reduction after isometric contraction, when the muscle contracts against resistance for about 10 to 30 seconds, releases for 2 to 3 seconds, and then stretches continuously and gently for at least 30 seconds. We used the same types of exercises for individual warm-ups, and the athletes were tested in the same order. For each test there were always two attempts. The results were recorded continuously.
First, the test group prepared the body for a physical load by having to run 400 m at 70% of maximal pace. Then there was a warm up based on the two types of stretching exercises. In the first week, dynamic stretching was performed, which was swapped in the second week for PNF stretching. The planning of the warm-up sequence was focused on the randomization of the results. This scheme was used to prevent body fatigue, to increase motivation, and to minimize the distortion of the results. After the given warm-up, the participants slowly jogged to the measuring station. The interval between the end of the warm-up and the beginning of the measurement was in the range of 2-4 minutes. We tried to minimize the delay between warm-up and measurements. The whole group was divided into two smaller groups. Two standardized motor tests were selected for the measurement of the explosive strength of the lower limbs: the Sargent test of the vertical jump, and the standing long jump. Explosive strength of the lower limbs was tested at both stations. Two attempts were carried out in each test. The whole measurement took approximately 10 to 15 minutes. Testing from the beginning of the warm up to the end of the strength measurements took about 35 to 40 minutes. One group of the participants first passed the standing long jump testing station and then continued to the second station testing vertical jump. After completing the performance at each site, the groups exchanged positions.
For a vertical jump test (Sargent test), the measurement is performed so that the tested subject is standing sideways to a wall on both feet and raises the arms as close as possible to the wall. The highest point of the fingers is marked with chalk on the wall. This point is labeled as the maximum reach in the standing position. The tested subject then steps back from the wall and makes a jump from the spot while trying to leave a mark with the fingers at the highest jump point [20]. To improve the accuracy of the measurement, it is advisable to paint the fingertips with a washable color [18]. The attempt was always monitored and recorded by two examiners.
When testing the standing long jump, the tested subject stands with the tips of the feet right behind the take-off line with feet slightly apart and carries out a squat and reaches backwards with both arms, then concurrently swings the arms while performing a two foot take-off and attempting to jump as far as possible. The individual lands on both feet and remains standing. The measurement is taken from the take-off line to the nearest point, which is the heel of the foot after landing [9]. Attempts with an overstep are not measured. The subject has three consecutive attempts and the best is recorded [20].

A measuring tape was used for testing the standing long jump. For the second standardized test (Sargent's test) we also used a measuring tape along with a basketball backboard. Tested subjects carried out both stretching methods at the same time, but the standardized tests were carried out consecutively. We tried to ensure the same measuring conditions. Before the standardized tests were started, the correct implementation was explained and demonstrated. Test results were recorded on prepared sheets.

Parameters of trained muscle groups in relation to the total number of repetitions in PNF stretching and dynamic stretching exercise were taken from a study on the impact of acute application of dynamic and PNF stretching on the explosive strength of the upper and lower extremities [14]. Quantitative expression of involvement of selected muscle groups during dynamic stretching. Muscle group/Number of repeats: Neck muscles 28×, Muscles of shoulder waist 48×, Hull muscles 32×, Muscles of the lower limbs 68×. Quantitative expression of the involvement of selected muscle groups during the stretching of PNF stretching – Muscle group Tension phase (s), Phase of stretching (s), Number of exercises, Total time (s): Neck muscles 15-15-3-90 s, Shoulder arm muscles 15-15-4-120 s, Flesh muscles 15-15-4-120 s, Muscles of lower limbs 15-15-8-240 s.

Statistical analysis

Differentiation in performance was determined by a paired t-test because we were dealing with parametric data (according Shapiro-Wilk normality test). The t-test is used to compare the mean values of the two sets, and to find whether the results of the measurements of one group differ significantly from those of the second group. With the use of a paired t-test, it is possible to verify whether the difference of the mean distribution values of variables is most commonly equal to zero.

The *p* value shown under test results entitles us to speak to a zero hypothesis. If *p* is less than 0.05, we reject the zero hypothesis with less than 5 percent error probability. The Statistica 12.0 program was used to calculate *p*.

Results

Interpretation of the results of footballers

The following is an evaluation of the standing long jump motor test: using dynamic warm-up, footballers achieved a better result on an average of 232.3 cm than the average after PNF stretching of 231.3 cm. It can be argued that, there are no statistically different results in the standing long jump test among the tested subjects since after the dynamic stretching the athletes achieved similar results to their performance after PNF stretching. Here is the evaluation of the vertical jump motor test: after using the dynamic warm-up, tested subjects showed an average performance of 56.74 cm. The average performance after the PNF warm-up was 55.26 cm. The participants have similar results after both dynamic and PNF stretching exercises.

Interpretation of the results of hockey players

With hockey players the research was carried out in the same manner as in the case of the footballers. Once again, the influence of different types of warm-ups on the performance was monitored and we chose two types of warm-up, dynamic and PNF stretching in both motor tests. In the case of the standing long jump test, after the dynamic warm-up tested subjects showed an average performance of 233.8 cm. After the PNF stretching the average performance was 229.2 cm. In the standing long jump test it is possible to see similar results after the application of dynamic stretching as it is after the application of PNF stretching, and there are no statistically different results.

Evaluation of the vertical jump test of the tested subjects showed that after the dynamic warm-up the average performance was 61.05 cm. After the PNF warm-up, the average performance was 57.42 cm. In the vertical jump test, we can see a significant difference between the application of dynamic stretching and PNF stretching. Differences are practically significant $\omega^2 = 0.152$ and since the result is higher than 0.1, the observed difference between the sets has a significant effect size.

Evaluation of motor test results after individual types of stretching

In the Figure 1 are shown average performance of the standing long jump test for footballers and hockey players (cm) and Figure 2 show average performance of the second test the vertical jump test (Sargent test). Hockey players achieved better results in the standing long jump test after dynamic stretching with an average of 233.8 cm than after the PNF stretching with an average of 229.2 cm. Even footballers achieved better results in this motor test after dynamic stretching, with an average performance of 232.3 cm, than after the application of PNF stretching with an average performance of 231.3 cm. The differences in the performance of footballers were found to be rather insignificant, but for the players and their trainer every little performance difference is important, even if it is negligible.

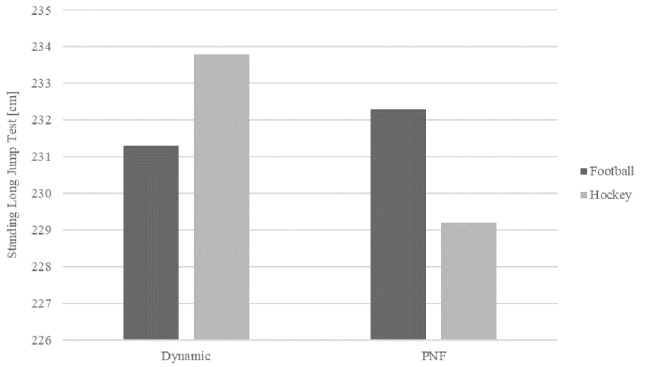

Figure 1. Average performance of the standing long jump test, footballers and hockey players (cm)

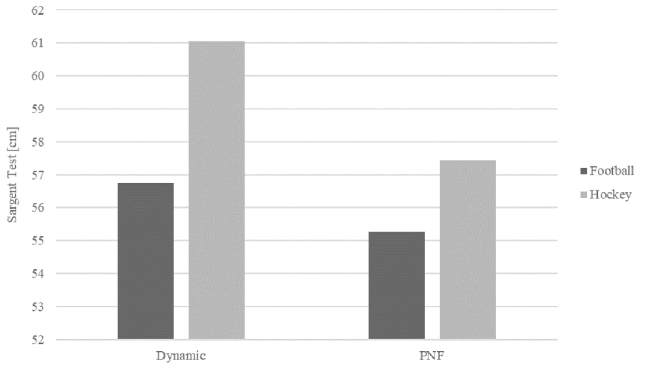

Figure 2. Average performance of the vertical jump test (Sargent test), footballers and hockey players (cm)

After the application of PNF stretching on hockey and footballers, statically different results in the standing long jump test were not found at a level of significance of 0.05. Tested subjects achieved similar results after the application of PNF stretching.

In regard to the average score for a vertical jump test after dynamic and PNF stretching by hockey players, the players achieved a better result once again after dynamic stretching, with an average of 61.05 cm, and after the PNF stretching they reached an average performance of 57.42 cm. Footballers in this test also achieved better results after dynamic stretching, where the average performance of 56.74 cm was higher than the 55.26 cm average after PNF stretching. Once again, only a slight difference in the performance of footballers was found. Therefore, it can be argued that, there are no statistically different results in the vertical jump test, and the participants achieved similar results after a dynamic stretching exercise.

After applying PNF stretching to hockey and footballers, it can be argued that at a significance level of 0.05, there are no statistically different results in the vertical jump test, and the participants, after PNF stretching, achieve similar results.

Discussion

This study confirmed the positive effect of stretching on performance in motor tests, although only the influence of the dynamic stretching exercise on the explosive strength of the lower limbs of hockey players proved to be statistically significant with a significant effect in size. It proved to be more effective than the application of PNF stretching techniques in the standing long jump test. Cacek and Bubníková [3] dealt with the difference between the effect of dynamic and PNF stretching on loads characterized by explosive strength and determined that there was no statistically significant difference in any test, but still they also found that performance was increased, although only by a few centimeters, which may mean that even a small improvement may be an important indicator for a trainer. Similar results were obtained in our study.

Significantly more effective was the influence of the application of dynamic stretching on the explosive strength of the lower limbs in hockey players than the application of PNF stretching techniques in regard to performance during the vertical jump test where there is an observed difference and it is practically significant.

There are many ways to apply dynamic stretching (difference in types of exercises, frequency of execution, duration of execution, number of repetitions, speed of execution). Similarly, PNF stretching (active, passive, with the help of a second person, etc.) can also be performed in different variants. Concerning the intensity of dynamic stretching, studies and literature are unclear and inconsistent. For example, Herman and Smith [11] are concerned with the intensity of dynamic stretching and they state that stretching is done at a slow pace, but the intensity is not precisely defined. Fletcher [7] in his study mentions that at a rate of 100 beats per minute performance improves in the countermovement jump test than if the stretching is applied at a rate of 50 beats per minute. The research of Holt, Travis, and Okita [12] looked at comparing the immediate effect of each stretching method (static, dynamic, and PNF) by measuring immediately after exercise. They reached the single conclusion that all PNF methods proved to be more effective than all other stretching methods. Their following conclusion was the finding that between various PNF methods, probably the most effective is Holt's 3-S method, but it is very demanding and cannot be used in all planes of motion. Davis, et al. [5] dealt with the comparison of the effect of three stretching

techniques (active stretching, static stretching and PNF technique) on the length of hamstring muscles during a four-week training program. They stated that when using all stretching techniques ($p \leq 0.05$), the length of hamstring muscles increased from the baseline, but in the static stretching group, the result was significantly greater than in the control group. They also noted that active stretching and PNF stretching are not significant enough to extend the length of hamstring muscles in adults aged 21-35 when applied in one repetition for 30 seconds more than three days a week. Both methods of the PNF system – Sölveborn's and passive – proved to be more effective than the static method [20].

Results of research on a similar topic have shown that PNF stretching reduces the stiffness of tendons [10]. O'Hora, et al. [15] showed that PNF stretching has two major drawbacks: first, a partner is required, and secondly, it involves a greater risk due to the necessity of providing for proper communication with a partner and responding appropriately to ensuring that the motion is carried out safely. They also state that self-PNF stretching could eliminate both of these drawbacks. For further research on efficacy testing and stretch testing, it may be advisable to have a longer duration of research and testing when repeat rates of the motor test and stretch in the stretch position should be increased and exercises changed to avoid adaptation of the body. Stretching could then show significant differences in research results.

It would be appropriate to conduct a study with different variants of dynamic and PNF stretching. Interestingly, studies with longer-lasting application of these types of stretch and its comparison with short-term effects in relation to explosive strengths would be interesting.

Conclusions

In the presented research, we investigated the effect of dynamic and PNF stretching on the explosive strength of lower limbs in footballers and hockey players. On the basis of the data obtained and processed, we have reached the following conclusions. The influence of dynamic stretching exercises on the explosive strength of the lower limbs of footballers has not proven to be significantly more effective than application of PNF stretching technique in the standing long jump test or in the performance of the vertical jump test. The influence of the application of dynamic stretching on the explosive strength of the lower limbs of hockey players has proven to be practical significant more effective than the application of PNF techniques on the performance of the vertical jump test.

Based on the research and the results obtained, we recommend choosing a stretching exercise of the dynamic type in warm-up, especially before performing physical activities characterized by the necessity for speed and strength.

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