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THE EFFECTS OF STATIC STRETCHING AND ISOMETRIC STRENGTH ON HAMSTRING STRENGTH AND FLEXIBILITY ASYMMETRY

Hamstring strength and flexibility asymmetry

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Abstract

Introduction. Considerable (over 10%) bilateral strength and flexibility asymmetry is one of the causes that increase the risk of hamstring injuries. The aim of this study was to define the effect of static stretching exercises and isometric strength exercises on bilateral asymmetry of hamstring strength and flexibility in athletes. ***Material and methods***. Thirty athletes participated in the study. They were randomly divided into three groups, i.e. two experimental ones (isometric and stretching) as well as the control group. Training programmes lasted for 4 weeks and were carried out during an off-season. Two tests were conducted, i.e. strength test (peak torque – PT) and flexibility test (knee range of motion – ROM). ***Results***. Significant decrease in the bilateral asymmetry of strength (by 4.19%) and flexibility (by 3.23%) was only observed in the group where stretching exercises were applied ($p<0.05$). Asymmetry in the isometric group did not change considerably ($p>0.05$). ***Conclusion***. The assumption was that static stretching exercises ought to become an essential part of training programmes during an off-season.

Key words: asymmetry, injury, muscle strength, range of motion, athletic performance

Introduction

One of the most common injuries among representatives of speed-strength events, including sprints, is the strain of hamstring muscles [1]. The following factors increase the risk of picking up this type of injuries: higher muscle tonus, too high stiffness of muscles when their extensibility is limited, coordination disturbances between main group of muscles as well as considerable strength and flexibility disproportions between both extremities (bilateral asymmetry) and between quadriceps and hamstring muscles [2].

As a form of prophylaxis, it is necessary to perform exercises that both strengthen and extend muscles. However, in most cases it is like groping around, since it is extremely difficult to control hamstring muscles in field conditions. It is too risky to carry out the strength test in an isolated position using body building equipment. Therefore, coaches do not implement such tests. Specially constructed devices which make it possible to measure many parameters connected with muscle strength accurately come in handy. Thanks to those devices it is possible to try to set an optimal strength proportion of antagonistic muscle groups including, the most commonly examined, knee flexors and extensors. This ratio, expressed by a maximal torque of hamstring muscles and quadriceps, has, according to some researchers, a high diagnostic value and may considerably help in preventing injuries. It ought to be added that its value depends on conditions in which a test exercise is done (e.g. angle velocities, kind of muscle work) as well as on sex.

Bilateral asymmetry occurs at all levels and is a natural phenomenon [3]. It is defined as the difference between the ability level of muscles of opposite extremities. Asymmetry of strength and flexibility is evaluated most often [4, 5, 6], yet asymmetry of jumping abilities [7], power or endurance [8] may also be defined. According to a number of researchers, strength asymmetry over 10% may result in the injuries of hamstring muscles [2, 9, 10]. Other researchers claim that 15% difference between the strength of the left and the right group of knee flexors as well as bilateral flexibility asymmetry of hip extensors at the same level (15%) increase the risk of incurring hamstring injuries [6]. There are also studies which did not reveal any significant dependencies between considerable bilateral asymmetry and injuries of lower extremities [11, 12].

Overloads stemming from repeated specific physical exercises may be the cause of asymmetry [13]. However, some research results contradict this theory. For instance, Zakas [14] did not observe any significant strength asymmetry expressed with H/Q (hamstring/quadriceps) ratio between a dominant and non-dominant leg as well as the left and the right leg in football players. Previous injuries may also be the cause of bilateral asymmetry [5, 15].

Most researchers focus on seeking accurate methods of evaluating muscle asymmetry and its connections with injuries. They pay less attention to studies which assess the effectiveness of exercise programmes aimed at decreasing bilateral asymmetry [16]. Therefore, the aim of the study was to define the influence of static stretching exercises and isometric strength exercises on bilateral asymmetry of hamstring strength and flexibility in athletes practising speed-strength athletics events.

Material and methods

Subjects

The study included 19 sprinters and 11 jumpers medium performance level. The average age of the men was 19.3 ± 4.0, body height 175.4 ± 8.7 cm, body mass 71.3 ± 6.4 kg. They were randomly divided into three groups. The isometric group performed the programme with isometric strength exercises, while the stretching group did static stretching exercises. The control group did not perform any physical exercises at that time.

The athletes were introduced to the testing procedures and informed about the aim of the study. Also, the pilot tests were carried out, during which a dominant leg was determined (in the case of jumpers it was a take-off leg, whereas in sprinters it was the leg situated in a front block during a block start) as well as the non-dominant one. The study was approved by the Research Ethics Committee of the Academy of Physical Education in Warsaw.

Measurements

Strength (peak torque – PT) and flexibility (knee range of motion – ROM) of hamstring muscles in both extremities were measured. Moreover, the ratio between the strength of hamstring muscles and quadriceps (H/Q ratio) was calculated. Also, the values of those parameters between a dominant and non-dominant leg were compared and then on this basis bilateral asymmetry was calculated.

Isokinetic test. PT of hamstring muscles in concentric conditions was measured with the use of the Biodex System 3 Pro dynamometer (Biodex Medical Systems, Inc, Shirley, NY) (Fig. 1.). Subjects were positioned on a seat set at the angle of 105° in relation to a backrest. They were secured with two straps which were fixed over the shoulders and crossed mid-chest. Both hands were also set in a crossed position on the chest. The thigh of the leg that performed the test was strapped to the seat. The other leg was left loose. The rotation axis of the knee (lateral epicondyle of the femur) was the same as the rotation axis of the torquemeter. Before the test the range of motion was set from 0 and 90°. Furthermore, the gravitation factor was defined and taken into consideration. The aim of the subject was to reach a peak torque during 5 repetitions at a velocity of $60°{\cdot}s^{-1}$. The subjects performed the test in random order. The protocol was as follows: each subject completed a 5-minute warm-up at 150 W on a cycle ergometer pedalling at a velocity of $80{\cdot}min^{-1}$ [17], followed by a 3-minute rest and the test. The testing session was carried out between 3 and 6 p.m. Best torque scores of 2 efforts were used for further analysis. The rest period between the trails was 5 minute.

Figure 1. Peak torque of hamstring muscles in concentric conditions was measured with the use of the Biodex System 3 Pro dynamometer

Active knee-extension (AKE) test. ROM in a knee joint was measured using a double-armed goniometer of transparent plastic. The protractor of the goniometer was divided into 1° increments. The arms of the goniometer were 30 cm (12 in) in length. Both extremities were tested. Before data collection, each subject was positioned supine with the hip and knee flexed to 90°. The lateral epicondyle of the femur as well as the lateral malleolus of the tibia and the greater trochanter of the femur were palpated and marked with a black highlighter pen. The subject then returned to the initial position. One researcher held the subject's thigh in a vertical position whereupon the participant extended the leg at the knee joint until terminal extension was reached and then held this position till the other researcher completed the measurement. The value of 0° corresponded with a full leg extension. The tests were carried out without prior warm-up between 10 and 12 a.m. The mean values of two measurements taken every 30 minutes made up the test result [18]. Using an intraclass correlation a reliability coefficient of 0.95 was calculated, which was slightly lower than the coefficient achieved in earlier studies (ICC = 0.96) [19].

Procedures

The study was carried out during an off-season. The experimental groups performed exercises during 3 sessions per week for 4 weeks. Each training session started with a 10-minute low intensity run, after which the groups began their tests. They were conducted by two researchers who changed groups every session. The description and procedure of performing exercises are presented in Table 1. Isometric strength exercises were done in the following way: contracting a muscle – 8 s, relaxing a muscle through shaking a leg – 8 s, and contracting again –

Table 1. Training protocol for isometric and stretching group

Isometric group	Stretching group
Stand in front of a gymnastic box (40 cm), place a straight leg on it and press the heel against the box. Do the same with the knee flexed at 45°.	Stand in front of a gymnastic box (40 cm), place a straight leg on it and bend your trunk forward. Do the same with the knee flexed at 45°.
Assume a supine position, lift one leg vertically with the other one flat on the floor. Press the heel of the lifted leg against your partner's hand.	Assume a supine position, lift a straight leg vertically with the other one flat on the floor. Hold your leg with your hands and pull it slowly to your torso.
Assume a supine position, lift your hips and a leg so that your torso and the lifted leg will be in a straight line with each other.	Straddle with your legs fully extended. Bend your trunk forward to one of your legs.
Stand on one leg with the other one flexed at 90°. Press the heel against your partner's hand.	Straddle with your legs fully extended. Flex your knee and move the heel to the thigh of the extended leg. Bend your trunk forward to the extended leg.

8 s. Static stretching exercises consisted in stretching a particular muscle group and holding this position for 30 s. The subjects were instructed to perform these exercises at submaximal intensity. Rest-periods between exercises lasted 20 s. Both exercise programmes were performed twice during each training session. All asymmetric exercises involved both extremities.

Statistical analysis

The obtained results were presented by way of: mean and standard deviation (SD). One-way ANOVA was conducted initially to examine whether there were differences among the 3 groups in pretraining values for each dependent variable. Changes in bilateral asymmetry were evaluated using one-way ANOVA, too. When F ratios were significant, post-hoc comparisons of means were analyzed with Tukey's test. The level of $p<0.05$ being considered significant. Statistica® 5.1 PL software was used in data analysis.

Results

The athlete's hamstring strength scores ranged from 153 to 206 N·m, H/Q ratio from 0.51 to 0.78, and hamstring flexibility from 16 to 32 degrees for the dominant and the non-dominant leg. The data concerning the tests (before and after) as well as the range of changes in bilateral asymmetry of strength, H/Q ratio and flexibility are presented in Table 2. Significant changes in strength and flexibility asymmetry of hamstring muscles were observed. In both cases the participants of the stretching group reduced asymmetry in a significant way ($p<0.05$) in comparison to the control group. The changes in bilateral asymmetry of the H/Q ratio were not significant. In all the groups the same tendency, i.e. asymmetry reduction, was observed.

Table 2. Mean ± SD value (in %) of strength, H/Q and flexibility asymmetry and their change (gain score=posttest-pretest)

	Control Group		Isometric Group		Stretching Group	
	Pre	Post	Pre	Post	Pre	Post
Strength asymmetry	9.74 ± 3.91	8.66 ± 3.16	9.12 ± 4.36	6.84 ± 3.62	9.05 ± 4.03	4.86 ± 1.13
Change	**-1.08 ± 2.34***		**-2.27 ± 2.15**		**-4.19 ± 3.30**	
H/Q asymmetry	5.85 ± 3.31	5.21 ± 2.26	6.20 ± 4.21	5.00 ± 3.21	6.08 ± 2.77	4.24 ± 2.19
Change	**-0.64 ± 2.09**		**-1.20 ± 2.03**		**-1.84 ± 1.77**	
Flexibility asymmetry	10.36 ± 4.45	9.12 ± 3.90	9.43 ± 4.32	7.93 ± 4.29	9.52 ± 3.97	6.29 ± 3.19
Change	**-1.24 ± 1.95***		**-1.50 ± 1.73**		**-3.23 ± 1.67**	

* – control group < stretching group, $p < 0.05$

Discussion

The issue of bilateral asymmetry is usually considered in the context of accuracy and diagnostics of its measurements [4, 7, 8, 20]. Its prognostication in the context of muscle injuries [9, 10, 15] as well as its influence on performance have also been subjected to analysis [3, 21]. Its no unequivocal guidelines concerning the structure of programmes aimed at reducing asymmetry have been determined as yet.

This study made it possible to observe the changes in bilateral strength and flexibility asymmetry of hamstring muscles brought about by two exercise programmes. The first programme aimed at improving muscle strength, while the other focused on improving flexibility. It was observed that bilateral asymmetry of both strength and flexibility of hamstring muscles decreased after implementing stretching exercises. As far as isometric strength exercises are concerned, they did not lead to any significant changes in asymmetry.

The assumption was that at the beginning of an off-season, i.e. after a 4-month intensive season, bilateral asymmetry would be considerable. As assumed, in both tests (of strength and flexibility) asymmetry was equal to 9-10%. According to some research [6, 10], asymmetry like that may pose a threat to the health of an athlete. Therefore, it is our opinion that exercise programmes aimed at reducing bilateral asymmetry ought to become an indispensable part of an off-season period.

The assumption was that high effectiveness of the programme with stretching exercises resulted from their beneficial influence on physiological and anatomical characteristics of this muscle group. Hamstring muscles belong to the group of tonic muscles [22], i.e. as a result of considerable repetitive dynamic overloads, typical of sprints and athletics jumps [23], these muscles react through an increased muscle tonus and decreased physiological length. Therefore, they are often too tense or even contracted, which undermines their capacities. Muscle stretching helps to improve this situation by effective lowering and balancing muscle tonus [24].

Another argument in favour of implementing stretching exercises is the fact that they positively affect the speed of rehabilitation after muscle strain injuries [25].

Some researchers are opposed to the idea of doing static stretching exercises by athletes of speed-strength events due to the fact that they have a negative influence on physical parameters [26, 27]. Nevertheless, the aim of an off-season period is to enable athletes to regenerate and recover after a year's cycle while the level of physical capacities is less important. Moreover, high muscle tonus characteristic of a season is not required during an off-season. Muscles with lower tonus are more relaxed and regenerate more quickly.

Some researchers – as a form of preventive measures – recommend implementing strength exercises during an off-season [28]. However, Clark et al. [29] observed that strength exercises (in this case eccentric exercises) increased bilateral strength asymmetry of hamstring muscles. On the other hand, Pattison and Hamzeh [16] did not observe any significant changes in the asymmetry of strength in long-distance runners who followed a standard programme of strength exercises. The results of those studies were confirmed in this work. Positive changes in asymmetry observed in the group performing isometric exercises were too small (ca. 1-2%) to be considered significant. Furthermore, isometric strength exercises lead to the increase in the stiffness of tendons and muscles (they increase muscle tonus) [30], which is not recommended in this period.

The lack of significant changes in the asymmetry of H/Q ratio may stem from its character, since, besides hamstring muscles, it also includes quadriceps, which were not subjected to exercises.

To sum up, unlike isometric strength exercises, the implementation of static stretching exercises helped to reduce bilateral asymmetry of muscle strength and flexibility. Therefore the assumption was that stretching exercises ought to become an indispensable part of training programmes during an off-season. They should be logically combined with other less intensive exercises. Simultaneously, optimal training solutions ought to be looked for incessantly.

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