THE IMPACT OF STRENGTH TRAINING WITH A SLOW ECCENTRIC PHASE OF MOVEMENT ON LOWER LIMB MOBILITY, SPRINT AND JUMP FOR DISTANCE PERFORMANCE

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KĽÚČOVÉ SLOVÁ: strength training, slow excentric phase, mobility, performance.

ABSTRACT

The aim of the study was to assess the impact of strength training with a slow eccentric phase of movement on the range of mobility of the lower limb joints, sprint performance and power of football players. The study included 15 men aged: 21 years ± 5, height: 175 cm ± 10, body weight: 70 kg ± 18, BMI: 22.9 ± 6.6 who train football in the senior team of the LZS Victoria Żyrowa club. The mobility of the lower limb in the sagittal plane was examined. A sprint performance test was carried out over a distance of ten and thirty meters. In order to test the competitors' power, a jump for distance test was performed. Circuit training consisting of 9 strength exercises was held once a week for a period of six weeks. The competitors' task was to perform 4 full circuits. The training program included a command to perform the concentric phase of movement at a rapid pace. In the eccentric phase, movement was to be controlled and extended. The training used showed a significant impact on increasing the range of joint mobility for football players. Muscle groups most at risk of injury like hamstrings, hip flexors, plantar flexors of the foot have been functionally stretched. The training had also a positive effect on sprint performance and increasing the player's power, tested by jump for distance.

INTRODUCTION

The contemporary sports rivalry places more and more demands on the players. Specialists investigating the demands of football players report that during a professional football match, the distance covered by a run ranges from 9700 to 13700 meters. Physical activity during a football game is characterized by a very different pace. From the observation it appears that from one second to two thirds of the match, the player is at an aerobic rate. For the rest of the game, one performs much more dynamic activities such as sprints, jumps and quick changes of direction. Due to such a high load during competition, injuries and traumas are very common. Lower limbs are the most vulnerable to injuries, especially in the area of ankles and knees. Strains and contusions of muscles usually block out playing and training for several consecutive days. More complicated injuries also occur, the most common of which are: ankle sprain, knee sprain, back thigh muscle tension and groin strain. These injuries lead to the athlete being banned from training and competition for several weeks, and in the case of serious injuries for several months (1). The correct alignment of body segments provides a well-balanced muscle performance that stabilises the joints and execution of movements, which has a crucial impact on the athlete's further career.

Restrictions on the range of joint mobility or disturbed central stabilization within the trunk can cause overload of the locomotor system and intensification of micro-injuries (2). The principle of effective performance of tasks imposed on a player is high football skills. Whereas high motoric dispositions: endurance, speed, strength and coordination are the prerequisites for a higher level of football skills. The motor preparation of a footballer for the season should start with speed development through strength to endurance. The physiological background of explosive efforts is the maximum anaerobic power, which depends on the speed, frequency and strength of muscle cell contractions limited by the functioning of the nervous and muscular system. Nowadays, the modern football game requires that endurance training be subordinated to speed and strength training and that more attention be paid to the quality rather than volume of the exercises used. The appropriate increase in strength allows players to run faster, block harder, jump higher, resist the effort of a long game and avoid injuries (1).

AIM

The aim of the study was to assess the impact of strength training with slow eccentric phase on the range of movement of lower limb joints, sprint performance and power of football players.

The following research questions have been asked:

1. Does football players have a disturbance in the movement of the lower limb joints in the sagittal plane?
2. Does strength training with a slow eccentric phase of movement help to increase the range of movement of lower limb joints in football players?
3. Does strength training with a slow eccentric phase of movement might lead to better performance in sprinting and more power for football players?

METHODS

The study consisted of 15 men aged: 21 ± 5 years, height: 175 cm ± 10, body weight: 70 kg ± 18, BMI: 22.9 ± 6.6, football players in the senior team of LZS Victoria Żyrowa. The training activity of players consisted of two training sessions per week and one match or sparring. The following tests were carried out before and after the training plan.

The examination of lower limb mobility was performed in the sagittal plane of both limbs. A goniometer was used to assess the range of limb movement. The maximum passive movement of the competitor was analyzed, except for the movement of the dorsal bend in the ankle, in which active movement was examined. This change was caused by the difficulty in maintaining the appropriate position of the competitor's limb during the examination. The sprint performance test was carried out at a distance of 10 and 30 meters. A "Witty Wireless Training Timer" was used to make an accurate measurement. In order to test the power of the athletes, a jump for distance test was performed. The measurement was made with a tape meter.

The workouts were held once a week for six weeks. The training session together with a typical football warm-up performed by the club's coach lasted about 1.5 hours. After a warm-up lasting about 15 minutes, the training was carried out in the form of a station consisting of 9 strength exercises. The competitors' task was to perform 4 full circuits of exercises with a break only when moving to the next station and for the time of waiting for the release of a given station by the previous competitors (the break time between the exercises was only about 1-2). The training load was selected individually by the competitors, who were ordered to perform 5-8 repetitions of the barbell squat and 8-10 repetitions of the remaining exercises, finishing each exercise with a minimum reserve of strength (reserve for 1-2 additional repetitions). The training program included the command to perform the concentric phase of the movement at a fast rate. In the eccentric phase the movement had to be controlled and extended (it should last about 3-4 seconds). The technique of performing the exercises, as well as the posture and position of individual body segments were constantly corrected during each training session.

Description of the training procedure

1. Barbell squat

Exercise selected because of its effect on improving the performance of a sprint and its relation to the maximum strength of the athlete (3). The player was ordered to maintain a neutral position of the spine when going down. Slow controlled movement helps to train the active flexibility of the hip, knee and ankle joint (4). Through the knees going forward in the lower phase of movement, the exercise functionally extends the soleus muscle.

2. Dumbbell row

Strong back and shoulders can help a player keep the opponent at a distance, are essential in a direct fight for the ball (1). The latissimus dorsi muscle is a key muscle for straightening the spine and increasing overall strength, through its effect on strengthening the entire torso (4). While performing the exercise, the competitor first performed the movement of the scapula retraction, and then only started the extension movement in the shoulder joint. The exercise helps to improve the posture and the particular position of the shoulders. Strong back muscles help to generate more power in the competitor (5)

3. Farmers walk

Walking with weight involves the glutees together with the torso muscles. These are important exercises for running or the rapidity of change of direction and strengthening of the body for the transmission of leg strength during repulsion and lifting. The key role in this exercise is given by the muscle quadratus lumborum, which is responsible for lateral stabilization of the trunk. Many training programs lack the weight transfer element (4). The examined contestants performed a walk with weight over a distance of 50 meters during the training circuit.

4. Romanian deadlift

Exercise to strengthen the back musculo-facial tape, in particular the lower back, the gluteal muscles and the hamstrings muscles. Strengthening these parts increases the power and speed of the player's sprint (3). Slowing down and controlling movement in the eccentric phase, while controlling the alignment of the spine, helps increase the range of movement in the hip joint. The muscles become permanently extended in the functional range, and not just for a short period of time as with classic stretching (6). In addition, studies show that strength training with a controlled slow eccentric phase significantly reduces the risk of injury to the musculo-tendinal trailers of the hamstring muscles in football players (7)

5. Decline crunches

The exercise was performed in order to strengthen the rectus and oblique muscles responsible for stabilizing the spine. If performed correctly, there appears little movement, only in the thoracic section of the spine. The wall of the abdominal wall acts as a stiff spring in most sports tasks. Its muscles are designed to stiffen the trunk in order to eliminate energy leaks for the most efficient transfer of power generated in the hips (4).

6. Calf raises

Pressing the first metatarsal bone to the ground during movement results in a stronger calf muscle performance. The supination of the back foot is controlled by the eccentric contraction of the peroneus muscles: long and short. This prevents excessive supination and protects the lateral ligament stabilisers of the ankle from damage (8). Controlled slow eccentric phase with isometric holding of movement for a second during the maximum stretch phase, will increase the functional range of dorsal bend movement in the ankle and protect the Achilles tendon from injury (9).

7. Bench barbell press

A stronger player will perform better in a direct fight, when pushing against the opponent (1). Chest, shoulder and triceps muscles may seem to be the most important for a footballer, but based on research, optimum results are achieved by strength training of the whole body, which develops symmetrically all muscle parts (10).

8. Lunges

In addition to increasing strength in a single-legged movement pattern, which is important for players, the exercise influences important parameters such as balance, proprioception, stabilization and coordination of a player (11). During the exercise, appropriate tension of the abdominal muscles helped to maintain a stable, neutral position of the spine (4). In order to achieve functional adaptation in muscle stretching and to increase injury protection, a slow and controlled pace during the eccentric phase of the exercise is essential (6). In the front of the inferior leg, we stretch and at the same time strengthen the muscles: gluteus maximus, quadriceps, semi-tendonous, semi-membranous, hamstrings. In the corrosive leg, we stretch: rectus femoris, iliopsoas, aponeurosis plantaris, partly also adductors of the hip joint

9. Hanging leg raises

During a sprint, athletes require power in the hip bend movement. Pulling the knees helps to build strength and power in the hip bending muscles. While exercising, it is important to control the position of the lumbar spine in order to protect it from excessive strain (4).

Statistical analysis

The test results were collected in an Excel spreadsheet and then submitted to the Statistica 13 software for statistical analysis. The basic characteristics were the measurable features, i.e. mean and standard deviation. Variable analysis was performed and after testing, the normality of sample size distribution was verified with Shapiro-Wilk test. Parametric and nonparametric tests were used. Statistical significance of the results was accepted at $p < 0.05$.

RESULTS

Analysis of the results of the range of movement measurements

The range of passive movement in hip, knee and ankle joints in the sagittal plane was evaluated using a goniometer. Optimal range of hip joint bending motion with straight knee proposed on the basis of R. Elson and G. Aspinall (12).

Goniometric examination revealed limitations of the range of movement in the hip joint bend at the straightened knee joint (53% of athletes), the hip joint bend (27% of athletes), the knee joint bend (27% of athletes), the knee joint flexion (33% of athletes), the dorsal joint bend (73% of athletes). There were no substandard mobility limitations in the hip joint flexion at the knee and sole flexion at the ankle joint. In joints where there was a restriction of mobility before the training program, it affected 43% of the athletes (Table 1).

The reexamination showed an increase in the range of joint mobility. The decrease in the range of movement of the joints in competitors is as follows: hip joint flexion with straightened knee joint (40% of competitors), hip joint extension (0% of competitors), knee joint flexion (7% of competitors), knee joint extension (20% of competitors), ankle joint dorsal bend (27% of competitors). 19% of the athletes after the training program was completed had mobility restrictions (Table 1).

Analysis of sprint and jumping performance results

The average sprint time at 30 meters was 4.38 (±0.23) seconds before the training program, and 4.35 (±0.23) seconds after the training program. Analysis of the results showed statistically significant differences (p<0.001) (Table 2).

The average sprint time over a distance of 10 meters was 1.874 (±0.114) seconds before the training program. The average sprint time at 10 meters after the training program was 1.840 (±0.107) seconds. Analysis of the results showed statistically significant differences (p<0.001) (Table 2).

The average distance before the training program was 2.232 (±0.194) metres and the average distance after the training program was 2.271 (±0.182) metres. Analysis of the results showed statistically significant differences ($p<0.001$) (Table 2).

DISCUSSION

The applied strength training with an extended eccentric phase of movement showed a significant impact on increasing the range of joint mobility of football players. The muscle groups most at risk of injury, i.e. hamstrings, hip flexors, sole flexors of the feet were functionally stretched. The training also had a positive impact on the performance of the sprint and increased the power of the player, tested by jump for distance.

The demands placed on modern athletes condemn their bodies to enormous strain. Lack of muscle flexibility can lead to injuries in the future. The optimum length of a muscles, which has been tested in the study, is related to its elasticity. Athletes with good muscle elasticity are more capable of overloading and less likely to be injured by a muscle (13). Past injuries in athletes can reduce tissue flexibility. Traditionally, in order to remedy this process, it is proposed to implement a programme of stretching exercises. Unfortunately, studies indicate that stretching has little impact on reducing the risk of recurrence of injury. Whereas researchers suggest eccentric training, which can improve strength, reduce the risk of injury and improve muscle flexibility (6). Evidence shows that an early stretching program for increasing flexibility can shorten the time to return to the sport, but the main advantage of stretching seems to be an increase in flexibility. The majority of studies suggest that stretching is ineffective in reducing the risk of injury, muscle pain after exercise and improving athlete performance. Increased flexibility after a stretching session takes about 30 minutes. This short-term increase is mainly due to temporary changes in viscoelasticity. A programme of stretching routinely performed for several weeks helps to improve the range of movement, but does not seem to be able to reduce the risk of injury. Eccentric training causes superstructure of sarcomers in line on animal models, increases the angle in the joint at which peak torque is generated and extends the muscle bundles. Application of eccentric training to increase flexibility would combine strengthening and stretching of muscle tissue (6).

Researchers from the Department of Clinical Therapy at the University of Limerick analyzed the research on a total of 285 people. Researchers performed a meta-analysis of research on the impact of eccentric training, eccentric-concentric training and stretching on the limb's flexibility. The measurements were related to the length of muscles, checked by ultrasound imaging and the range of movements in the joints examined by the goniometer. Training sessions in the analyzed studies lasted from 6 to 14 weeks. In order to analyse precisely the influence of a given muscle activity, equipment isolating a particular activity was used in the training, for example the eccentric movement of the muscle itself. There were differences in training in terms of number of repetitions, series, intensity, but all 6 studies showed that eccentric training increases muscle length and range of movement, regardless of the examined joint or muscle group. Coherent evidence in six high-quality studies has confirmed the hypothesis that eccentric training effectively increases the flexibility of the lower limb (6).

In conclusion, static stretching increases flexibility but has little impact on reducing the risk of injury. Eccentric training is an effective way to improve the elasticity of the lower limb by assessing both the range of movement and the length of the muscle bundles. The effect is evident in all tested lower limb muscle groups, suggesting that it is not specific to any single muscle

CONCLUSIONS

1. Football players, in spite of their high physical activity, were affected by disturbances in the range of movement of the lower limb joints in the sagittal plane. Restrictions on mobility in most players were not great, but could have a significant impact on the risk of injury and limit the maximum performance during game.

2. Strength training with a slow eccentric phase of movement seems to be an effective way to increase the range of movement of joints in football players.

3. Strength training with a slow eccentric phase of movement may help to improve sprint performance of the

players. The simple jump for distance test also showed an improvement in power in the players.

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Tables

Table 1: Mobility ranges obtained in the second study after the training programme

	HIP						KNEE				ANKLE			
	Flexion (extended knee)		Flexion (flexed knee)		Extension		Flexion		Extension		Plantarflexion		Dorsiflexion	
	L	R	L	R	L	R	L	R	L	R	L	R	L	R
1.	96° (+5)	97° (+2)	140°	140°	27° (+1)	27° (+1)	151°	150°	0°	0°	72°	71°	21° (+2)	22° (+2)
2.	79° (+5)	77° (+5)	138°	136° (+1)	22° (+3)	23°	146°	140°	IS	IS	68°	65°	16° (+4)	17° (+3)
3.	91° (+3)	90° (+4)	137° (+1)	139°	28°	29°	140°	135° (+5)	0°	0°	74° (+1)	74°	23° (+1)	24°
4.	97°	96° (+1)	156°	153° (+3)	32°	30° (+1)	149°	149°	0°	0°	71°	70°	25°	25° (+1)
5.	92°	92°	130°	135°	27°	28°	140° (+1)	140°	0°	0°	73°	54°	12° (+4)	13° (+3)
6.	84° (+4)	84° (+4)	145°	146°	20° (+2)	20°	135° (+5)	136° (+5)	0°	0°	62°	62°	24° (+4)	28°
7.	102° (+2)	105°	141° (+1)	144°	30°	30° (+2)	141° (+3)	144°	0°	0°	75° (+2)	78°	25° (+6)	31°
8.	97°	94° (+4)	150°	150°	30°	30°	145°	145°	0°	0°	72°	72°	22° (+9)	22° (+9)
9.	92° (+10)	92° (+2)	140° (+7)	140°	23° (+2)	23° (+4)	141° (+8)	142° (+7)	0°	0°	70°	70° (+1)	20° (+8)	21° (+4)
10.	74° (+4)	74° (+4)	140°	132°	20° (+8)	21° (+3)	140°	140°	IS	IS	68°	68°	21° (+2)	20° (+3)
11.	83° (+3)	83° (+3)	145°	144°	25° (+1)	25°	145°	146°	0°	0°	61° (+9)	70°	13° (+2)	19° (+2)
12.	81° (+9)	87° (+4)	140°	140°	28°	28°	144°	144°	0°	0°	70°	65° (+2)	21° (+1)	21° (+2)
13.	69° (+3)	72° (+2)	129° (+1)	129°	30°	30°	145°	145°	IS	IS	69°	68°	18° (+5)	20° (+2)
14.	110°	111°	145°	146°	40°	40° (+2)	150°	150°	0°	0°	66°	63° (+4)	22° (+3)	22° (+3)
15.	108°	105° (+3)	143° (+1)	144°	32° (+2)	33°	149°	148° (+1)	0°	0°	68° (+1)	68°	20° (+2)	20 ° (+2)

Legend: L - left leg, R - right leg, IS - incomplete straightness (no full knee joint straightness). Red indicates reduced mobility ranges compared to normal. Green indicates the improvement achieved.

Table 2: Sprint and jumping performance measurements.

	SPRINT				JUMP FOR DISTANCE PRE	
	Pre		Post			
	30 m	10 m	30 m	10 m	Pre	Post
1.	4,53 s	1,95 s	4,47 s (-0,06 s)	1,89 s (-0,06 s)	2,11 m	2,13 m (+2 cm)
2.	4,19 s	1,73 s	4,15 s (-0,04 s)	1,71 s (-0,01 s)	2,09 m	2,14 m (+5 cm)
3.	4,23 s	1,84 s	4,19 s (-0,04 s)	1,80 s (-0,04 s)	2,44 m	2,46 m (+2 cm)
4.	4,43 s	1,81 s	4,38 s (-0,05 s)	1,79 s (-0,02 s)	2,22 m	2,26 m (+4 cm)
5.	4,78 s	2,14 s	4,72 s (-0,06 s)	2,08 s (-0,06 s)	1,91 m	1,99 m (+8 cm)
6.	4,44 s	1,87 s	4,39 s (-0,05 s)	1,82 s (-0,05 s)	2,44 m	2,47 m (+3 cm)
7.	4,22 s	1,85 s	4,18 s (-0,04 s)	1,80 s (-0,05 s)	2,28 m	2,33 m (+5 cm)
8.	4,15 s	1,88 s	4,13 s (-0,02 s)	1,82 s (-0,06 s)	2,43 m	2,47 m (+5 cm)
9.	4,53 s	2,03 s	4,50 s (-0,03 s)	2,02 s (-0,01 s)	2,27 m	2,28 m (+1 cm)
10.	4,09 s	1,76 s	4,07 s (-0,02 s)	1,74 s (-0,02 s)	2,39 m	2,44 m (+5 cm)
11.	4,51 s	1,79 s	4,47 s (-0,04 s)	1,77 s (-0,02 s)	-	-
12.	4,29 s	1,82 s	4,31 s (+0,02 s)	1,80 s (-0,02 s)	2,21 m	2,23 m (+2 cm)
13.	4,34 s	1,89 s	4,32 s (-0,02 s)	1,84 s (-0,05 s)	1,83 m	1,91 m (+8 cm)
14.	4,87 s	2,0 s	4,87 s (0,00 s)	1,98 s (-0,02 s)	2,21 m	2,23 m (+2 cm)
15.	4,11 s	1,75 s	4,09 s (-0,02 s)	1,74 s (-0,01 s)	2,42 m	2,46 m (+4 cm)

Legend: s - second, m – meter. The improvement achieved is marked in green. The red colour indicates a worse result than in the previous study.