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APPLICATION OF NEW DIFFERENT TECHNOLOGIES IN STRENGTH TRAINING AND PREVENTION OF INJURIES IN FOOTBALL PLAYERS

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Abstract

On the example of 36 football players between the ages of 17 and 35 years, the research was carried out with the main goal of investigating the way of developing specific strength and power in football players, to prevent injuries and faster return of injured players to function, under the influence of adapted training exercises in top football players. In order to achieve the goals of the research, four technologies related to strength and power training were applied, namely: flywheel technology (YoYoTechnology Inc., Stockholm, Sweden), VersaPulley (Heartrate Inc., California, USA), whole body vibrations (advenor vibration machine), MuscleLabTM (Langesund, Norway). The experimental program was applied during six working weeks after four training sessions per week. The trainings were applied with a circular work method, and the respondents were placed at four stations. The results of the research indicate that the six-week experimental training program for improving strength and preventing injuries had a positive effect in increasing strength and power and reducing the percentage of injuries to the back box and tendons. Based on the obtained results, it can be stated that for a period of six weeks, in the entire sample of subjects who applied the program, there was an increase in strength and power and a decrease of muscle injuries of the back lodge and tendons.

Key Words*: football, strength, prevention, training, technologies*

Introduction

Modern soccer requires players to demonstrate a high level of functional abilities, technical-tactical efficiency, in a word, a morph functional universality so that they could act in different situations of the game, often in circumstances such as lack of time, limited space and active interference by the opponent. Hence, only a good level of motor and functional abilities ensures adequate physical preparation of football players who act effectively under conditions of high psychophysical load during the entire period of 90 minutes of the game. Recently, strength and power training as well as injury prevention training programs are becoming more and more popular for this kind of preparation of football players. Until recently, in the professional football clubs in Macedonia, too little emphasis was placed on training for strength and power, as well as the prevention of sports injuries. The reason for this fact may be the long-standing belief that strength training by increasing muscle volume reduces speed and football technique. The fact is that professional football teams in our country usually have only one fitness coach (sometimes without a full-time contract). The application of new and different technologies in strength training and injury prevention among soccer players is extremely important in working with soccer players at a high professional level. Instruments and props used for training include vibration platforms, weights, Russian bells, medicine balls, balance plates, ropes, elastic bands, tires, etc. Strength training and prevention of sports injuries includes a wide range of exercises that are performed only with the weight of one's own body. This type of training designed for football players is considered the most complete way of training, because they work on all important motor characteristics: strength, power, explosiveness, speed and endurance. It can be said that the most useful is taken from all sports and completed in a very diverse concept. In all exercises, the idea is to engage as many muscle groups as possible at the same time. The application of this type of training is a powerful weapon that, with a good combination of exercises, activates all the muscles in the body. Specifically, because of the combination of exercises that activate all the muscles in the body, this way of training and injury prevention in research has resulted in minimal side effects of muscle damage. The new

technologies that were applied in the research fit within the concept of the football game, are related to the development of the strength and power of the football players and contain the key situational activities during the match that include anaerobic type of work, with a large number of sprints, aggressive and powerful duels of an explosive character.

The research had three general goals, namely: development of specific strength and power, prevention of injuries through optimal exercise and faster return to the training process of injured players, under the influence and use of new technologies in the training process among top football players who play in the first Macedonian football league.

Materials and Methods

Experimental training program

We applied the experimental program during six working weeks after four training sessions per week. The trainings were applied with a circular method of work, and the respondents were placed at stations in groups of two players. The first two weeks we worked: three rounds at each station, with a duration of 20 seconds per station, and a break between stations of 90 seconds.

1. First station: stand with one foot on a balance board, and with the other foot hit a soccer ball with the inner part of the foot, which is passed by a teammate with a hand 2-3m away.

2. Station: alternating step with the left and right leg facing forward, under load with an elastic band, placed around the hips with a length of 3 meters

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3. Third station: TRX hamstring curls, Raising the legs to the chest from a supine position (posterior bed)

4. Fourth station: jumps on crates with a height of 30-60 cm.

The third and fourth week: we worked three rounds at each station, with a duration of 30 seconds each, and a break between stations of 90 seconds.

1. First station: Skip in a place under pressure on an elastic rope with a length of 5 meters.

2. Station: Rehearsal of a push-up and a high jump under load with an elastic band

3. Station: Hitting a 10 kg medicine ball with two hands from the mat

4. Fourth station: pulling in a sprint a sled weighing 40 kg at a distance of 30 meters

5. Fifth station: Step forward alternately with the right and left leg and twist to the left and right with a 10 kg medicine in hand.

Fifth and sixth weeks: we worked three rounds at each station, with a duration of 40 seconds per station, and a break between stations of 90 seconds

1. First station: Kneeling with a Russian bell (kettlebell) of 10 kg

2. Second station: Jump on a bench with a height of 80 cm with a vest of 20 kg.

3. Third station: Stand in a push-up with your legs resting on a balance ball, alternately pulling your knees to your chest and returning back.

4. Fourth station: 5-meter sprint with a cone touch in different directions under the load of a 5-meter elastic band.

5. Fifth station: Jumps with two legs over the groin with a height of 80 cm

6. Sixth station: Pulling an elastic rope backwards with an alternating step on the left and right leg.

Results

This research was done in FK.Macedonia Gjorce Petrov professional football club from the Macedonian first football league on 36 respondents football players aged 17-36 years.

The three main goals of this project were:

1) Developing specific strength and strength;

2) Prevention of injuries through optimal exercise;

3) Faster return to play of injured players by working on a rehabilitation program with the monitoring of a physiotherapist in the club.

To achieve these goals, we used the following technologies related to strength and power training:

- Flywheel Technology (YoYoTechnology Inc., Stockholm, Sweden)
- Versa Pulley (Heartrate Inc., California, USA)
- Whole body vibrations (advenor vibration machine)
- MuscleLabTM (Langesund, Norway)

Traditional weight training was almost eliminated from the training program. We used the traditional training with weights, only for the assessment of strength and power. This fact helped to reduce the duration of the training sessions and increase the motivation of the players.

The goal of this research is to present this experience at the highest Football level. The scientific background in the research is to describe and explain each training intervention.

2. Eccentric training: is the key to injury prevention

It is well known that eccentric muscle actions generate more force at a lower activation level and cause less muscle damage than concentric contractions do. So it is generally accepted that muscle injuries often occur when a muscle is suddenly overstretched-stretched beyond its limits. Unfamiliar eccentric exercise often results in muscle damage and symptoms that include loss of strength, soreness, and muscle weakness. It requires full recovery, then a repeated cycle of the same exercise that results in minimal symptoms of muscle damage and is referred to as the "repetition effect". The exact mechanism of this adaptation is not well defined but it is thought that there may be neural, mechanical and cellular adaptations.

It is obvious that if the tissue threshold and strength are increased, the loads are reduced and then a protective effect can occur. These are the main reasons why nowadays eccentric training is accepted as a recommended model for preventing muscle injuries. On the other hand, eccentric training treatment has been shown to be successful in the rehabilitation of chronic tendinosis. Both randomized and nonrandomized studies have indicated very good short-term clinical outcomes after performing eccentric training in both Achilles and patellar tendinopathies.

Unfortunately, the positive effects of eccentric exercise mechanisms as a treatment for tendon injuries are not well known.

Possible explanations are:

1. Increase in tensile strength
in the tendon;
2. Effect of stretching and lengthening of the tendon and reduction of the amplitude of movement in the ankle joint;
3. Visible changes in tendon pain.

Figure 1. Flywheel

2.1. Flywheel (Yoyo) technology

The accumulated experience of six weeks of work shows that players who applied regular training four times a week did not suffer any further injuries in the muscle group of the posterior box and tendons. We cannot conclude that this training program was the key factor in injury prevention, but it is supported by the available evidence. We were able to use the Multiterratana flywheel design (see Figure 2) because our players were familiar with half-squat exercises. With this training unit we avoided unwanted back injuries while working with a high level of load. It was possible to monitor the intensity of the training through a rotary encoder and a force sensor connected to ("Musclelab") which also provides real-time biofeedback. Another feature of this instrument is that it can be used to assess the strength and power of both legs.

Figure 2. Leg press in Zamaec MultiGym: strength levels are unlimited for the legs, with no load on the upper body.

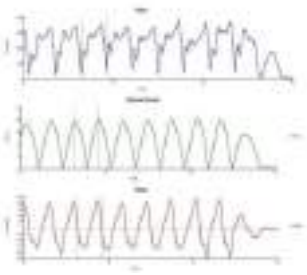

Figure 3. Intensity tracking training with the Yoyo Multigym in real time helps to increase motivation and performance.

2.2 Versa Pulley

Similar in concept to YoYo technology, variable inertia

and the unrestricted three-dimensional motions are represented by the use of a cone instead of a wheel. In this way it is possible to incorporate more complex specific movements. The intensity of the portable unit is much lower than the flywheel.

An overload of 250 to 900 N (depending on the intensity level) is obtained compared to over 900 N in the Yoyo handle when performing at maximum speed. However, the difference between the two handles is that the Versa Pulley provides high eccentric speeds at moderate to low forces while Yoyo provides high forces at moderate to low eccentric speeds. Both training concepts are needed to cover the strength-velocity spectrum.

The possibilities for exercises with the Versa Pulley are almost limitless, as with the others but the difference is in the eccentric overload that can be obtained. Important exercises for soccer players are: push-

back swings with the leg and hip for posterior box prevention, leg-behind-leg crossovers focusing on the hip adductors, leg rotations to prevent anterior cruciate ligament (ACL) injuries.

Figure 4. Left: Portable VersaPulley. Right: arm extensor exercise

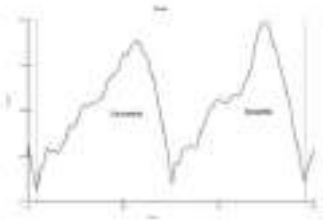

Figure 5. One-Repetition Optimum Values When Performing Hand Pulls with the VersaPulley. While the peak values are similar 800 N (conc) vs. 886 N (ecc), the RFD (Rate of Force Development) during the last 300 ms to peak force of each movement presents large differences: 498 N (conc) vs 1112 N (ecc).

2.3. Muscle band (eccentric training)

A very cheap business that can be used to perform eccentric training is called Tirante MusculadorTM.

Focusing on problem muscles such as the rectus femoris or biceps femoris can be achieved with exercises that entail active tension and stretching. The extension of the hip causes the necessary tension which is illustrated in Figure 6.

Figure 6. Eccentric exercise for the quadriceps with the "Tirante musculadorTM" which allows for hip extension and thus additional involvement of the rectus femoris.

With free weight exercises such as the squat or leg press, it is not possible to perform hip extension as shown in Figure 6. A hip extension action is required in order to achieve biarticular function of the rectus femoris. Electromyographic studies revealed similar activities in the vastus muscles when comparing this exercise to the 150 kg half-squat, the rectus femoris was activated much more. In addition, the muscle is injured disproportionately compared to the three monoarticular ones
large quadriceps muscles.

3. Whole body vibrations

In the past few years in our country we have experience with this method of work. We used a vibration platform (advenor vibration machine) which could meet our needs in the Football Clubs in Macedonia. It was very important to learn how these platforms really work. This is not a new training method; this method has been used in Russia for more than 40 years. However, until the 1990s there were few reports of whole body vibration as a training method for athletes. The whole body vibration training method consists of applying mechanical vibration to the body via platforms, cables or weights. We use vibrations with an amplitude of 4 mm and a frequency ranging from 26 Hz (for recovery) to 35 Hz (for strengthening). This platform provokes sinusoidal vibrations with a rapid and brief change in muscle length that is detected by muscle spindles, which subsequently innervate the efferent nerve fibers of the muscle. In this way, an

increase in muscle activity is usually observed with values higher than those recorded during voluntary muscle activity. This method can produce improvements in strength, power and performance similar to those seen with regular strength training.

Figure 7. Different exercises with different vibration platforms

We were able to use various features of the vibration platform. We were able to adjust the frequency of the platform to vibrate with 0.1 Hz accuracy. This is an important factor because the optimal frequencies are in different ranges for each muscle (see figure 8). Also, the small portable vibration rig provides a more unstable environment than a large commercial rig. And a wider variety of exercises can be performed, such as the "Rejection Squat" (see Figure 9). Good clinical results have been shown in patients with chronic patella and tendinopathy after performing eccentric squats on the table in a 25º decline. Another very useful exercise to achieve eccentric quadriceps action is hip extension over a platform (see figure 10).

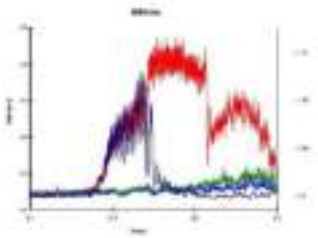

Figure 8. Increasing vibration frequency from one hertz to one second can indicate the optimal frequency for different muscles. In this example the vastus medialis peaked in EMG activity between 30 and 35 Hz while the gastrocnemius medialis peaked between 25 and 30 Hz.

Figure 9. Left: The Vibration Decline Squat. Right side vibration step.

Figure 10. Eccentric quadriceps exercise on a vibration platform.

4. Musclelab

Musclelab is one of the most complete systems found for assessing muscle behavior. It is a lightweight device that can be easily transported to the training ground. Several research groups have reported good accuracy for the device. One of the most interesting features of this device is online biofeedback. This device helps to increase motivation and even performance power. With this portable "lab", a wide variety

of dynamic and isometric muscle tests can be performed. Various sensors such as linear encoder, EMG sensors, contact mat with infrared lights, force sensor, goniometers, and so on should be used for performance. In order to know how muscle strength is expressed, the following tests are used:

-Strength, speed and power can be assessed with four to five different loads (usually 20, 40, 60 and 80% of 1RM).

It is possible to answer the following questions: What is the optimal load for each player to lift in each exercise (and according to the time of the season) based on his goal of the training? Does the player have the right muscle performance at that time? Does the player have any muscle imbalances or which limb should be repaired? Do training programs produce expected adaptations? (see Figure 11)

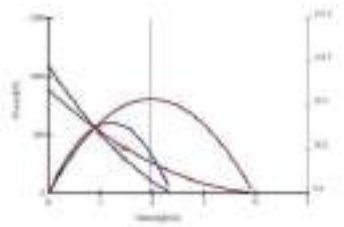

Figure 11. Force-velocity and power curves before and after 5 weeks of training at optimal training load (45% 1RM = 40 kg).

- Muscular endurance. Following the already described protocol, we can identify a complex of exercises that will avoid overtraining or any undesirable adaptations. It is also possible to determine how a player responds to muscle fatigue over time (see an example from a professional striker in Figure 12).

Figure 12. One set of training with optimal load (in this case 40 kg or 45% of 1RM)

In a professional and well-trained soccer player, 5 to 7 repetitions above the maximum force (red line) can be performed, when fatigue begins (2 repetitions below the force threshold) the training should be prepared to avoid unwanted adaptations.

-Electromyography (EMG) synchronized power supply with output.

With this test it is possible to answer the following questions: Which exercises for each player bring out the greatest activity of each muscle? What is the optimal frequency for vibration platform training?

The player receives biofeedback in real time while the way the exercise is performed can be changed, if necessary (see example in figure 13)

Figure 13. Above: EMG biofeedback while working with a YoYo leg (MuscleLab is over the table).

Bottom: Lateral rotation of the foot mainly affects the biceps femoris (left) while medial rotation mainly affects the semimembranosus (right).

-Jump tests. How much does each player jump in different situations? Flight and contact times are recorded.

Discussion

Based on the values and percentage differences, it can be concluded that the experimental treatment in the treated subjects led to significant effects. From the results shown in table 1, it can be seen that in a sample of flywheel subjects who were treated with the training program, there are significant differences between the group that did the exercises and the control group that did not apply the exercises. The comparison of injury rate (the main target of intervention) could be made between the periods August - January and February - June.

Compared to the first five months of the season, the injury rate was reduced by 38% (for all players). The incidence of injuries was 40% lower in players who did the preventive training program compared to

those who did not do any specific training from the prevention program. Missed training days due to injury were reduced even more among those players who did the prevention training program.

Current research indicates that research with this instrument has been done during the last decade. Askling et al (2003) reported that hamstring and hamstring injuries were prevented in Swedish Premier League players following preventive training with this technology. One group of players performed 16 sessions of specific hamstring and hamstring exercises during the preseason (4 sets of 8 repetitions).

Another control group did not perform any additional specific hamstring and hamstring exercises. After the end of the season, in the flywheel group there were three injuries to the hamstring muscles and tendons, and ten in the control group. Moreover, the first tendon injury in the exercise group occurred 4 months after completing the training program. In the period that followed, the players in the flywheel group significantly increased their muscle strength and their running speed over 30 m.

Any experienced coach knows how difficult it is to increase sprint speed in already well-trained players. In a study of Italian professional players by

Bosco et al (2001), 17 players applied a training program in the preseason doing 5 sessions of 90º squats (60 seconds of exercise with 60 seconds of rest in between). After one month (5 sessions at

week) players significantly increased their jumping ability and leg flexor flexibility. Unfortunately, this study did not include a control group to determine whether whole-body performance increased in the vibration treatment or other training performed during that preseason.

More relevant to specific football requirements is the study

of Berschin et al (2003). They involved a whole-body vibration program during the pre-season training of 24 professional rugby players (6 weeks; 3 sessions per week). Exercises were performed over a 5x3' squat platform with the load increasing each week to 70% of 1RM. Another group did training with the same weight (5x12 repetitions with 70% of 1RM performance was explosive).

After 6 weeks, the players who did whole-body vibration training improved their performance in any tests of jumping, speed and agility significantly more than the group that did the same weight of weights. In addition, players reported feeling more powerful and stable when performing directional changes.

Findings from the Icelandic League indicate a significant relationship between average height jump of players and team success. A trend for increasing leg strength was also found. Despite the fact that the Icelandic Football League is not fully professional, these data indicate that optimal conditioning and injury prevention programs should be a priority in modern football training (Arnason et al., 2004).

For top-level players, program intervention controls are rare. Studies on the prevention of injuries in non-professional soccer players record a percentage of reduction

between 43% and 87%. Top level players were studied by

Askling et al. (2003) who found that hamstring and hamstring injuries were reduced by 70% compared to the control group. It is unrealistic to attempt a controlled experiment at the top players.

Despite certain limitations, the research can be an inspiration for fitness and sports coaches in football teams to improve the strength to discover and prevent the weaknesses of their players, especially during fitness training in the preparatory period and individual training in accordance with the results obtained from the diagnostics during the overall annual training cycle. Coaches should have a good knowledge of the general and specific tasks that a player should perform in the game.

In football, it is strictly recommended for certain positions to select players who, with their morpho-functional characteristics, are as compatible as possible with the requirements of that playing field. The presented data can also serve as certain norms and standards for top soccer players from the point of view of research for improving strength, power and injury prevention.

Conclusions

The accumulated experience of six weeks of work shows that players who applied regular training four times a week did not suffer any further injuries in the muscle group of the posterior box and tendons. We cannot conclude that this training program was the key factor in injury prevention, but it is supported by the available evidence.

The results of the research represent valuable material for scientists, but also for coaches, experts and football analysts. Taking into account that football is one of the most popular sports in the world, when selecting talented players, tests should be used to assess physiological and motor and specific motor performance, together with anthropometric and somatotype research, the growth and development of players should be monitored. However, unfortunately with this project it was not possible to continue and

confirm the success of these statistical data on the use of the training program for the prevention of injuries in football, during several years.

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