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Original research papers

THE EFFECTS OF EXERCISES WITH ELASTIC BANDS ON SELECTED ELEMENTS OF PHYSICAL FITNESS IN MIDDLE-AGED AMATEUR TENNIS PLAYERS

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Abstract
Introduction. The purpose of this study was to assess the effectiveness of elastic band exercises programme in assisting the training of amateur tennis players. ***Material and Methods.*** Study participants comprised 22 male amateur tennis players (participating in a minimum of two training sessions per week) aged 40-60. The participants were divided into two equal groups. Subjects from Group 1 were engaged in elastic band exercises after the main training. Prior to each intervention, the movement range of the shoulder joint and the velocity and precision of the service were measured (via the ITF test). The measurements were repeated after four weeks. Group 2 (control) underwent the same measurements but they did not perform any additional exercises. Differences between the results of individual measurements were determined using the Wilcoxon matched-pairs test, and differences between the groups were determined using the Mann–Whitney U test, with a level of significance of $p \leq 0.05$. ***Results.*** Group 1 showed a significant improvement in service precision ($p < 0.001$). In Group 2, the results of both measurements were similar. Group 1 showed a lower service speed at the beginning, but after four weeks the progress was statistically significant ($p < 0.001$). Group 1 also showed a significant improvement in the movement range of the shoulder joint, albeit only on their dominant side. ***Conclusions.*** The elastic band exercises may improve the velocity and precision of the service in tennis. The use of the aforementioned method to assist in the training of tennis players seems justified.

Key words: elastic band, tennis, physical fitness, range of motion

Introduction

The nature of the game, which is tennis, causes specific physiological and mechanical loads on the musculoskeletal system. This is particularly evident in the upper limb [1]. The repeatability of the same movements in the upper limb and training the correct shot technique at each level may predispose to overload injuries in the shoulder joint [1, 2]. Full range movement in the shoulder joint is necessary to maintain proper function in the entire upper limb and has a significant impact on trauma, especially in athletes (e.g., tennis players) [3, 4]. Selected exercises for shoulder girdle muscles in full range of motion significantly contribute to reducing the risk of injury or accelerate the rehabilitation process after injury [5, 6, 7, 8]. Muscle imbalance between the upper limbs and/or limitation of the range of motion, especially in athletes using the predominantly dominant side, should be minimized through appropriate therapy and an individualized exercise program [8, 9, 10, 11].

Sports injuries involving the shoulder complex are both common and unique, and even the best specialist can find it difficult to diagnose and treat them. Most injuries occur from direct or indirect contact or are the result of repetition of the same movements. Chronic injuries are affected by, among others, the fatigue in muscles and joints, which are constantly flexed and stretched with each movement. Correct interpretation of the athlete's symptoms, history and biomechanics is the most important key to success in preventing and treating all injuries [12, 13, 14]. Certain movement patterns specific to sports are developing where, e.g., in tennis players, volleyball players or handball players, the main role is played by the upper limbs and making overhead movements requiring similar work of the shoulder complex [15]. On an ongoing basis, we discuss how to better understand the clinical problems associated with the treatment of shoulder complex injuries and it is certainly a very well developing field of science [16, 17]. Assessment, prevention and treatment of athletes with shoulder injury requires a global view of the biomechanics of the entire body. Understanding the discipline-specific biomechanics, and in the case of tennis, especially the upper limb, is most important in the injury prevention and treatment. During training, remember this and use appropriate stretching exercises [10, 18, 19].

It is necessary to determine the causes of injury to introduce the prevention strategy. A decrease in muscle strength may be one of the causes. Therefore, one of the ways to minimize the risk of injury is strength training. Sportsmen can perform different exercises to achieve progress in muscle strength (isometrics, isokinetics, etc.). Choosing the right exercises determines the effectiveness of achieving the goal. In the sports training and rehabilitation process, it is important to do exercises regularly. When a coach or a physiotherapist recommends doing exercises on your own, it is important that they are simple, without special equipment. An example that perfectly combines all these requirements could be the elastic band [20, 21, 22, 23, 24, 25].

Training with elastic bands (e.g., Thera-Band) is one of the most effective ways to increase muscle strength and muscle endurance. Elastic bands are based on the stretching properties of latex or other elastic polymers. Thanks to this, the elastic band provides resistance not only in the vertical plane, but in all planes in the full range of motion. Using these properties allows for more dynamic muscle work and avoiding sudden changes in resistance. Exercises with elastic bands seem to be particularly often used in rehabilitation and functional training [26, 27, 28, 29].

The aim of the study was to assess the impact of exercises with elastic bands on selected elements of physical fitness in 40-60-year-old amateur tennis players.

Material and methods

The study involved 22 men aged 40 to 60 who were amateur tennis players. Their training experience in tennis was at least 10 years. All participants attended tennis training sessions (at least two 90-minute sessions per week) with the same coach and realized the same training program. None of the tennis players trained anything else. Everyone worked in offices (sedentary work).

Participants of the research were randomly divided into two groups. Group 1, the study group, consisted of individuals who, after tennis training, carried out additional exercises with elastic bands. Group 2, the control group, included the study participants who did not perform additional exercises (Tab. 1).

Table 1. Characteristics of the study participants (mean value ± standard deviation)

Group	Number of subjects [n]	Age [years]	Body mass [kg]	Body height [cm]	BMI [kg/m^2]	Training experience [years]
1 (study)	11	51.72 (± 6.88)	88.49 (± 10.75)	180.5 (± 4.38)	27.19 (± 4.11)	18.33 (± 7.08)
2 (control)	11	54.75 (± 6.94)	84.61 (± 7.83)	178.75 (± 6.34)	26.86 (± 2.69)	23.04 (± 9.21)

At the beginning of the study there were 24 individuals (12 in Group 1 and 12 in Group 2), but two of them did not perform the training in the 8-week period because of illness.

Among all men participating in the research, an interview was conducted before they joined the study. It concerned existing cardiovascular and respiratory system diseases and past injuries to the upper limbs and spine which made it impossible to carry out the test. Those without the aforementioned diseases and injuries were qualified for the tests.

The full study consisted of two parts, before and after the intervention. The pre- and post-four-week schedule was performed in the same order and evaluated the same parameters.

In the first stage of the research, data from the survey on the nature of sports injury, training, lifestyle and diet were collected. The next step was to measure the range of motion (ROM) in the shoulder joint using a goniometer. The test was performed in a supine position on both upper limbs. The following movements in the shoulder joint were examined: flexion, extension, abduction, internal rotation, external rotation [30].

Subsequently, the measurements on the tennis court concerned the repeatability, accuracy and speed of the service. Before starting the measurement of the service, each of the participants was subjected to a 10-minute warm-up and 10 trial services per service side.

The service test was constructed on the basis of a modified International Tennis Federation Test. In the full ITF Test, the parameters of all basic tennis strikes were measured. For the purposes of this test, only the service test was used. Each studied person was to perform the service in four different directions, with 3 service attempts in one direction. In total, each participant performed 12 two-way service attempts in four directions (two external and two central). One attempt consisted of two services as in the match conditions (the first and the second service). If the first service did not land in the indicated zone, it was necessary to perform the second service, and if it also turned out to be inaccurate, 0 points were granted. For hitting the first service, 2 points were received, while for the second one, 1 point was granted. The fastest hit service was also registered [31].

In the second stage, individuals were randomly assigned to two groups. The first group, after the basic training, carried out a set of exercises with an elastic band [32]. The second group was the control group. The respondents from both groups did not change their lifestyle or did not perform extra exercise, i.e., they carried out the training as before the study.

The study was approved by the Research Ethics Committee of the Józef Pilsudski University of Physical Education in Warsaw (No. SKE 01-38/2023).

Statistical analyses were conducted using Statistica version 12. The scores were statistically analysed. Normality of distribution was determined with the Shapiro-Wilk test. All the results indicated that the distribution of the variables was not normal. Therefore, non-parametric tests were used. The differences between the measurements were established based on the Wilcoxon matched-pairs test, and the differences between the groups were evaluated with the use of the Mann-Whitney U test. Statistical significance was set at $p \leq 0.05$ for all statistical procedures.

Results

In Group 1 (study group), a significant progress of the results of the service accuracy test was recorded ($p < 0.001$). In Group 2 (control), despite the best result during the first measurement (14.92), a slightly higher result was observed (Tab. 2). One person in Group 2 achieved the lowest score (9 points), which could affect the final results of this group.

In Group 1, the lowest initial service speeds were observed (111.92 km/h), while the progress of the result was significant ($p < 0.001$). The respondents from Group 2 obtained similar results in the first and second measurement (Tab. 2).

Table 2. Accuracy (scores) and speed (km/h) of tennis service (mean value ± standard deviation)

Test	Group	Pre	Post	Differences
Accuracy [scores]	1	11.5* (± 2.15)	14.42 (± 2.61)	0.000
	2	14.92* (± 3.56)	15.11 (± 3.09)	0.317
Speed [km/h]	1	111.91 (± 20.43)	118.58 (± 20.77)	0.002
	2	118.55 (± 12.63)	118.08 (± 12.58)	0.778

* – $p < 0.05$ – differences between groups.

In Group 1, there was a significant improvement in the range of motion in all directions (flexion, extension, abduction, internal and external rotation) in the shoulder joints of the dominant and non-dominant shoulder (exercises were performed bilaterally). In this group, the difference between the measurements

Table 3. Range of motion of shoulder joint (°) (mean value ± standard deviation)

Group		1			2		
Measurement		Pre	Post	Differences	Pre	Post	Differences
Dominant	Flexion	172.5 (± 5.97)	175.33 (± 6.81)	0.041	174.58 (± 3.91)	174.75 (± 3.68)	0.438
	Extension	46.25 (± 6.74)	49.1 (± 8.01)	0.009	42.50 (± 6.03)	42.08 (± 5.91)	0.131
	Abduction	169.92 (± 8.46)	172.08 (± 10.22)	0.024	172.08 (± 7.25)	172 (± 7.07)	0.754
	Rotation – internal	60.17 (± 10.54)	64.67(± 10.94)	0.000	53.83 (± 10.04)	53.08 (± 10.12)	0.099
	Rotation – external	85.67 (± 5.52)	87.58 (± 3.91)	0.049	86.33 (± 6.71)	86.25 (± 7.03)	0.722
Non-dominant	Flexion	170.50 (± 7.71)	173.25 (± 8.65)	0.007	175.25 (± 3.94)	175.58 (± 4.14)	0.503
	Extension	45.25 (± 9.85)	47.58(± 9.62)	0.001	43.75 (± 6.75)	43.92 (± 6.47)	0.701
	Abduction	165.67 (± 11.01)	168.75 (± 12.41)	0.003	172.00 (± 7.07)	172.17 (± 7.1)	0.551
	Rotation – internal	59.83 (± 9.91)	64.25 (± 9.97)	0.001	60.75 (± 9.07)	60.5 (± 10.14)	0.462
	Rotation – external	82.42 (± 6.23)	84.92 (± 6.31)	0.002	86.00 (± 5.21)	86.25 (± 5.15)	0.338

was statistically significant ($p < 0.05$) in the flexion and external rotation movements of the dominant shoulder. The higher level of static significance ($p < 0.01$) was observed in extension for the dominant side, and in flexion, extension, abduction and external rotation for the non-dominant side. The highest level of significance ($p < 0.001$) concerned internal rotation for both sides. In the control group, all values of the range of motion in the shoulder joint remained constant and no statistically significant increase or decrease in these values was observed (Tab. 3).

Discussion

As in other sports, body injuries in tennis often occur as a result of overloading of the upper and lower limbs and torso. These injuries can be associated with the necessary adaptations of the musculoskeletal system. Repeatable movements cause above-average work of the same structures and their load, creating muscle imbalance. By reducing strength and flexibility, muscle imbalance can disrupt biomechanics and lead to a reduction in maximum force generation [14, 33]. Upper limb overloads and impacts are also influenced by the types of racket handles used by the player, mainly when it comes to forehand grip, because the remaining hits offer fewer possibilities of individual adjustment of the grip. Abrams et al. investigated these relationships on the example of almost four hundred non-professional tennis players. It turned out that with the "western" and "semi-western" grips, injuries on the elbow side occurred more often, while with the "eastern" grip, injuries on the radial side occurred more often [6].

Identifying the most frequently damaged parts of the body in tennis is extremely important in determining targeted preventive training. Studies show that the most frequently damaged parts of the body in tennis are lower limbs (39-65%), followed by upper limbs (24-46%) and head/torso injuries (8-22%) [8]. The most common body injuries in tennis at all ages are muscle strains and ligament ruptures occurring secondary to overloads. A particular problem arises in the group of adults starting to learn tennis, because they usually experience a lower level of physical fitness and thus weaker mechanisms of injury prevention and treatment [34].

Currently, many strategies are used to identify possible causes and minimize the risk of bodily injuries [35, 36, 37]. One of them is individually tailored physical training aimed at improving movement patterns, with the use of instruments and tools such as elastic bands. Other methods include education on injuries to players, parents and coaches, regular screening tests and properly selected tennis equipment: shoes, rackets, strings, balls and surface [33].

The accuracy and reliability of the stretchability of Thera-Bands during concentric and eccentric exercises were studied by Rathleff et al. [9]. The measurement consisted of a single movement of dissipation in the shoulder joint from 0 to 90° and was defined as "Time Under Tension", "TUT". During the exercises, the study group was to repeat the movement of the shoulder joint abduction (0-90°) 10 times at their own pace, i.e., there was no specific time in the contraction phase, but the movement had to be steady without stopping, with the maximum Thera-Band tension at the end of the movement. Rathleff's study shows the effectiveness and efficiency of elastic band exercises based on the results from the sensor placed on the Thera-Band. After obtaining the individual result of the patient from the "time of a single contraction TUT" and the result of the sum of all repetitions, it is possible to objectively create a home exercise program for the patient with the correct measurement of the weight and the number of repetitions [9].

Hughes et al. [38] also studied the properties of Thera-Band during the shoulder joint abduction exercise. In the first phase of testing, the exercise was performed actively up to at least 150° without and with a 15-pound weight. The selection of this weight was made on the basis of an estimation of the work of the strongest silver Thera-Band tape. In the further testing procedure, random Thera-Band colors were selected for each participant and the participant was tasked with performing the shoulder abduction five times with a stop at 30°, 60°, 90°, 120° and 150°. Thus, each participant made 30 repetitions of Thera-Band color. The results of the linear regression analysis presented the contraction duration curve for the average of all samples of each Thera-Band color. The lowest contraction level was recorded in yellow at 30° abduction, and the highest in silver at 150° abduction. It is therefore possible to adjust the weight based on different thicknesses (colors) of the bands. The results of this study confirm the effectiveness of the Thera-Band exercises [38].

In programming appropriate exercises to increase the range of movement in the shoulder joint with the use of elastic bands, it is also necessary to determine the effects of exercises on muscle work. Park et al. [39] studied isometric horizontal abduction with Thera-Band during three exercises: forward bending, lowering the shoulder blades and bending and straightening the arms at the wall in patients with a scapular wing. During the exercises, with the help of a superficial EMG, they recorded the activity of the pectoralis major, the serratus anterior and the ratio of these muscles to each other. The activity of the pectoralis major in the subjects was significantly lower during forward bending and bending/straightening the arms against the wall with isometric horizontal abduction than the activity of the serratus anterior. These results suggest that practicing isometric horizontal abduction with Thera-Band may be a useful and effective method to stimulate the activity of the serratus anterior muscle and reduce the activity of the pectoralis major muscle, which is the main problem in the dysfunction of the shoulder blades, but also in many problems with limited movement in the shoulder joint [39].

Currently, new methods of exercise supporting sports training and prevention of body damage are being sought. Various instruments and tools such as Gymstick, sensorimotor pillows, Swiss balls or elastic tapes are used for this purpose [40, 41, 42, 43]. The results obtained for the purposes of this study indicate that exercises with elastic tape have a beneficial effect on selected elements of strength endurance in men practicing tennis. The most crucial goal in terms of importance in reducing the risk of injury is to improve the range of motion in the shoulder joint. Symmetrical exercises of the upper limb using elastic band proved to cause the greatest progress not only in terms of movement in the shoulder joint, but also in the speed and accuracy of the service. This indicates that it is a very effective method and can be used in training and injury prevention. The improvement in service speed is probably the result of the increase in muscle strength due to the resistance properties of the elastic band. More effective muscle work during exercises in full mobility improves joint work and thus increases mobility. The accuracy of the service depends on these two factors and technical skills.

Doubts in terms of the reliability of the author's own research may be raised by the relatively low size of the group. On the other hand, it was a highly selective and uniform group with strictly defined requirements. The obtained results reliably present the dependencies of this population.

The present study was conducted in a group of 40-60-year--old men. In the future research, it would also be necessary to examine female players. The comparison of the effects of training in male and female groups would be interesting. The quality of research can also be improved through cross-sectional studies on individuals of different ages and different sports experience.

The disadvantage of the study may also be the fact that the speed measuring device is not a professional tool used during official tournaments and measurement errors are possible. It would be reasonable to use more advanced devices in the future.

The research was performed using elastic bands. These are very popular accessories for physical exercises. However, there are many other tools and devices, e.g., Gymstick, Swiss ball or floss band. It is necessary to verify their effectiveness when they are used alone or combined.

Research on training support, the identification of the risk of injuries, as well as the way in which they are prevented and treated, should be continued and carried out on a wider scale, taking into account both sexes, different age groups and levels of individuals playing tennis. A useful element would be to measure the dynamic range of motion and to use professional measuring equipment.

Conclusions

1. Exercises with elastic bands had a positive effect on the range of motion as well as the speed and accuracy of the service. It seems reasonable to use the above method in supporting the training of tennis players.
2. Training with the use of elastic bands should be used in the process of improving fitness and preventing injuries. It makes it possible to reduce muscular dystonia and improve biomechanics of the movement.
3. The obtained results constitute the basis for continuing the research with a wider study group and using more advanced research technologies and tools.

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