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Assessment of the effects of kinesiotaping on selected elements of physical fitness in middle-aged, amateur tennis players

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Abstract
Introduction. **Kinesiotaping (KT) is an increasingly popular procedure used in the rehabilitation and biological restitution of athletes.** Aim of Study. **The purpose of this study was to assess the effectiveness of kinesiotaping in assisting the training of amateur tennis players.** Material and Methods. **Study participants comprised 22 male amateur tennis players aged 40-60 years, taking part in a minimum of two training sessions per week. The participants were divided into two equal groups. Group 1 underwent muscle and ligament KT in the shoulder area. The tapes were applied four times, for seven days each time. Prior to each intervention, the movement range of the shoulder joint and the velocity and precision of the serve were measured (via the ITF test). The measurements were repeated after four weeks. Group 2 (control) underwent the same measurements but without the application of KT. 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 serve precision ($p < 0.01$). In Group 2, the results of both measurements were similar. Group 1 showed a higher serve speed both prior to and after the four-week intervention. The difference between the first and second measurements was statistically significant ($p < 0.01$). Group 1 also showed a significant improvement in the movement range of the shoulder joint, albeit only on their dominant side (with applied KT).** Conclusions. **The muscle and ligament application of KT may improve the velocity and precision of the serve in tennis. The use of the aforementioned method to assist in the training of tennis players seems justified.**

KEYWORDS: kinesiotaping, tennis, physical fitness, range of motion, amateur sport, middle-aged men.

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What is already known on this topic?
Kinesiotaping is a method practiced in supporting rehabilitation and sports training. Its originator doctor Kenzo Kase thought that the use of tapes may lead to such physiological effects as pain reduction by stimulating the nervous system, strengthening of weakened muscles, reduction of swellings or subcutaneous haemorrhages, and the correct alignment of joints.

Introduction

Tennis is a sport that can be taken up throughout the entire year. Practicing tennis requires proper physical preparation both on and off the court. Tennis is characterised by quick and energetic starts, rapid halts, repeated movements, and engagement of several groups of muscles during various strikes [1-3]. The intensity of a match varies, ranging from periods of maximal and submaximal exercise to longer periods of moderate and low exercise [4, 5].

Physical preparation for a sport needs to take into account speed, agility, strength, and flexibility [4]. Tennis is a game that involves unexpected situations, where both quick reactions and starts – defined as the 'first step' – are of crucial importance. A high-class tennis player must be exceptionally efficient at moving in all directions: forward, backward, and sideways. Tennis training should take into account these specific patterns of movement; this is why tennis players practice quick sprints and halts at a distance of approx. 20 metres [4, 6]. Strength training is as important to the proper functioning of muscles and joints as it is to preventing injuries. This holds especially true in the shoulder complex, where eccentric contraction, primarily of the muscles of the rotator cuff, i.e. the infraspinatus and teres minor muscles, perform a key role during strikes and especially during the serve. These two muscles are necessary for protecting the joint during the sudden eccentric contraction that slows down the player's movement following a serve. Appropriate strength and range of motion (ROM) in shoulder joint rotators constitute the most important factors for stability, and they decrease the risk of overuse injuries during the extreme motions required by the striking technique. It should be noted at this point that tennis induces both positive and negative skeletomuscular adaptations [6, 7]. The positive adaptations, without question, include an increase in muscle strength, while negative ones include a decrease in ROM and flexibility. The negative adaptations are accompanied by a high repeatability of the same movements and strong muscle contraction. This may result in future microinjuries of the tensed muscles followed by scars, additional microinjuries, and ultimately, a structural decrease in ROM, development of incorrect biomechanics, decrease in efficiently, and a greatly increased risk of a major injury [8, 9]. Another significant problem among tennis players are injuries of the lumbar spine, which usually result from a small ROM in this section of the spine and in the posterior muscles of the thigh (the semitendinosus, semimembranosus, and biceps femoris muscles). The decreased ROM can be explained by the low and bent body posture required in tennis. Tennis training should take this fact into account and incorporate appropriate stretching exercises [9-11]. Physiotherapeutic forms of training assistance are becoming increasingly popular today [12-14]; and one of these forms is kinesiotaping (KT).

Aim of Study

The main cognitive objective of this research was to assess the effect of kinesiotaping applications on selected elements of physical fitness in amateur male tennis players aged 40-60 years.

Material and Methods

Study participants comprised 22 male amateur tennis players ages 40-60 years, who underwent at least two 90-minute training sessions per week. The participants were divided into two groups. Group 1 (study) comprised players who underwent KT. Group 2 (control) comprised individuals who underwent no special procedure. The groups did not differ statistically in terms of age, body mass, or body height (Table 1).

Each participant was interviewed prior to the study. This interview concerned disorders of the circulatory and respiratory systems as well as past injuries of the upper limbs and the spine that would constitute contraindications to participation. Only participants with none of the aforementioned disorders or injuries were qualified for the assessment.

The full assessment consisted of two parts: before and after the four-week intervention. The individual steps for both parts were conducted in the same order. Both parts assessed the same variables.

First, data from a questionnaire were collected concerning the nature of the participants' training sessions, injuries, lifestyle, and diet. Next, ROM in the shoulder joint was measured using a goniometer [15]. The measurement was conducted while lying down, for both upper limbs. The following motions in the shoulder joint were assessed: flexion, extension, abduction, internal rotation, and external rotation.

Subsequent measurements on the tennis court concerned the repeatability, precision, and speed of the participants' serve. Prior to the measurement of the serve, each participant performed a 10-minute warm-up and 10 trial serves on the same serving court.

Table 1. Participants' characteristics (mean values ± standard deviation)

Group	Number of participants [n]	Age [years]	Body mass [kg]	Body height [cm]	BMI [kg/m^2]
Group 1 (study)	11	51.36 ± 5.13	83.36 ± 4.03	180.81 ± 5.13	25.51 ± 0.99
Group 2 (control)	11	53.27 ± 7.04	84.09 ± 8.02	178.91 ± 6.62	26.25 ± 1.69

The serve test was constructed on the basis of a modified International Tennis Federation (ITF) Test. The full ITF Test measures the parameters of all basic tennis strikes; for the purposes of this study, only the serve was assessed. Each participant was asked to perform serves in four different directions, with three attempts for each direction. In total, each participant performed 12 serve attempts on two sides of the court in four directions (two external and two central). Each attempt consisted of two serves, just as during a match (first and second serve). If the first serve failed to land in the indicated zone, a second serve had to be performed. If the second serve missed as well, zero points were awarded. Two points were awarded for a successful first serve, and one point was awarded for a successful second serve. The fastest successful serve was also registered [16].

During the second stage, participants were divided into two equal groups. Group 1 underwent muscle and ligament KT [17]. Group 2 (control) underwent no special procedure. The participants in either group did not change their lifestyle or take up additional exercise. In other words, they trained in the same manner as they had before the assessment. After the four-week training and four 7-day applications of KT (Group 1), all parameters were measured again according to the same procedure.

The methodology of KT was determined based on the original study by Shakeri et al. [18]. A complete application of KT consisted of four parts (Figures 1 and 2):

1. Y-shaped tape applied on the supraspinatus muscle: from the origin of the supraspinatus muscle (the greater tubercle of the humerus) to the insertion (the supraspinatus fossa), with a 0% tension in the tape. The participant bends their neck laterally in the opposite direction with their arm reaching the opposite hip behind their back.
2. Y-shaped tape applied on the deltoid muscle: from the origin (the deltoid tuberosity of the humerus) to the insertion (the acromial end of the clavicle, the acromion of the scapula, and the spine of the scapula), with a 0% tension in the tape. To attach one end of the tape to the internal part of the deltoid muscle, the patient must rotate their arm externally and adduct it horizontally. To attach the other end of the tape to the posterior part of the deltoid muscle, the patient must rotate their arm internally and abduct it horizontally.
3. I-shaped tape attached from the acromion of the scapula to the head of the humerus, with a 50-70% tension in the tape. The patient rotates their arm externally, flexes it at the elbow joint, and slightly abducts it horizontally.
4. Y-shaped tape on the inferior side of the trapezius muscle: from the thoracic section of the spine to the central (internal) edge of the scapula, with a 50% tension in the tape.

Data analysis involved basic statistical tools, i.e., arithmetic means and standard deviations. Differences between the results of the individual measurements were calculated using the Wilcoxon matched-pairs test. Differences between the groups were determined using the Mann-Whitney U test. The minimal level of significance was set at $p \leq 0.05$. The calculations were performed using MS Excel and Statistica 10, licensed for the Medical University of Warsaw.

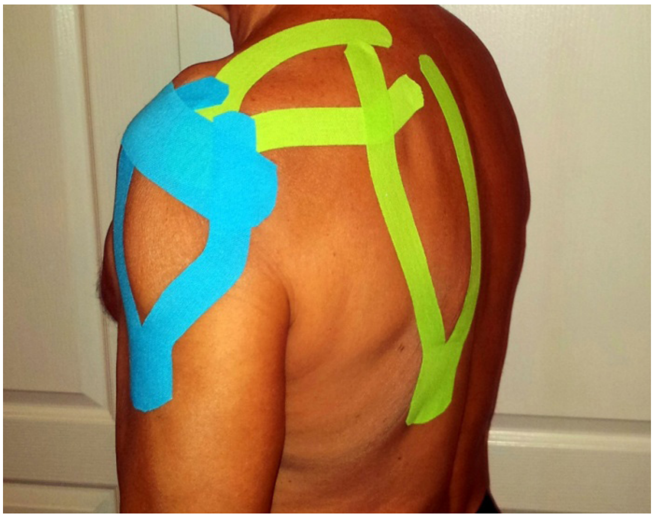

Figure 1. KT application – back view

Figure 2. KT application – side view

Table 2. Precision of serve tests [scores]

	Before	After
Group 1	12.73 ± 2.15	15.73** ± 2.61
Group 2	15.91 ± 3.56	15 ± 3.09

**p < 0.01

Table 3. Speed serve tests [km/h]

	Before	After
Group 1	128.36 ± 20.43	131.73** ± 20.77
Group 2	119.82 ± 12.63	119.18 ± 12.58

**p < 0.01

Results

Group 1 showed a significant improvement in serve precision ($p < 0.01$). The results of both assessments in the control group were similar (Table 2). One subject in Group 2 obtained the lowest score (9 points), which may have affected the final results of the group. As many as three participants from Group 1 achieved a very high result in the second assessment: two participants scored 19 points and one scored 20 points.

Group 1 displayed faster serves both prior to and after the four-week intervention (mean values amounted to 128.36 and 131.73 km/h, respectively). The difference between the first and second measurements was statistically significant ($p < 0.01$). Tennis players from Group 2 achieved similar results in the first (119.82 km/h) and second assessment (119.18 km/h) (Table 3).

Group 1 showed a significant improvement in the ROM in the shoulder joint, but only on their dominant side (with the applied KT). The greatest improvements were observed for extension, adduction, and internal rotation ($p < 0.01$). No significant differences were observed in the non-dominant limb (without the applied KT). In the control group, no values of ROM in the shoulder joint were significantly changed (Table 4).

Discussion

Tennis is a sport for all ages, and the reasons and aims for taking it up can vary considerably depending on the player's available funds, age, fitness, and personality. Regular physical exercise increases the individual's energy expenditure, causing not only a decrease in body mass, but also providing numerous other beneficial effects. The physiological effects of exercise include an increase in muscle and bone mass, a decrease in fat mass, improved glucose tolerance and decreased insulin concentration, and a decrease in the resting and active blood pressure and heart rate [4]. Playing tennis recreationally promotes an active lifestyle. However, competitive tennis and participation in professional tournaments are, unfortunately, always tied to greater strain and increased risk of injury. Injuries caused by sport-specific movements are related to overuse microinjuries and sudden acute accidents [9, 10].

Table 4. ROM of shoulder joint [°]

		Before		After	
		Group 1	Group 2	Group 1	Group 2
Dominant	Flexion	176.36 ± 4.29	175 ± 3.82	178.18* ± 3.63	174.09 ± 3.86
	Extension	40.81 ± 6.05	43.36 ± 5.5	42.91** ± 5.13	43 ± 5.21
	Abduction	175.74 ± 5.68	172.73 ± 7.24	176.64** ± 5.01	172.63 ± 7.05
	Rotation – Internal	52.36 ± 7.31	55.45 ± 8.75	55.73** ± 6.91	54.73 ± 8.68
	Rotation – External	85.45 ± 4.43	86.54 ± 7.63	86.64* ± 3.35	86.36 ± 7.35
Non-dominant	Flexion	176.27 ± 6.29	175.91 ± 3.12	176.54 ± 5.54	176.36 ± 4.29
	Extension	41.18 ± 5.23	44.64 ± 6.55	44.54 ± 3.21	44.82 ± 4.29
	Abduction	174.45 ± 5.97	172.45 ± 7.23	175.35 ± 6.09	172.54 ± 4.29
	Rotation – Internal	62.27 ± 7.03	61.91 ± 9.23	63.09 ± 7.29	61.82 ± 4.29
	Rotation – External	83.91 ± 3.78	86.54 ± 5.08	85.18 ± 3.06	86.72 ± 4.29

* p < 0.05; **p < 0.01

Tennis requires specific coordination and technical skills involving well-balanced strength, speed, agility, and flexibility. Every athlete, amateur, and trainer aims to improve their tennis skills, which can be achieved through an effective individualized training plan [5, 9]. As with many other sports, the biomechanics of tennis strikes is also analysed and refined, in order to achieve a more effective training regimen, and prevent and rehabilitate injuries [3, 19]. Together with the development of modern technologies in sport over the last two decades, interest in the application of technology and biomechanics for the benefit of athletes has increased significantly [20, 21]. For instance, Fortenbaugh et al. [19] analysed footage from special cameras to determine the relationship between the speed of the ball and body posture in baseball players. A greater ball speed correlated with an appropriate distribution of training between the pelvis and the upper trunk and a greater maximal external rotation in the shoulder joint, faster extension of the knee joints, and greater frontal bend of the trunk during a throw. A disturbance to these proportions occurring at any stage of this mechanism led to an increased strain in the upper limb [19]. Supportive and, at the same time, relatively modern methods for training and rehabilitation include kinesiotaping, as described in this study.

ROM in the shoulder joint contributes to its correct functioning in everyday activities; in sports, full values of ROM are very important in order to achieve the correct technique, limit joint strain, and prevent injuries. Decreased ROM, e.g. in the shoulder joint, may predispose an athlete to injuries in this joint by activating impingement syndrome, leading to a superior labrum anterior posterior (SLAP) tear [22].

The requirements imposed on the dominant limb during a serve are also high in terms of ROM. Dilman [23] determined that in a group of Australian athletes, the angle of maximal external rotation during the cocking phase with a 90° flexion of the elbow joint amounted to as much as 154°, and the angle of adduction amounted to 83° [23]. Such high values of ROM in the shoulder joint may lead to overuse injuries. Repeated maximal external rotation during the cocking phase produces permanent adaptations in the dominant limb. A higher external rotation in the shoulder joint may occur at the cost of weakened anterior joint capsule. The mechanism of this adaptation in tennis players may be compared to the greatly-increased external rotation in baseball players, who frequently experience anterior instability of the shoulder joint. In addition, amateur and novice tennis players show technique compensations in the form of an increased pronation of the forearm, which leads to increased internal rotation during a serve. This compensation not only incorrectly increases the topspin rotation of the strike, but it also generates a higher strain on the posterior muscles of the rotator cuff during the follow-through phase when the external rotators contract to counteract the internal rotation of the arm following the strike [24].

A kinematic analysis of ROM required for a correct strike found high rotation values of the head of the humerus. Several studies also assessed active ROM, and ROM of the shoulder joint. Chandler [25] measured the active ROM of internal and external rotators at a 90° adduction in the shoulder joint in young tennis players [25]. The results of these measurements indicated a significantly lower range of internal rotation in the dominant limb compared to the non-dominant limb. External rotation was non-significantly higher in the dominant limb. Similar results were obtained by Ellenbecker [26], who measured internal and external rotation with a 90° angle of adduction and stabilisation in the spatula. Significantly higher ranges of external rotation in the dominant limb were observed only in men, albeit both sexes had a significantly lower range of internal rotation in the dominant limb than in the non-dominant limb [26].

A clinical trial conducted by Thelen et al. [27] indicated that KT positively affects the ROM limited by osteomuscular pain in the shoulder joint. However, any measured, statistically significant, improvement only lasted up to three days, thus reducing the relevance of the method. These results may indicate that the potential benefits of KT are limited to an increase in the painless ROM in the shoulder joint directly after application. The reduction in the pain may be related to the gate control theory of pain, as the tape stimulates neuromuscular pathways by increasing input feedback. The immediate improvement in the ROM may stem from the fact that in this case, KT helps direct a person's movement in the shoulder joint, which decreases the mechanical irritation of the related soft tissue structures. Of doubtless importance here is the placebo effect, which may in theory assist the entire process. In sum, as indicated by Thelen et al., most participants who underwent KT reported an improvement and did not need further rehabilitation within four weeks following the study [27].

Djordjevic et al. [28] compared both mobilisation with movement and mobilisation with KT to a supervised exercise programme in patients with shoulder joint pain. The mobilisation with movement was based on Brian Mulligan's concept: a manual therapy technique wherein the therapist manually sustains a specific glide in a painful joint while the patient actively performs a movement in the same joint. If the performed movement is painless, the positioning for the specific glide is considered appropriate. Mobilisations of this type are based on the analysis and correction of even the slightest positioning errors in the joint, which, according to Mulligan's theory, occur due to minor damage to the bone tissue around the joint [29, 30]. Incorrect positioning in a painful shoulder joint causes small but significant changes in the anteroposterior translation of the humerus during arm lifting in persons with impingement syndrome. KT used alongside this method allows for more intense stimuli with regard to the position of the joint and proprioception [31]. The aforementioned study lasted 10 days, after which both groups showed an improvement in the ROM of the painful shoulder joint, albeit the group who underwent mobilisation and KT displayed these effects more often and quicker. Researchers believe that a concurrent application of the two methods may prolong and intensify their outcome, as both methods aim to achieve the same effect in terms of the correction of joint position. This study confirmed that KT may assist joint structures, reduce soft tissue inflammation, and decrease pain. Through its effect on the sensorimotor system and proprioception, it may help control posture, position the scapula, and support the weak muscles of the rotator cuff and the deltoid muscle, e.g. in hemiparetic patients with shoulder joint subluxation [28].

The results of the collected studies indicate that, despite the many years since the initial development of KT, there is no straightforward evidence that the method is effective as a part of long-term therapy and the assessment of its effects is very subjective. However, the more studies that are conducted on the subject in the future, the better our understanding of the matter will become [32-37].

The results of this study indicate that selected applications of KT have a beneficial effect on selected elements of special fitness in male tennis players. The most significant aim as far as reducing the risk of injury is improving the ROM in the shoulder joint. The improvement in serve speed occurs likely as a result of an increase in muscle strength due to the resistive properties of the elastic tape. More effective muscle work during full-mobility exercises improves joint work, thus increasing mobility. Serve precision both depends on these two factors and on players' technical skills.

KT may also to some extent affect the precision and speed of serving and ROM, as confirmed by the results of this study. Serve precision was the variable that showed the greatest improvement, which may be due to the fact that the tape tangibly supports a person's movements through its effect on the skin and soft tissues. The improvement in serve speed was in this case dependent not on muscle strength, but rather on greater relaxation and the functioning of the muscles within a higher ROM. Another significant factor in KT is its psychological influence, which is very frequently taken into account when assessing the effectiveness of the method [38-40]. Needless to say, tennis is a game in which an athlete's effectiveness depends not only on their physical fitness, but on their mental endurance and ability to concentrate as well. Positive expectation greatly affects serve performance, the effectiveness of which shows the highest correspondence with psychological factors. These positive expectations may have significantly contributed to the much-better end results achieved in the group who underwent KT.

The low sample size and the fact that only men participated in this study may cast doubt on the reliability of this study. However, the sample was uniform and selected with great care according to strict requirements. The obtained results reliably reflect the characteristics of this population.

Research on assisting training, identifying the risk of injury, and methods of preventing and treating injuries should continue on a larger scale and encompass both sexes, different age groups, and skill levels of tennis players. Measuring the dynamic ROM and using professional measurement equipment would prove useful in these pursuits.

Conclusions

Applying KT to muscles and ligaments may improve the speed and precision of serves in tennis players. The use of the aforementioned method to assist the training of tennis players seems justified.

This study proved the usefulness of KT in contributing to an improvement in the ROM of joints. The muscle and ligament techniques of KT may assist tennis players in their training.

The obtained results form the basis for further research with greater sample sizes and using more advanced technologies and research tools.

What this study adds?

Kinesiotaping (especially muscle and ligament applications) can help improve the quality of movements. Therefore it may be an element of injury prevention in amateur players practicing health training.

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