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Physio training as important part of education of young tennis players

Authors' Contribution:
A Study Design
B Data Collection
C Statistical Analysis
D Manuscript Preparation
E Funds Collection

Ewa Waldzińska

Faculty of Health Sciences, Lomza University of Applied Sciences, Lomza, Poland

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Abstract

Background & Study Aim: Developmental trends in tennis require coaches to engage in comprehensive work with players from the early stages of training. It is important to note that in a long-term training program for young athletes, in addition to teaching technique and tactics, attention should be given to the motor development of the players. Furthermore, in order to ensure the holistic development of young athletes and injury prevention, it is essential to incorporate medical training based on exercises that improve joint stability, kinesthesia, and neuromuscular coordination into the sports training process. The aim of the research is the broaden knowledge of physio training in the of young tennis players.

Material & Methods: The study included 54 tennis players aged 10-12 years. The participants were divided into two subgroups. The first group (n = 27) underwent physio training according to a yearly training program that was developed. The second group (control, n = 27) did not participate in the program and continued their training according to previous assumptions. Three sensorimotor tests assessing proprioception of the lower limbs, upper limbs, and spine were used in the study. Both groups underwent the sensorimotor tests twice, before the start of the training and after one year of training with the physiotherapist.

Results: The analysis of the research results showed that physio training improves joint functionality in all participants involved in the exercise program. In the group of tennis players who underwent the sensorimotor training cycle, neuromuscular coordination significantly improved.

Conclusions: The proprioception tests conducted served to monitor the effectiveness of the physiotherapist's training with the tennis players. It is recommended that sensorimotor training be an integral part of education (sports training) in tennis.

Keywords: injury prevention • joint functionality • kinesthesia • neuromuscular coordination • technique

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Author's address: Ewa Waldzińska, Faculty of Health Sciences, Lomza University of Applied Sciences, 14 Akademicka Str., 18-400 Lomza, Poland; e-mail: ewaldzinska@al.edu.pl

Proprioception – *noun* awareness of the positions of the parts of the body in relation to each other, or of your own body in relation to the position of others [25].

Kinaesthesia – *noun* the fact of being aware of the movement and position of parts of the body [25].

Training session – *noun* a period of time during which an athlete trains, either alone, with a trainer or with their team [25].

Innovative agonology – is an applied science dedicated to promotion, prevention and therapy related to all dimensions of health and regarding the optimization of activities that increase the ability to survive from micro to macro scales [19, p. 274].

INNOAGON – acronym 'innovative agonology' [20].

INTRODUCTION

The activities of an athlete, especially at a professional level, involve the risk of sports injuries, micro-injuries or musculoskeletal overload. The extent of this phenomenon is so common across sports that it is sometimes said that 'sport is a hotbed of sports injuries'. However, it is not only athletes who are at risk of injury. In addition, there are ailments that are associated with a lack of exercise [1, 2].

Tennis is a discipline that requires all-round motor preparation of the player. The specific features of the game are constant movement, sudden changes of direction, sudden braking and acceleration over a short distance. Tennis is a technically complex sport. It is a game in which an interval effort of a speed and power nature prevails. The specifics of the game and related training require from players a variety of skills, including highly developed conditioning and coordination of motor skills and mental predispositions. [3, 4].

The demands on tennis players are increasing, as a dynamic and offensive style of play is preferred. For this reason, the course of match action is definitely increasing in pace and intensity. These trends and a number of other pressures make it fundamental to have the right level of preparation for a tennis player right from the early stages of training [5-7].

The modern drive to maximise performance in competitive sport is, in a sense, the essence of sporting competition. Exhaustive competition can contribute to various types of injuries. Therefore, injury prevention, the provision of professional first aid is of utmost importance [8-10].

Forced training of a tennis player's technical and tactical skills insufficiently supplemented with motor preparation and sensorimotor training may lead to overloading of the musculoskeletal system, micro-injuries. This may cause chronic injuries, which exclude the tennis player from competition for a long time (in extreme cases, exclude him/her from further career).

Current developmental trends in tennis place high demands on coaching staff, indicating the need to work comprehensively with the player from the early stages of training. Hence, the inclusion of specialised exercises to improve kinaesthesia in the training plan will minimise or exclude musculoskeletal overload, micro-injuries and sports injuries. Currently, some sports medicine specialists associated with the practice of tennis are of the opinion that this type of training is a prerequisite for success (understood more broadly than sport performance) in the modern game on the court [8, 9, 7, 10]. This view can be extended as a directive befitting any sport: sensorimotor training should be an integral part of sports training because, in addition to influencing performance, it also, above all, significantly reduces the risk of injury.

The aim of the research is the broaden knowledge of physio training in the of young tennis players.

MATERIAL AND METHODS

Participants

The study involved 54 tennis players aged 10-12 years training in clubs in the Podlaskie Province (Poland), divided into two groups: A (experimental, n = 27) implemented physio training as a complementary element of the annual training programme; B (control, n = 27) implemented a training programme based on previous assumptions developed at the club.

Study design

The evaluation of the effectiveness of sensorimotor training with adolescent tennis players was based on three sensorimotor proprioception tests of the joints of the lower limbs, upper limbs and spine. In both groups, sensorimotor tests were performed twice: before the start of training, and after the players had worked with a physiotherapist for one year.

The annual physio training plan for the tennis players was 90 hours. The classes were led by a qualified physiotherapist. The players' sensorimotor training load varied and was driven by the training period. The physiotherapist aimed to improve the deep sensation of the lower limb joints, upper limb joints and spinal joints of the tennis players using, among other things, elastic bands, sensorimotor cushions and rehabilitation balls. Mobile and unstable surfaces were used in training (e.g. barefoot training). Exercises with so-called 'closed kinematic chains' were mainly used, respecting the principle of graded difficulty.

Initially, these were exercises in isolated positions and static training. After mastering the skills of the first stage, static training with the inclusion of an unstable base was used, followed by dynamic training also with an unstable base. In the final stage of exercise, dynamic training with unstable ground and lower and upper limb movements was included. In addition, proprioception exercises with elements of coordination exercises were used in the physio training. Tennis equipment was used in the training to recreate match situations. Sensorimotor exercises conducted using the circuit training method were incorporated into the training cycle.

In addition, based on a survey (questionnaire recommended by the Podlaskie Voivodeship Tennis Association), data was collected on the injury severity of adolescent tennis players in both groups. The questionnaire included questions about the length of playing experience, tennis training load (including the number of tennis tournaments played) and other types of physical activity Questions also concerned the health status of the athletes, past injuries, if any, microinjuries and their recurrence. The tennis player interviewed also answered questions about injury prevention measures taken.

Proprioception tests and way of conducting them

(1) proprioception of the lower limbs and trunk while sitting on a rehabilitation ball
Starting position: sitting on a rehabilitation ball (ball diameter 55 cm); feet hip-width apart, with the head of the torso forming a straight line, hands on hips.

Movement: straighten one leg at the knee joint. Hold the position for 10 sec. Keep the pelvis stable, not allowing the pelvis to move while straightening the knee. At the same time, attention is paid to the symmetry of one side of the body in relation to the other.

Evaluation criteria: answer 5 variants of the question (concerning the right and left side of the body separately) – *is it possible to straighten the knee joint:* a) without rotation of the pelvis? YES/NO; b) without pelvic tilt? YES/NO; c) without lateral tilt of the trunk? YES/NO; d) without lateral trunk tilt? YES/NO; e) without shoulder line asymmetry? YES/NO.

(2) active lateral support
Starting position: lying sideways, forearm supported, elbow bent at 90°, forearm in intermediate position, hand pointing forwards; other hand resting on hip; legs joined, bent at hip and knee joints, feet on ground.

Movement: lift the hips off the ground combined with straightening the legs at the knee joints; active support lying sideways maintaining a neutral pelvic position in a straight line with the legs and torso; hold the position for 10 seconds.

Evaluation criteria: answer 5 specific questions (concerning the right and left side of the body separately) – *is it possible to:*;a) do transition from lying on your side to active side support? YES/NO; b) perform the test without rotation of the trunk and pelvis? YES/NO; c) perform the test without lateral torso bending? YES/NO; d) perform a scapula withdrawal test in the supporting limb? YES/NO, e) perform the test without rounding the thoracic segment? YES/NO.

(3) External rotation of the arm loaded with the elastic band
Starting position: elastic band interlaced through a post at shoulder height, ends of the band held in the hands; Standing in a small straddle, head and back form a straight line, shoulders visited to a 90° angle, elbows bent forward, set at shoulder height; keep shoulder blades in an intermediate position between retraction and extension and elevation and depression; distance from the point of suspension of the elastic band is 4 foot lengths; holding the band 'pick up the slack' (slight tension).

Movement: slow 90° external rotation movement with one arm. Upright position should be maintained for 10 seconds; back in neutral alignment; thoracic region and pelvis facing forward (do not allow rotation in the trunk and pelvic joints).

Evaluation criteria: answer 7 specific questions (concerning the right and left side of the body separately) – *is it possible to perform the test*: a) without bending the back? YES/NO; b) without bending the back? YES/NO; c) without rotation in the upper thoracic region in relation to the pelvis? YES/NO; d) without lifting the scapula? YES/NO; e) lowering of the blade? YES/NO; f) without lowering the elbow and extending the head of the humerus forwards? YES/NO; g) without twisting or tilting the head? YES/NO.

Statistical analysis

The data analysis presented in the figures is based on the proportions of observed empirical variables of groups A and B, taking into account research methods and periods. The empirical variables presented in the table are based on the identified frequency (n) of events (location of damage to body parts). The ordinal variable is the summed number of events (starting with the largest) in the annual tennis training cycle. In the case of an identical number of events, identification is based on the same ranking position (RP), but the alphabetical order of the name of the body part where the injury was located applies.

RESULTS

On the first testing date, the adolescent tennis players correctly performed movement tasks with the right lower limb in 62% and 94% after completing the one-year physio training programme (group A) in 94%. Similar results apply to the left lower limb: 60% and 90% respectively. The results of the same test of group B show a slight improvement in the tested bodily functions. In the first term, the correct performance of the right lower limb motor task was 64% and in the second term 77%. The result for the left lower limb was similar, respectively: 62% and 75% (Figure 1).

The results of the active support test lying sideways confirm the significant improvement in the tested body functions of the tennis players in the experimental group (A). Before the experiment, the correct performance of the movement task, concerning the right side of the body, was 60% and after physio training it was 90%. A similar progression concerned the left side of the body: 59% positive responses and at the second testing date 88%. In group B, there was a slight improvement in performance, corresponding to: 57% and 64% (right side of the body) and from 59% to 67% for the left side of the body (Figure 2).

There was a significant improvement in the results of the *external rotation test of the arm loaded with the elastic band* for the right side of the body of the tennis players in the experimental group: from 61% of the movement task correctly performed to 88% as a result of physio training. Similar proportions of results for the left side of the body: from 59% to 83%. The results of the tennis players in group B show a slight improvement in both the right side of the body (from 60% to 71%) and the left side (from 57% to 70%) (Figure 3).

During the pre-experimental study, micro-injuries, and musculoskeletal strain, mainly of the joints and soft tissues of the dominant upper limb (5 cases), were found among tennis players in

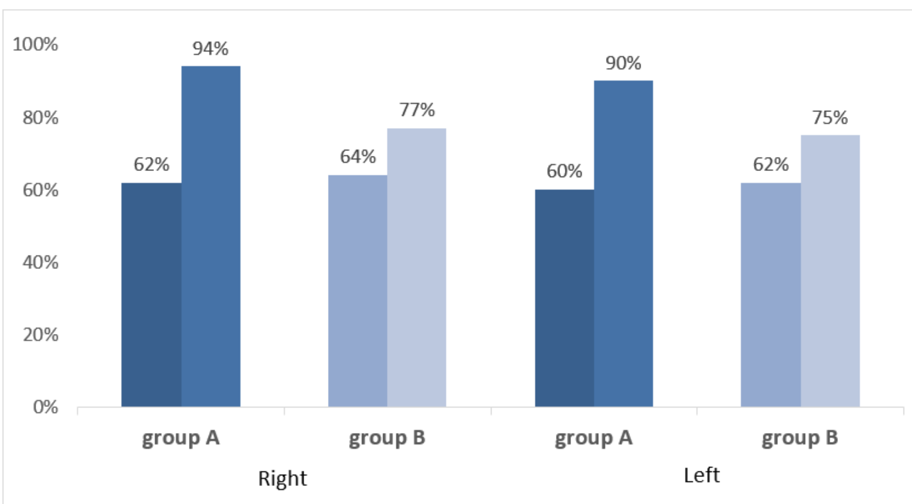

Figure 1. Results of *proprioception testing of lower limbs and trunk in a sit-up* on a rehabilitation ball before and after one year of training of juvenile tennis players (in each pair of columns, the order is: I and II examination).

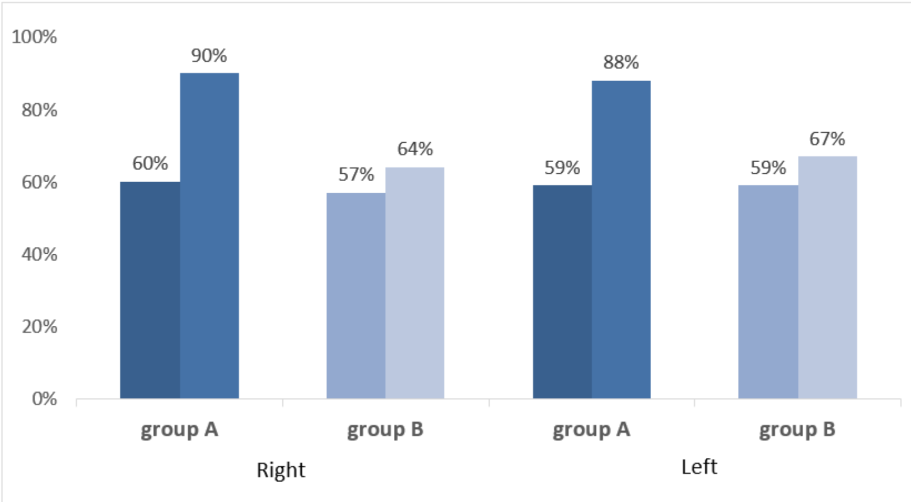

Figure 2. Results of *the active support test lying* sideways before and after the one-year experiment ((in each pair of columns, the order is: I and II examination).

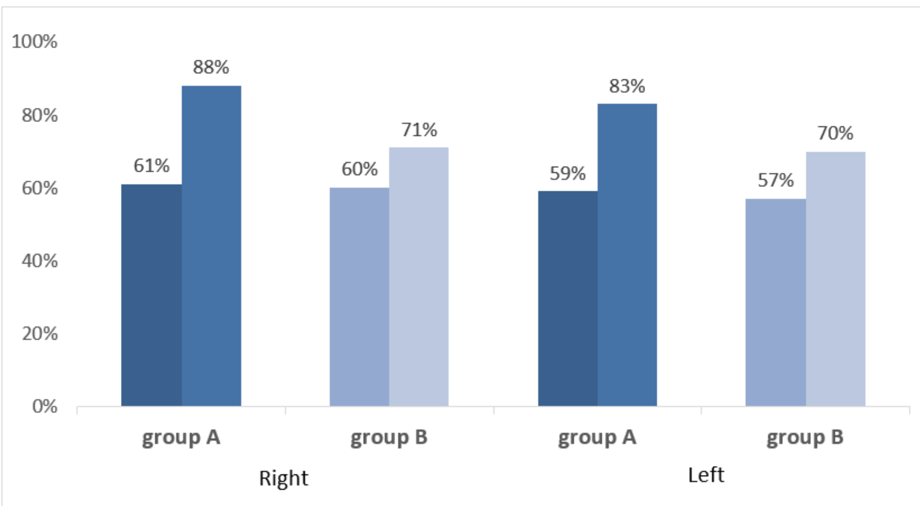

Figure 3. Results of *the external rotation test of the arm loaded with the elastic band* before and after the one-year experiment (in each pair of columns, the order is: I and II examination).

group A. A single case of ankle sprain, and patellofemoral joint strain were reported. The extent of injuries related to soft tissue pain, muscle pulls, and sprains. In contrast, among the tennis players in group B, single cases of overload of the joints of the dominant upper limb (3 cases), overload of the ankle joint area (2 cases) were shown. The results of the second survey showed a reduced number of musculoskeletal overload incidents among tennis players in group A (2 cases of musculoskeletal overload located in the dominant upper limb), while group B again had single cases of overload of the joints of the dominant upper limb (3 cases), overload of the area of the ankle joint (2 cases) and a new case of overload of the patellofemoral joint.

The most common location of injury was in the shoulder joint, while the least was found in the knee joint. The generalised results of the pre – and post-experimental questionnaires clearly demonstrate the effectiveness of physio training (Table 1).

Table 1. Injury rate of the tested tennis players before and after the experiment.

Body injuries			First test		Second test		Sum of results		
RP	**injury location**	**limb**	**A**	**B**	**A**	**B**	**A**	**B**	**total**
1	shoulder joint	right	3	1	0	1	3	2	5
		left	0	0	0	0			
2a	ankle	right	1	1	0	1	1	2	3
		left	0	0	0	0			
2b	elbow joint	right	1	1	0	1	1	2	3
		left	0	0	0	0			
2c	wrist joint	right	1	1	0	1	1	2	3
		left	0	0	0	0			
3	knee-joint	right	0	0	0	0	1	1	2
		left	1	0	0	1			
	Total		**7**	**4**	**0**	**5**	**7**	**9**	**16**

DISCUSSION

Tennis is a very popular sport, practised on all continents from an early age. Thanks to the scalability of equipment, i.e. the use of age-appropriate racquet and court sizes and ball types in sports training, children as young as pre-school age can begin their tennis adventure [11].

However, tennis is a sport characterised by significant asymmetry in body loading, which can lead to muscle imbalances and postural problems. Playing tennis on a regular basis requires numerous and repetitive movements that place strain primarily on one side of the body, which can lead to overload and injury. Significant asymmetry in tennis affects both the upper and lower body. Service, forehand and backhand strokes lead to unequal stress on the muscles of the arm, shoulder and spine. In addition, short-distance running and sudden changes in direction generate loads on the knee and hip joints, which can lead to overuse and injury [12].

Abadi et al. [10] show that the incidence rate (IR) of musculoskeletal injuries is relatively high at 30.8 injuries per 1000 player hours. Understanding the characteristics of the injury and associated risk factors can help to develop a prevention programme and identify risks in future tournaments, especially those played in tropical climates [10].

In a study by Minghelli and Cadete [13] performed on a group of 218 tennis players aged between 9 and 72 years (the measurement tool was a questionnaire on population characteristics and aspects related to injury epidemiology), 86 athletes (39.4%) reported an injury over a 12-month period (107 injuries in total) and 76 athletes (34.9%) over a six-month period (95 injuries in total). There were 3.49 injuries per 1,000 hours of tennis training. The most common injuries were joint injuries (29.5%), followed by tendinopatie (22.1%), located in the ankle (20%) and wrist (15.8%), both resulting from exploitation (23.2%). Tennis players who trained three or more times per week were 2.29 more likely to be injured (95% CI: 1.28-4.13; p = 0.006), those who trained more than 4.5 per week were 2.04 times more likely (95% CI: 1.16-3.60; p = 0.013), elite tennis players were 2.81 times more likely (95% CI: 1.41-5.59; p = 0.003), and those who trained more frequently on the ground court were 4.11 times more likely to be injured (95% CI: 1.46-11.55; p = 0.007). In the sample analysed, observational data revealed a high incidence of injury for tennis players, with joint injuries being the most common type, with the most affected body area being the ankle and wrist joint [13].

This empirical reasoning underlines key mission of the physiotherapist in the prevention and treatment of injuries associated with the asymmetrical nature of tennis. Through individual assessment and analysis of a player's movement, physiotherapists can identify muscular and biomechanical imbalances, and develop training and rehabilitation plans that help maintain 'muscle balance' and avoid injury. In addition, under the care of a physiotherapist, players can work on muscle strengthening and stabilisation, balancing body load and improving movement technique to minimise the risk of injury. In addition, physiotherapists can help select the right sports equipment and track the body's progress and adaptation to training [14].

There is a consensus in the literature on injury among tennis players regarding the need to implement appropriate exercises in training plans to prevent sports injuries. However, it has not been clearly established which exercise routines are most effective [13, 10]. Królak emphasises that due to the increasing number of injuries in modern tennis, it is necessary to prepare and implement effective training programmes for tennis players with a physiotherapist from the early stages of training [12]. Specialised proprioception (sensorimotor) training to improve joint stabilisation and kinesthesia will reduce the number of sports injuries and at the same time maintain training continuity [15, 16].

Methods assessing deep sensory performance, i.e. proprioception, are still not very accurate and are still imperfect. They are unable to determine whether the exercises used in sensorimotor training increase the number of mechanoreceptors in joint structures and muscles. On the other hand, some scientific studies confirm an improvement in the degree of deep sensory and kinaesthesia abilities when appropriate behaviour is included in the training plan. However, it is not clear whether these abilities increase as a result of an increase in the number of mechanoreceptors, or through strength gains or improved motor coordination. It is scientifically confirmed that the use of sensorimotor training has a positive effect on explosive strength gains, improved neuromuscular control, joint function and balance ability. In addition, scientific evidence shows that sensorimotor training can be used successfully for injury prevention in many sports disciplines [15-18].

The analysis of the results of our own research is testimony to the fact that, using simple diagnostic methods and appropriately selected exercises based on physiotherapeutic knowledge and practice (in fact, appropriate physio training sessions), the expected preventive effects can be achieved. However, in discussing these results, I emphasise the importance of two, in my opinion, innovative elements from the perspective of injury prevention in all human physical activity.

Firstly, the validity of precise language in communication in the relationship: coach÷athlete and athlete's social environment; coach ÷ physiotherapist; physiotherapist ÷ athlete etc.; training practitioners ÷ scientists and scientists among themselves. In the language of the new applied science – innovative agonology (acronym INNOAGON [19, 20]) – term 'development' is only used in positive connotations [21, 22]. Secondly, the momentous discovery of Kalina et al. [23], changes the motor paradigm in the earliest period of ontogeny, when the child experiences the first difficulties of maintaining vertical posture – toddlerhood. The authors conclude this finding with these words: '(...) the most obvious implication of this finding is the need to move away from the paradigm of «toddlerhood and pre-school motor development». According to the scientific facts, an adequate name for this stage of ontogenesis is «the first period of positive and negative changes in human motor skills already at toddlerhood and pre-school age»' [23, p. 222]. In my opinion, this discovery will soon change the approach, not only of teachers of particular sports, to stimulate a child's motor skills in a modern way before they lose the phenomenal ability with which the vast majority is born with. A phenomenon that definitely starts to increase in the fourth calendar year of life. The authors describe this discovery in simple terms: '(,...) an increasing number of children, every time they fall backwards, expose their upper limbs and, to a lesser extent, their head to damage during a collision with the ground, and only a few retain the ability characteristic of the majority of two-year-olds (under these circumstances, they always protect their upper limbs and head in such a way as to avoid colliding these parts of the body with the ground ...). Thus, this phenomenon is organic in nature and the [fun form of falling] FFF-based method of revealing it makes it possible to diagnose it as early as toddlerhood' [23, p. 222].

Therefore, being aware of these scientific facts, in this thesis I did not use the term 'development', but spoke about the changes caused by the innovative 'physio training' method.

Although collapses are not common occurrences in tennis [24], some end in loss of life. One of the most famous occurred during the junior semi-final of the US Open on 10 September 1983 between Patrick McEnroe (John's younger brother) and Stefan Edberg, later winner of six Grand Slam tournaments. After Edberg's serve, the ball hit 61-year-old line judge Richard Wertheim. Experts ruled that it was not the impact of the tennis ball, but the fall and hitting his head on the court surface that caused the umpire's death. Other recent: On 4 February 2020 in Kathmandu, Nepal, 15-year-old tennis player Kent Yamazaki, during one of his practices before an ITF Grade 5 tournament, fell over on the court and hit his head on the ground; despite the quick response of the emergency services, the boy died a short time later in hospital.

CONCLUSIONS

The proprioception tests conducted served to monitor the effectiveness of the physiotherapist's training with the tennis players. It is recommended that sensorimotor training be an integral part of education (sports training) in tennis.

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