A Comprehensive Review of Physical Fitness in Junior Tennis Players

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Abstract

Physical fitness is an essential part of tennis performance. This article is a review of physical preparation for junior tennis players that underlines the importance of physical fitness and its role, including speed and agility, strength and conditioning, resistance training and flexibility. The importance of physical training in today's game of tennis is highlighted by methodological, scientific and practical considerations that are considered to be the main ones in the physical training of those who practice modern tennis at all levels

The most important conclusion after the review of the five articles was that there is a significant change in average height and weight. During the junior period, junior athletes are considered a distinct group whose physical development is subject to significant fluctuations, with periods of rapid growth and change during adolescence.

Keywords: *physical preparation, tennis, physical testing, specific junior preparation*

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1. Introduction

Physical preparation is considered one of the milestones of success in tennis, especially for young players. A well-developed physical program enhances athletic performance, prevents injury and enhances overall preparation. This review will examine the key components of the physical preparation of junior tennis players, including speed and agility, strength and conditioning, resistance training and flexibility. The importance of the physical training in today's game of tennis is highlighted by methodological, scientific and practical considerations that are considered to be the main ones in the physical training of those who practice modern tennis at all levels, namely: the high level of scientific information worldwide; gradually establishing a practical physical training approach that should begin with the analysis of official game statistics; considerable efforts to equip the sports halls, gyms and courts with simple and easy to use facilities; the worldwide elevated status of international tennis competitions, where top champions contribute significantly, underscores and validates the importance of tennis academies. These institutions incorporate valuable strategies and tactics that enhance the physical training of tennis players. Basic parameters are the tendencies of the total offensive character of the game, with the fundamental aspect of athletic training. A correct evaluation of the

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performance can be checked in official games as well as in training. The development of motor skills and physical training in tennis ensures, through this complex process, the biological and functional substrate of the effort required by the competition requirements.

Enhancing performance represents one of the key goals of engaging in sports, aiming to maximize this improvement. The junior years serve as the foundation for the upcoming senior years.

The junior stage of tennis players starts with national tournaments, followed by international ones. The most valuable players can occupy a decent ranking after transitioning to seniority. So, it is a fact that tennis players need good physical qualities to execute complex strokes and compete efficiently against elite opponents.

Raid and Fernandez (2012) highlighted tennis as an anaerobic sport, characterised by short, intense bursts of energy interspersed with periods of low-intensity activity. This particularly happens in Grand Slam matches, especially the demanding five-set men´s matches, which can last up to five hours. This sport´s physical demands include rapid changes in direction, acceleration and deceleration, as well as repeated high-intensity strokes of varying duration, averaging around 90 minutes.

Previous research has indicated that tennis players require a diverse range of physical attributes, including speed, agility, strength and endurance, to achieve high-level performance.

Under these circumstances, this paper aimed to find the most relevant conclusions that set the standard in the physical performance of young tennis players.

2. Findings. Identifying the Key Problems

Junior tennis players' physical preparation faces several challenges that hinder their development and as well as physical performance. Some of the primary issues identified in the recent literature are hypermobility and flexibility issues.

Some of the young players exhibit hypermobility, which can lead to a lack of stability around the joints. Further, this condition increases the risk of injuries such as tendonitis or muscle tears due to joint dysfunction. On the other hand, players may have reduced flexibility, limiting their range of motion and affecting physical performance. A balanced approach to flexibility training should be essential to prevent injuries and enhance athletic performance.

Another issue identified among junior players is the lack of a solid foundation of strength. Many young athletes do not follow adequate strength training, which is decisive for injury prevention and overall athletic development. Without a foundational strength, players may struggle to cope with the physical demands of the sport, which leads to injuries as well as decreased performance levels.

Another problem is that many times, athletes learn incorrect techniques during training, which can have long-term consequences on their physical

development and performance. If a player learn an incorrect technique, it becomes challenging to correct it later on. Proper coaching and structured training programs are important to ensure that young players develop the correct movement patterns from the start.

Another problem is the inappropriate load of the training or the state of overtraining. Junior players frequently face issues related to overtraining or lifting weights that are too heavy for their age or development level. This can lead to physical burnout and injuries. It is critical for the training problems to be age-appropriate, gradually increasing weight and intensity while allowing enough recovery time.

Many young athletes engage in general fitness training rather than tennis-specific exercises that address the unique demands of the sport. Training should include specific movements that mimic on-court actions, including agility drills and plyometric exercises designed for tennis. A structured approach to flexibility and recovery is often overlooked by junior players. Regular mobility exercises before practices and matches, along with an appropriate recovery routine post-exercise, are essential for maintaining muscle length, preventing stiffness, and enhancing overall performance. Addressing these issues through adequate training programs that emphasise strength, proper technique, flexibility, sport-specific conditioning, and recovery can significantly improve the physical preparation of junior tennis players.

3. Discussion

Looking at the publications from recent years regarding world literature, specific to physical training, it can be noticed that this is a current topic. To reach the top, players now require not only strong technical and tactical skills but also exceptional physical preparation.

3.1 The first reviewed study subject was „Testing the fitness of tennis players. How valid is it?", which aimed to study the effects and effectiveness of an individualized database for a dedicated fitness training program specialized for junior tennis players. The kids were aged between 12 and 18 years. This study has been performed by the German Tennis Federation. The evaluation tests helped to examine the motor capacities of junior players with different performance levels, both in the laboratory and on the field. They concluded that field methods are much more effective than laboratory ones. If tennis players are tested at different times of the year, an individual profile can be obtained. The purpose of this study was to describe and evaluate different physical tests that have been recommended by institutions such as national tennis federations and specialists in the field.

The following age categories U12, U14, U16 and U18 took part in the evaluation tests. For each motor quality test, another sample, female or male, was used from one of the previously mentioned categories. They used aerobic endurance testing, where accepted laboratory tests were selected to measure aerobic power. The field tests were used to assess anaerobic resistance, endurance and strength testing,

and speed and skill testing.

A significant increase in average height and weight is observed in male players starting with U16 players. For instance, the average height and weight increase from 1.60 m and 47 kg at U14 to 1.74 m and 60.2 kg at U16.

Regarding strength and power, there's a notable increase from U12 to U18, particularly evident in grip strength, which rises from an average of 21.6 at U12 to 49.8 at U18. While there is minimal difference in performance between U12 and U14 (for example medicine ball throw = 10.90). In terms of endurance, a steady increase is observed, with the average time rising from 12.4 s to 17.7 s.

For endurance speed testing, it has been observed that in tennis, the use of semi-specific tests (MMST, Yo-Yo, IR and 30 15 IFT) seem to be a good recommendation, however, there is little scientific evidence supporting their use in tennis, particularly in the context of tennis-specific physical demands. It also must be mentioned that in all the tests presented, the running distances, the movement characteristics, and the muscle groups involved still offer considerable differences compared to the specific tennis profile. The cumulative duration of the sprints was deemed adequate, especially when correlated with the fastest time recorded. Therefore, the 20m sprint can be considered a suitable measure of speed, given its practicality. However, additional research is required to establish its reliability and validity.

One problem with resistance and strength testing is that functional activities have angular velocities that are far beyond the capabilities of isokinetic assessment techniques. Furthermore, they are only part of the assessment and rehabilitation process.

So, there must be other endurance measurements that should be included in the testing procedures of tennis players. The speed and agility of tennis players is a problem, as tennis is a complex sport related to movements and there are only a few studies that analyse the speed and agility components of players, so it has been difficult to present specific tests. Based on the results obtained by using the presented fitness tests, the most suitable tests for junior tennis players were identified.

3.2 Another study, entitled " In-season effect of a combined repeated sprint and explosive strength training program on elite junior tennis players, " published in Strength and Conditioning Research on February 29, 2015, aimed to investigate the impact of combined explosive power training (ExpS) combined with repeated sprints (RS). This training was performed twice a week on the performance (jumping ability, sprint, and repeated sprints) of junior elite tennis players during the competitive season. Sixteen players ranked within the ATP and participating in international tournaments took part in this eight-week study and training program.

The objective of the study was to determine the combined effect of explosive power (ExpS) with repeated sprint training (RS) in elite youth players and to determine whether it could lead to substantial improvements in neuromuscular performance. Eight male tennis players were assigned to an experimental group (TG) and another eight to a control group (CG). Both groups were tested before and after

an eight-week specific conditioning program.

The average age of the participants was 16.9 years, with an average weight and height of 74 kg and 180 m. All players were ranked between 120 and 280 on the International Tennis Federation (ITF) junior tour. The experiment took place during the early summer competitive season, from April to May. To familiarize the players with the testing procedures, a full training session was conducted one week prior to the pretest. Pre- and post-tests were administered on separate days, with a low-intensity training session in between. The participants did not have cardiovascular or pulmonary diseases.

Both the experimental group (TG) and the control group (CG) underwent the following evaluation tests: 5-meter sprint, repeated sprint ability (RSA) test, vertical jump test, and maximal aerobic test. Following the 8-week training experiment, significant improvements were observed in sprint, jump, and RSA performance (p-values between 0.56 and 1.12), except for RS test ($p = 0.72$) and maximal aerobic performance ($p = 1.0$).

Although the effects might be somewhat more visible if working separately on these motor skills, the results obtained in this study show that the inclusion of a combined program seems to be an effective tool to improve neuromuscular performance, such as single jumps and sprints and repeated sprints, for players with a high level of training. However, previous research on these two motor skills, which has been carried out separately, shows that a combined training does not have the same beneficial effect. These improvements seem to be clearly related to the concept of training specificity, emphasizing that in complex sports such as tennis, motor skills need to be treated separately, therefore athletes require specific training sessions that should be part of their training program.

3.3 The study written by Ching-Ching Hiang, Jong-Chang Sai, and Jinn-Yen Chiang with the title "An analysis of specific fitness tests for female junior tennis players" was presented at the International Conference on Biomechanics in Sport, in Tsukaba, Japan and was published on 18.07.2016.

The experiment involved female junior players with an average age of 15.7 + -1.1 years. The subjects completed a questionnaire containing information about how the experiment would be conducted, their injury history and information about the training they were doing.

3.4 The UTSA fitness testing protocol (Bemstein, 2008) was utilized in this study. This protocol uses five stages of motor skill assessments: anthropometric measurements, muscular endurance and general endurance tests, strength, flexibility, speed and agility tests. According to the USTA competition training manual, each of these five motor qualities is classified into four distinct levels. These can be classified as excellent, good, medium or needs improvement.

The selected subjects did not suffer any injuries in the past 6 months. The testing procedure started after 20 minutes of individual warm-up, which consisted of

low intensity stretching forward, lateral running and jumping with increasing intensity. In between the tests the players did not have breaks. Testing started with measuring the body dimensions of the players. Grip strength, measured with both hands, was assessed along with resistance tests (one-minute trunk flexion, medicine ball throw, vertical jump, forward trunk bend, hexagon test, and spider test). Mean and standard deviation were calculated for each test. The grip force (7.8%) and hexagon test performance (11.1 ± 1.3 seconds) were rated as excellent. Push-up performance was rated as good.

3.5 Torres-Luque indicated that 80% of a player's movement on the playing surface had a radius of 2.5m, 10% 2.5-4.5m, 5% over 4.5m radius. On average, a player moves 3 m per shot and between 8-12 m within each point. In one out of three matches, players make, on average, between 300 and 500 high-intensity movements. According to the results of this study, flexibility but also speed, and agility need to be improved. Adequate flexibility helps players execute those wide shots, achieve quick changes of direction, and hit volleys from almost any low position. Players can work more on mobility. It was also recommended that they work more on the speed and agility side to enhance their acceleration and deceleration ability. Hence, they concluded that from the normative values of the fitness tests, national-level players should work more on flexibility, speed and agility. Coaches and fitness trainers can make individual profiles of players based on their strengths and weaknesses. This would lead to a more effective design of the physical training program.

3.6 The research conducted by Sue D. Barber-Wistin , Alex Hermeto and Frank R. Noyes titled "A six-week neuromuscular training" which was published in the Journal of Athletic Enhancement on 15.12.2014, aimed to analyze the effect of tennis-specific training on neuromuscular and athletic performance indices of junior tennis players.

One of the objectives of this study is to examine the impact of a program that combines components of a knee ligament injury prevention program with other exercises to improve athletic performance. The second is to improve single-limb dynamic balance, correct lower limb asymmetry, increase speed and agility and improve endurance. Forty-two players aged 14 to 16 participated in the six-week program, which was led by certified tennis coaches. The players who participated in the study had a minimum of two years' experience on the professional circuit. The tools used for testing were the single-leg long jump , triple jump, basic speed and agility tests, forehand and backhand tests, sprint lap around the tennis court to the net and back, abdominal endurance tests and a neuromuscular training program. The experiment was carried out as follows: three days before the first day of training and 3 to 5 days after the last day of training, the athletes were subjected to a series of field tests under the supervision of a coach. The tests were previously used to determine the speed, agility, dynamic balance and abdominal strength of junior tennis players. The tests were videotaped and used to educate players on the following: knee flexion, lower limb alignment, lower limb work and stroke

mechanics. Looking at the statistical analysis of the training program, it can be observed that the tests indicate, improvements in the running test to the net and back, with differences of -2.51 ± 1.18 seconds (-4.54 - 0.30). Another good result of the training program can be observed in the abdominal endurance test and backhand from the baseline with the following results: 74 seconds ± 75 (-14-396) effect size 0.94, 0.7 ± 0.7 (-1.0-2.0) 0.88 and 3.5 ± 3.8 (-5.0-10.0) with effect size of 0.85 seconds.

The study data show improvements between baseline and final test for each program. Statistically significant improvements were found for both the agility and abdominal endurance tests after the first, second and third training programs. The proposed six-week training program brought significant improvements in speed, agility, dynamic balance and abdominal endurance in junior tennis players.

3.7 Another study, with the cooperation of Jaime Fernandez-Fernandez, David Sanz, Jose Manuel Sarabia and Manuel Moya, titled "The Effects of Sports Specific Drills Training or High-Intensity Interval Training in young tennis players" was published in the International Journal of Sports Psysiology and Performance on 02.08.2017. The aim of this study was to compare specific exercise training combined with interval training (HIT) with training containing only specific exercises. It was hypothesized that if the specific exercise training is combined with interval training (HIT), it will result in clear improvements in motor skill levels over specific exercise training alone. They aimed to observe whether there are significant differences in aerobic performance using a mixed program.

Twenty well-trained tennis players with an age of 14.8 ± 0.1 years, a weight of 63.8 ± 7.1 kg and a height of 174.7 ± 4.8 cm, of which 16 were right-handed and 4 were left-handed players, participated in this study. The players were ranked in the top 50 players nationally in singles (U15), trained 15 ± 2 h/week and with a training background of 6 ± 1.2 years, who focused on specific tennis training (i.e., technical and tactical skills), then aerobic and anaerobic training (i.e., on and off-court exercises) as well as core training. The experiment was conducted over 8 weeks.

The tennis exercises consisted of two 16-22 minute sets of exercises on the tennis court, separated by 3 minutes of passive rest, while the MT consisted of a specific exercise session and an interval training using 16-22 minutes of intense running at 90-95% capacity, correlated with the speed obtained in the 30-15 intermittent fitness test (VIFT). These two were separated by a 3 minute passive rest. In relation to the procedures used, it is mentioned that the tests were performed before and after training. They measured: maximal oxygen uptake (VO2 peak), LIFT, speed (20 meters (m), divided into distances of 5 and 10 m), agility test and the jump called counter mouvement jump (CMJ). When a significant difference was found for the main effect, a post-hoc Bonferroni analysis was performed. SPSS V.20 was used for statistical calculations. Effect sizes were calculated and interpreted in terms of >0.2 (small), 0.5 (moderate) and i>0.8 (large). Statistical significance was set at the $P < 0.05$ level. Even though both training programs resulted in significant improvements in aerobic performance, a mixed program combining VIFT-based

tennis drills and running led to greater gains and should be considered the preferred training method for improving aerobic power in young athletes.

3.8 Another study conducted named "Impact of fitness characteristics on tennis performance in elite junior tennis players" written by Alexander Ulbricht , Jaime Fernandez-Fernandez, Alexander Ferrauti and Alberto Mendez-Villanueva was published in April 2016 in the Journal of Strength and Conditioning Research and it aimed to test and verify whether the level of motor skills are related to the competitive level of the players. The second objective was to compare the level of performance between the national team and the regional players. More research is needed as physical research related to performance is not well understood.

The study was conducted between 2009-2012 on a sample of 902 male and female tennis players in Germany. They were part of the national and regional selection group and were assessed by using a series of standardized anthropometric and physical performance tests implemented by the Deutsche Tennis Bund (DTB) at the national level. Players from all federations in the country were selected and tested. The study was conducted over 6 years and included boys as follows U12 n=126, U14 n=225, U16 n=165 and girls U12 n=97. As previously mentioned 2 groups were used, regional along with national. The first group, called the "regional team" consisted of the most talented players from each region selected by the regional federation based on their technical or tactical skills and competitive performance. At regional level, 755 players were selected, of which 287 girls and 468 boys. From the national team, a total of 147 players participated in the study, 78 boys and 69 girls.

The tools used for evaluation measured grip strength, vertical jump, 10 and 20 meter sprint test, serving speed, overhead, left and right medicine ball throw and finally the Hit and Turn test.

Protocols were conducted over a 3-week period starting at the end of September. Testing sessions were undertaken between 14:00 and 20:30. To ensure standardization of test administration throughout the study period, all tests were performed in the same order using the same operable test devices. All reliability tests were conducted on an indoor tennis surface (Rebound Ace surface, temperature, 24.4-26.48°C, relative humidity, 54.4-61.0%, Kestrel 4000 Pocket Weather Tracker, Nielsen Kellerman, Boothwyn, PA, USA). Testing began after a 15-minute individual warm-up, which consisted of multidirectional forward, sideways, and backward acceleration, jumping and sliding exercises, and jumping and sliding jumps of increasing intensity. The physical performance tests that they performed were carried out in the same order of their description (anthropometric measurement, grip grip strength, counter modern jump [CMJ], 20 m sprint, tennis specific sprint [TSS] [MBT], serving speed and tennis specific endurance test [tennis hit and return test]). The recovery time between the different tests was at least 3 minutes. Independent sample t-tests were used to determine differences between national and regional players in anthropometric and physical performance characteristics. In addition, the standard difference, or effect size (ES), of the variation in each parameter between the national and regional groups was calculated using the

cumulative standard deviation. The threshold values for Cohen's ES statistics were 0.2 (small), 0.5 (moderate) and 0.8 (large). Spearman rank correlation ratios were used to determine the relationship between the performance variables (0-0.1), small (0.1-0.1), small (0.1-0.3), moderate (0.3-0.5), large (0.5-0.7), very large (0.7-0.9), almost perfect (0.9) and perfect.

As for the statistical results, these were observed in the serving speed of the national players with a result of 120.60 + -8.7 and the regional players with a result of 112.24 + -9.19, so a significant difference of 8.36. Significant differences can also be observed in MBT overhead, forehand and backhand segmental strength (cm) with a difference of 19.81, 50.82 and 35.63 and an ES of 0.23, 0.49 and 0.35. Statistically significant differences were observed between group levels (i.e., national and regional), and selected female and male national players exhibited better levels of performance, mainly in the most predictive physical characteristics (i.e., serving speed, MBT strength, and tennis-specific endurance).

Aerobic endurance levels (i.e. maximal oxygen uptake, V-O2max) are important in tennis because oxidative metabolism helps replenish energy sources during a match, allowing players not only to perform explosive actions repeatedly (e.g., shots and movements on court) but also to ensure rapid recovery between repetitions, especially during long matches. In this respect, values above 60 m reported in elite tennis players seem to confirm the importance of having a medium to high aerobic capacity.

4. Conclusions

Following the reviewed literature, starting with U16 juniors, there has been noticed a significant change in average height and weight (14-15 years old) leads to a decrease in player's performance followed by a rebalance after the age of 16, thus the physical, and technical, tactical and psychological preparation of the athletes must be treated very carefully during this period.

It has been shown that women have a higher heart rate than men. This happens due to longer ball exchanges and actual game time.

Young athletes are a distinct group whose physical development is subject to significant fluctuations, with periods of rapid growth and change during adolescence. This can make it challenging for coaches to differentiate between true performance enhancements and the effect of the maturing process.

Exclusively in tennis, reaction time, quickness of the first step, the speed over short distances, the capacity to quickly change direction and lateral movement are undeniable determinants of performance. Tennis players spend about 48% of their time moving laterally.

Acceleration is an important component in many sports, including tennis. Quickness and speed in lateral movement (4-5 m), as well as the ability to rapidly cover short distances, are essential for returning the ball and efficiently positioning oneself for the next stroke.

In-game differences between the heart rates have been observed, with the server having a significantly higher heart rate than the receiver. At the start of junior

year, one should already consider planning the tournaments, usually within one year in advance.

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