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ORIGINAL ARTICLE

Comparison of the effects of isoinertial and traditional strength training in male tennis players

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Abstract

The goal of the research was to determine the effects of six weeks of isoinertial training on explosive strength, speed, and agility compared to traditional strength training in tennis players. The subjects, thirty male tennis players aged 20 to 35, were divided into three groups: the experimental group 1 (E1; n=10), which performed strength training on an isoinertial device; the experimental group 2 (E2; n=10), which performed traditional strength training; and the control group (C1; n=10). E1 and E2 groups had a total of six weeks of training with two training sessions per week, with three exercises per training session performed in four series for six to eight repetitions. The results showed that isoinertial strength training has a positive effect in the variables squat jump (SJ), countermovement jump (CMJ), 5-meter sprint (5M), 20-meter sprint (20M), agility T-test (T-test), and 505 agility test (505). Post hoc analysis revealed that there are significantly better effects of isoinertial training compared to isodynamic training in the countermovement jump (CMJ), 5-meter sprint (5M), and 20-meter sprint (20M). The E1 group had significantly better results than the C1 group in all tests. The E2 group had significantly better results compared to the C1 group in the variables SJ, 20M, and T-test. The results also show that six weeks of isoinertial training produce better results in the development of variables CMJ and 20M compared to the traditional strength training group. Accordingly, fitness and tennis coaches should also use this training method when working with tennis players.

Keywords: strength training · tennis · isoinertial training · eccentric training · flywheel

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Introduction

Tennis belongs to the group of technically complex sports that require strong conditioning, technical-tactical, and mental preparation from the athlete (Fernandez-Fernandez et al., 2009). It is a sport characterized by short movements of high intensity during a variable time period from 3 to 15 seconds. There is no clearly defined duration of the match, with an average time of 1.5 hours (Kovacs, 2006). However, some matches last up to 5 hours (Dobos et al., 2021). Canós et al. (2022) state that competitive tennis is becoming more and more dynamic, requiring faster reactions during the game.

Although strength and conditioning programs in tennis typically emphasize predominantly concentric exercises (Barber-Westin et al., 2010; Behringer et al., 2013; Mainer-Pardos et al., 2024), most specific tennis movements involve large numbers of accelerations and decelerations at the joints that require both concentric and eccentric changes in muscle length. For example, tennis strokes involve a clear transition from eccentric muscle contraction to high-speed concentric contraction. Thus, most determinant tennis movements involve a succession of eccentric contractions immediately before the concentric phase, taking advantage of the elastic rebound tendency of muscle tissue in what is known as the muscle stretch-shortening cycle (SSC) (Behringer et al., 2013, as cited in Canós et al., 2022). The strength training method that addresses this importance is known as isoinertial flywheel training, a method that offers the possibility of overloading the eccentric contraction (Petré et al., 2018). The concept of isoinertial training using flywheel devices has been developed in the recent past, and the first evidence supporting its effectiveness as a conditioning method dates back to the early 1990s (Berg & Tesch, 1994). Flywheel exercises were initially proposed to alleviate neuromuscular dysfunction and concomitant musculoskeletal atrophy in astronauts caused by the absence of gravity during long-duration space travel (Dudley et al., 1991; Norrbrand et al., 2008). Since then, many studies have been conducted to examine the effects of isoinertial training on strength and power (Canós et al., 2022; Sagelv et al., 2020; Stojanović et al., 2021), jump performance (Canós et al., 2022; di Cagno et al., 2020; Stojanović et al., 2021), sprint (Canós et al., 2022; Raya-González et al., 2021; Stojanović et al., 2021; Westblad et al., 2021), change of direction (Stojanović et al., 2021), and injury prevention (De Hoyo et al., 2015) in the sports population.

A meta-analysis by Maroto-Izquierdo et al. (2017) concluded that flywheel isoinertial training with overload is superior for muscular hypertrophy, maximal strength, and power compared to traditional strength training. However, to the best of our knowledge, just a few studies examined the effects of isoinertial training on tennis players. One of them (Fernandez-Fernandez et al., 2023) evaluated the effects of isoinertial training on shoulder function, and one analyzed the effects of isoinertial training on shot precision and upper body strength (Centorbi et al., 2023), while two other studies (Canós et al., 2022, 2023) compared the effects of machine-based and flywheel training methods on physical performance in young tennis players. Canós et al. (2022) found that both training methods improve lower body strength, short sprinting, and agility after four and eight weeks. Slightly greater results were observed in countermovement jump for the flywheel training group compared to the machine-based group, while from week 4 to week 8, sprint and agility results decreased in the flywheel training group.

Even though there are studies that have analyzed how isoinertial training affects lower body strength, speed, and agility, they have focused on young tennis players. Therefore, this study aims to investigate the effects of six weeks of isoinertial training on explosive strength, speed, and agility compared to traditional strength training in male tennis players aged 20 to 35.

Method

Sample

A total of 30 male tennis players, aged 20 to 35 years, were included in this study. All participants were informed about the experimental procedure and agreed to participate in this study, according to the Helsinki Declaration. The following eligibility criteria have been implemented: (1) they train tennis for a minimum of 3 years; (2) they train regularly; (3) they have 4 tennis training sessions weekly; and (4) they don't have any acute injuries. The sample was randomly divided into three groups, two experimental groups, and one control group: the E1 group (age: 24.90±5.59 years; height: 182.90±4.25 cm; weight: 73.40±10.23 kg) which performed strength training on isoinertial device; the E2 group (age: 25.80±6.18 years; height: 184.30±8.19 cm; weight: 74.30±9.56 kg) which performed traditional isodynamic strength training with free weights; and the C1 group (age: 26.60±6.15 years; height: 185.40±9.00 cm; weight: 74.30±11.58 kg) that did not perform strength training.

Sample of measuring instruments

All the testing and training procedures were conducted at the sports facility of tennis club Crvena Zvezda, in Belgrade, during March and April of 2022. The measuring sample consisted of two anthropometric tests: body weight and body height; two lower-body explosive strength tests: squat jump (SJ) and countermovement jump (CMJ); two speed tests: sprint on 5 m (5M) and sprint on 20 m (20M); and two agility tests: t-test and 505 test.

Body height. A stadiometer (SE206, Seca, Germany) was used to measure body height. Measurements results were read with an accuracy of 0.1 cm.

Body weight. A digital scale was used (BEUER BF700, Germany), with an accuracy of 0.1 kg.

Squat jump. The subject stands sideways to the wall, on which a centimeter scale was installed. The subject stands upright for a few seconds, then lowers into a half-squat position with an angle of approximately 90 degrees between the thigh and the lower leg and holds this position for two seconds, after which the subject performs a maximal vertical jump, trying to touch the centimeter scale on the wall as high as possible with the dominant hand, from which the result was recorded. The test was performed twice, with a one-minute break between tests, and the better result was recorded. The jump height was measured in centimeters.

Countermovement jump. The Sargent jump test was used to assess countermovement jump. The subject stands sideways to the wall, on which a centimeter scale was installed. The subject stands upright for a few seconds, then lowers into a half-squat position until the angle between the thigh and lower leg is approximately 90 degrees, and immediately, without stopping, performs a maximal vertical jump, trying to touch the centimeter scale on the wall as high as possible with the dominant hand. The test was performed twice, with a one-minute break between tests, and the better result was recorded. The jump height was measured in centimeters.

5- and 20-meter sprint. The testing has been carried out on a clay tennis surface. The subject starts from a high start position approximately 30 cm away from the starting line and runs the 20-meter distance at the maximum possible speed. The time is measured using 3 light gates, placed at the starting line, at 5 meters, and at 20 meters (Microgate-Witty, Italy). The result recorded is the time the subject achieves in the 5-meter and 20-meter tests. The subject performed the test twice, with a one-minute break between tests, and the better result was recorded.

T-test. The participant takes a position about 30 cm in front of the starting line and from a high start runs to cone 1, touches it with his hand, and then moves to cone 2 by side-stepping in the most natural stance, then in the same manner moves to cone 3, touches it, and returns to cone 1. After touching cone 1, they run backward to the finish line. Light gates are set up at the start to measure the participant's result. The test was performed twice, with a one-minute rest in between, and the better result was recorded.

505 agility test. The participant is in a high start position 30 cm in front of the start line. A participant runs 15 meters, crosses the marked line with one foot, turns around, and runs another 5 meters. The time is measured (using the light gates placed 10 m from the goal), for which the subject ran the 5 m section from the light gate to the line, turned 180 degrees, and ran another 5 meters. The test is performed twice for right and left directions, with a one-minute rest in between, and the better result is recorded.

Testing procedure

Initial testing and familiarization with the exercise protocol were conducted 48 hours before the first training session, while the final testing was done 48 hours after the last training session. Testing was performed in the morning hours. Before testing, every participant did a standardized warm-up, which consisted of running for 5 minutes, followed by a set of various mobility and flexibility exercises.

Training procedure

Experimental groups E1 and E2 performed 2 training sessions per week, for 6 weeks. Group E1 performed exercises on isoinertial trainer (K-Box, Bromma, Sweden), while group E2 performed the same exercises but with free weights. Both groups performed the same three exercises: half squat, Romanian deadlift, and Bulgarian split squat. Group E2 performed each exercise for 4 sets with 6 to 8 repetitions. For the E1 group, each set of exercises on the isoinertial device began with 2 attempts at a lower intensity for familiarization with the exercise, with the range of motion, and then continued with 6 to 8 repetitions with maximal effort. The load for every participant was determined during the initial testing for both the E1 (isoinertial device) and E2 (free weights) groups, which also served to familiarize the participants with the program.

Statistical analysis

Statistical analysis was performed in statistical software SPSS, version 20.0. Descriptive statistics were calculated for every variable. The Shapiro-Wilk test was used to examine if data is normally distributed. A paired t-test was used to identify differences between initial and final measurements for every group. A mixed model repeated measures ANOVA (3 groups x 2 time points) was used to identify differences between the groups under the influence of the experimental treatment. The significance level was $p<0.05$. For variables with statistical differences, a post-hoc analysis with LSD test was used to identify between which groups statistical differences exist.

Results

The results of the Shapiro-Wilk test indicated that all the variables, except for the variable Age, were normally distributed.

Table 1 presents the characteristics of participants for groups.

Table 1. Characteristics of participants

Variable	Isoinertial strength training (n=10)			Traditional strength training (n=10)			Control group (n=10)		
	M±SD	Min	Max	M±SD	Min	Max	M±SD	Min	Max
Age	24.90±5.59	20	34	25.80±6.18	20	34	26.60±6.15	20	34
Height	182.90±4.25	175	189	184.30±819	171	200	185.40±9.00	166	198
Weight	73.40±10.23	60	89	74.30±9.56	60	90	74.30±11.58	53	87
BMI	22.09±2.57	18.4	26.3	21.86±1.89	18.8	24.5	21.16±1.57	19.2	23.1

Results of t-test and mixed model repeated measures ANOVA are presented in Table 2. In the E1 group, a statistically significant difference between initial and final testing was observed for every variable, with a notable increase between initial and final tests: squat jump (Δ% 0.7), countermovement jump (Δ% 0.6), sprint on 5 m (Δ% 3.4), sprint on 20 m (Δ% 3.3), T-test (Δ% 3.7), 505 test for right leg (Δ% 2.5), and 505 test for left leg (Δ% 3.0). For the E2 group, the only variable with a statistically significant difference between initial and final testing was the T-test (Δ% 2.1). In the control group, there were no differences between initial and final testing in all variables.

Results of mixed model repeated measures ANOVA revealed significant differences in Time x Group interaction for the variables countermovement jump ($p=0.006$), sprint on 5 m ($p=0.022$), and sprint on 20 m ($p=0.007$). For countermovement jump, post-hoc analysis showed that there are differences between E1 and E2 groups ($p=0.045$), and between E1 and C1 groups ($p<0.001$). For sprint on 5 m, post-hoc analysis revealed a statistically significant difference between the E1 and C1 groups ($p=0.008$), while for the sprint on 20 m, a statistically significant difference was noted between the E1 and E2 groups ($p=0.034$), and the E1 and C1 groups ($p=0.008$)

Table 2. Pre- and post-results of analyzed parameters

Variable	Isoinertial strength training (n=10)		Traditional strength training (n=10)		Control group (n=10)		p-value
	Pretest	Posttest	Pretest	Posttest	Pretest	Posttest	
	M±SD	M±SD	M±SD	M±SD	M±SD	M±SD	
SJ	26.26±0.75	26.45±0.77*	26.54±1.41	26.57±1.47	26.73±1.66	26.67±1.78	0.120
CMJ	26.91±0.76	27.08±0.75*	27.22±1.54	27.22±1.68	27.49±1.68	27.38±1.75	0.006‡¶
5M	1.61±0.33	1.55±0.28*	1.50±0.25	1.48±0.28	1.40±0.17	1.43±0.16	0.022¶
20M	3.90±0.51	3.77±0.45*	3.74±0.41	3.74±0.44	3.48±0.31	3.52±0.31	0.007‡¶
T-test	11.98±0.88	11.53±0.89*	11.95±1.00	11.70±0.91*	11.73±0.68	11.81±0.64	0.067
505 RL	2.86±0.31	2.79±0.29*	2.66±0.29	2.64±0.31	3.01±0.48	3.05±0.44	0.227
505 LL	2.87±0.24	2.79±0.23*	2.82±0.31	2.82±0.34	2.81±0.18	2.83±0.26	0.217

Discussion

The aim of the study was to analyze the effects of isoinertial training compared to traditional strength training in senior male tennis players. Research has shown that isoinertial training lasting 6 weeks, and 12 training sessions leads to positive effects in the variables of lower limb strength, sprinting, and agility. Also, it was determined that there is a statistically significant difference between isoinertial training and traditional strength training in the variables CMJ and sprint 20 m.

In the countermovement jump (CMJ) test, the E1 group improved their result by 0.6%. Canós et al. (2021) state that when testing tennis players in a group of 8 subjects after four weeks of isoinertial training, there were great positive effects, while in the repeated measurement after eight weeks there were negative effects of isoinertial training, which may be a consequence of an inadequate training process, but also the age of the respondents and their training experience. Research on young basketball players has shown that a similar training program shows that isoinertial training is more effective than traditional training (Stojanović et al., 2021). Research on a sample of female soccer players showed that even a shorter period of isoinertial training shows positive effects on jumping ability (Pecci et al., 2023), and similar results are also found in young soccer players (Fiorilli et al., 2020). This kind of movement is natural for tennis players because it is used when performing a serve as well as a jump when hitting high balls.

In the 5-meter sprint (5M) test, the subjects of the E1 group improved their result by 3.4%. Short-distance sprinting is a central component of a tennis player's game, and the 5-meter sprint is tested as an important performance that is characteristic of tennis players and seems to depend on growth and maturation along with physical fitness (Kramer et al., 2021), similarly related for maturation they also state in the research (Myburgh et al., 2020). In their research, Kramer et al. (2021) also state that this sport requires hitting balls at high speed. Short-distance sprinting is not only important for the return ball in a match, but it is also important throughout the match. Small differences in speed can thus translate into different advantages or disadvantages for the player. Post hoc analysis revealed statistically significant differences between groups E1 and C1, but not between groups E1 and E2. It can be concluded that isoinertial training improves the ability of explosive power and short-distance acceleration. The testing has been carried out on a clay tennis surface, so it must be taken into account that the loose terrain had an impact on the test performance and results.

In the 20-meter sprint test (20M), group E1 improved their result by an average of 3.3% on the second measurement. In the 20-meter sprint test, tennis players achieve average results depending on the level of the competition. In our research, the subjects achieved results of 3.90 seconds, which is similar to the research results of Leone et al. (2006) of 3.84±0.28 seconds, as well as in the research conducted by Kilit and Arslan (2019) of 3.70+-0.2 seconds, and slightly slower than another study of 3.43 seconds (Kilit et al., 2019), where tennis players were divided into two groups: advanced and average, where the advanced had results of 3.39 seconds on average. A study conducted by Maroto-Izquierdo et al. (2017) concluded that six-week isoinertial training improves 20-meter running ability by 10% in professional handball players, which is 6.7% better than the present research.

In a sport such as tennis that requires short explosive movements with many changes of direction, isoinertial training can significantly improve a tennis player's ability for linear speed. It is known that physical abilities have a great influence on successful tennis playing (Girard & Millet, 2009), so coaches use these types of training to improve the performance of athletes during the competition (Buonsenso et al., 2023; Centorbi et al., 2023), as well as for monitoring the athlete's development (Jidovtseff et al., 2008).

Flywheel training is becoming more popular, but only a small number of studies have analyzed how this kind of training affects tennis players, despite the fact that there are an increasing number of studies that have shown the benefits of this type of training on motor skills that are essential for successful tennis playing. There are several limitations in this study. Only male tennis players were included, and there was a noticeable age difference between the participants. Future studies should focus on the effects of flywheel training on tennis players, especially female players.

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