In-Season Effect of a Combined Repeated Sprint and Explosive Strength Training Program on Elite Junior Tennis Players

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Abstract

Fernandez-Fernandez, J, Sanz-Rivas, D, Kovacs, MS, and Moya, M. In-season effect of a combined repeated sprint and explosive strength training program on elite junior tennis players. *J Strength Cond Res* 29(2): 351–357, 2015—The aim of this study was to analyze the effects of a combined explosive strength (ExpS) and repeated sprint (RS)-training program (2 times per week) on performance (sprint, jumping ability, and RS ability [RSA]) in young elite tennis players during a competitive period. Eight competitive internationally ranked male junior tennis players participated in an 8-week training intervention. After training, except for percentage of decrement in the RS test ($p = 0.72$) and maximal aerobic performance ($p = 1.0$), all performance variables (i.e., sprint, countermovement jump, and RSA) were significantly improved ($p \leq 0.05$; effect sizes ranging from 0.56 to 1.12). Although one can expect greater effects of ExpS or RS training programs alone than a combined program, the results obtained here show that the inclusion of a combined ExpS and RS training program seems to be an effective training tool to improve neuromuscular performance (i.e., changes in jumping ability and single sprint) as well as RSA in high-level tennis players.

Key Words multiple sprints, competition, complex training

Introduction

Tennis involves intermittent high-intensity efforts interspersed with periods of low-intensity activity, during which active recovery (between points) and passive periods (between changeover breaks in play) take place, over an extended period of time (i.e., in some cases >5 hours) (18,31). Thus, it has been suggested that competitive tennis players need a mixture of fitness qualities such as speed, agility, repeated sprint ability (RSA), and power, combined with a well-developed aerobic fitness to achieve high levels of performance (19). Tennis players must be able to react as fast as possible to actions performed by the opponent. Initial acceleration and agility are various explosive actions that are crucial when the player is involved in fast game play. Initial acceleration can be referred to as short sprint (0–10 m) (32), and agility can be recognized as the ability to change direction, start, and stop quickly (47). Speed is the ability to achieve high velocity, and it is a manifestation of strength (i.e., explosive force: early portion of force time curve or rate of force development) applied to a specific movement or technique (13). The average sprint distance performed by tennis players is 4–7 m in the course of a point, with an average of 4 changes of direction (COD) (40). Because most of these situations take place at the baseline moving from side to side, maximal speed cannot be achieved and is unlikely to be a limiting factor in tennis (49). Consequently, the optimal design and implementation of training strategies that enhance these specific fitness qualities (e.g., explosive strength [ExpS] and RSA) are of significant interest to tennis coaches and physical trainers.

To the best of the authors' knowledge, a paucity of scientific consideration has been afforded to establishing an evidence base for tennis-specific training (e.g., strength and sprint training) in light of its popular integration into current practice (42). For example, regarding strength training, just a few studies have been conducted with male and female tennis players of different levels (e.g., college and prepubertal) and evaluating the effects of different training programs (e.g., basic strength and plyometric training) on tennis performance (e.g., serve velocity) (1,17,33,34,46).

Improvement in fitness qualities such as sprinting speed is generally thought to be training specific, with specially designed speed and ExpS training programs shown to improve neuromuscular qualities (i.e., sprinting speed, and jumping height) (6,11,38,48), whereas repeated sprint (RS) training programs showed higher impact on single and repeated shuttle sprint performance (5,19). The improvements in these 2 different fitness qualities (e.g., shuttle sprinting speed

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or jumping abilities) in response to different exercise programs illustrate the concept of training specificity (35,43) and suggest that both training contents could be part of the training program, especially in young athletes. However, to the best of our knowledge, no previous study analyzed whether cumulated improvements obtained through different training programs are likely to be obtained while combining both training types, ExpS ad RS. This becomes especially important in a sport like tennis, where the busy schedules limit the number of training sessions dedicated to fitness development during the competitive season. Moreover, during the past few years, tennis players have been observed to devote a great amount of time to improving their tennis skills throughout technical and tactical training, with an average of 15–20 hours of technical training per week even at a young age (41). As a consequence, finding training strategies to improve fitness with less time is warranted.

Thus, the aim of this study was to analyze the effects of a combined ExpS and RS training program in young elite tennis players. We hypothesized that the combination of both training programs would result in substantial improvements in neuromuscular performance (i.e., changes in jumping ability and single sprint) as well as RSA.

Methods

Experimental Approach to the Problem

To analyze the effects of combined RS and ExpS on linear single sprint, vertical-jump performance, RSA, and aerobic performance, a group of 16 tennis players were matched into a training (TG) and a control group (CG) and were tested on these qualities before and after an 8-week specific conditioning program. The intervention took place at the beginning of the summer competition season (April to May). To ensure familiarization with the test procedure, all players completed a full training session 1 week before the pretest. The pre- and post-tests were conducted on 2 separate days with 1 day of low-intensity training in between. Testing consisted of countermovement jump (CMJ), RSA, and maximal aerobic performance for each subject was assessed using a 30-15 Intermittent Fitness Test (30-15 IFT) (4). During the training intervention, the TG performed 2 training sessions per week (every Tuesday and Thursday afternoon [16–17 hours], at the start of the session, after a standardized 8-minute dynamic warm-up), in addition to their normal training requirements (e.g., on-court or tennis sessions were designed by coaches to address the specific priorities of each athlete) for 8 consecutive weeks. The CG followed their normal tennis training (5 times a week), in addition to 1–2 self-regulated moderate- to low-intensity injury prevention (e.g., core training, shoulder strengthening, and flexibility) sessions. Because the players were at the beginning of the summer competitive season, singles and doubles tennis matches were played every weekend (club competitions, first and second national division) during the experimental period. To reduce the interference of uncontrolled variables, all the subjects were instructed to maintain their habitual lifestyle and normal dietary intake before and during the study. The subjects were told not to exercise on the day before a test and to consume their last (caffeine-free) meal at least 3 hours before the scheduled test time. The participants had to complete at least 85% of the training sessions and all tests to be included in the analyses.

Subjects

Sixteen competitive male junior tennis players (mean ± *SD*; age: 16.9 ± 0.5 years; weight: 74.7 ± 5.3 kg; height: 1.80 ± 3.6 m) with an international ranking between 120 and 280 (International Tennis Federation ranking) participated in this study. Players were divided into a training group ($n = 8$) and a CG ($n = 8$). The mean training background of the players was 8.0 ± 2.6 years, which focused on tennis-specific training (i.e., technical and tactical skills), aerobic and anaerobic training (i.e., on-and off-court exercises), and basic strength training. They were all free of cardiovascular and pulmonary diseases and were not taking any medications. Written informed consent was obtained from the players and their parents. The study was approved by the institutional research ethics committee, conformed to the recommendations of the Declaration of Helsinki.

Training Intervention

Training sessions consisted of a combined RS training (3–4 sets of 5–6 × 15–20-m sprints [forwards and side to side shuttles, with 1 or 2 COD], interspersed with 25 seconds of active recovery) (5), and ExpS (3–4 sets of 4–6 exercises × 12–15 repetitions, including maximal bilateral and unilateral CMJs to a 20-cm box [multidirectional], multilateral hops [hurdles], plyometric jumps [hurdles], step multilateral calf jumps, agility drills [ladders], and resisted standing start sprints [multidirectional]. Each repetition and set was interspersed with at least 45 seconds and 3 minutes of passive recovery, respectively) (Figure 1).

Measurements

Sprint Test. Owing to its good reproducibility, linear sprint tests ranging from 10 to 30 m are used as general measures of linear acceleration and speed (13). Running speed was evaluated by 30-m sprint times (standing start) with a 10-m split time. Time was recorded with photoelectric cells placed 10 m apart (Time It; Eleiko Sport, Halmstad, Sweden). Each sprint was initiated from an individually chosen standing position, 50 cm behind the photocell gate, which started a digital timer. Each player performed 3 maximal 30-m sprints, separated by at least 2 minutes of passive recovery. The best performance was recorded. The intraclass correlation coefficient (ICC) was 0.87, and *SEM* was 0.09.

Repeated Sprint Ability. The RSA test involved 6 repetitions of maximal 2 × 15-m shuttle sprints (~6 seconds) departing every 20 seconds (adapted from a previous running test that has been shown to be reliable and valid in estimating RSA) (5).

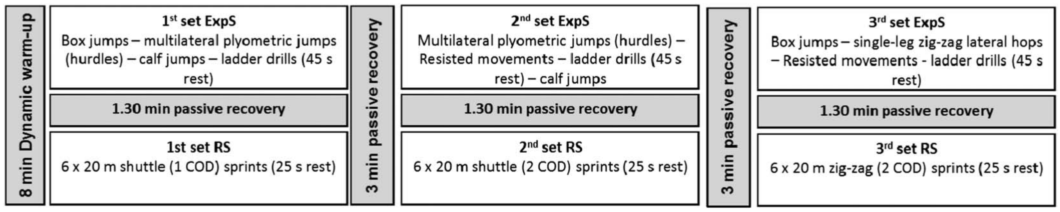

Figure 1. Schematic representation of the combined (ExpS and RS) training program. ExpS = explosive strength training; RS = repeated sprint training; COD = changes of direction.

During the approximately 14-second recovery between sprints, subjects were required to stand passively. Two seconds before starting each sprint, the subjects were asked to assume the start position as detailed for the 10-m sprints and await the start signal from an experienced researcher. Strong verbal encouragement was provided to each subject during all sprints. Three scores were calculated for the RSA test: the best sprint time (RSAb, seconds), usually the first sprint, the mean sprint time (RSAm, seconds), and the percent sprint decrement (%Dec) calculated as follows (5): 100 − (mean time/best time × 100). Intraclass correlation coefficient C values for RSAb, RSAm, and %Dec were 0.81, 0.73 and 0.49, respectively.

Vertical Jumping. The vertical jump is a common action in most sports and is biomechanically similar to various acceleration and game-related dynamic movements (23,36). It would, therefore, seem valid to include some form of vertical-jump assessment to evaluate explosive power in tennis. A CMJ without arm swing was performed on a contact platform (Ergojump; Finland). Each player performed 3 maximal CMJs interspersed with 45 seconds of passive recovery, and the best result height for each was recorded (36). The ICC for this test was 0.92.

Maximal Graded Aerobic Test. Maximal aerobic performance for each subject was assessed using a 30-15 Intermittent Fitness Test (30-15 IFT) as previously described (4). Briefly, the 30-15 IFT consists of 30-second stages interspersed with 15-second passive recovery periods. The initial running velocity was set at 8 $km \cdot h^{-1}$ for the first 30-second stage and speed was increased by 0.5 $km \cdot h^{-1}$ every 30-second stage thereafter. Subjects were instructed to complete as many stages as possible, and the test ended when the subject could no longer maintain the required running speed. The peak velocity achieved in the test (kilometers per hour) was determined as the subject's VIFT. The reliable final running

TABLE 1. Mean (±*SD*) changes in performance after RS and ExpS.*

	IG				CG			
Variables	Pretest	Posttest	ES	% Difference	Pretest	Posttest	ES	% Difference
10 m (s)	1.84 ± 0.1	1.79 ± 0.1†‡	0.74	−3.7	1.86 ± 0.1	1.88 ± 0.1	−0.25	1.2
20 m (s)	2.99 ± 0.1	2.94 ± 0.1	0.56	−2.2	3.01 ± 0.1	3.03 ± 0.1	−0.26	0.5
30 m (s)	4.47 ± 0.1	4.37 ± 0.1	1.08	−3.3	4.39 ± 0.1	4.39 ± 0.1	−0.01	0.0
CMJ (cm)	41.7 ± 2.1	42.6 ± 1.8†‡	−0.27	2.2	40.50 ± 1.0	40.39 ± 0.1	−0.08	−0.3
RSAb (s)	6.08 ± 0.1	5.98 ± 0.1†§	0.65	−1.4	6.16 ± 0.1	6.23 ± 0.1	−0.58	1.1
RSAm (s)	6.19 ± 0.1	6.10 ± 0.1†§	0.78	−1.3	6.30 ± 0.1	6.33 ± 0.1	−0.25	0.4
%Dec	−1.88 ± 0.7	−2.14 ± 0.7	0.19	9.6	−2.06 ± 1.2	−1.64 ± 0.5	−0.28	−20.4
VIFT ($km \cdot h^{-1}$)	19.8 ± 0.6	19.8 ± 0.6	0.09	−0.4	19.6 ± 0.6	19.8 ± 0.6	−0.26	1.1

*RS = repeated sprint; ExpS = explosive strength training; IG = intervention group; CG = control group; CMJ = countermovement jump; RSAb = repeated sprint ability best; RSAm = repeated sprint ability mean; %Dec = percentage of decrement; VIFT = velocity of the intermittent fitness test.
†Significant ($p \le 0.01$) differences between pre- and post-test.
‡Differences between groups ($p \le 0.05$).
§Differences between groups ($p \le 0.01$).

speed (VIFT; ICC = 0.96) of this test has been shown to be an accurate tool for individualizing intermittent shuttle running exercise (4,7).

Statistical Analyses

All data are presented as mean (±*SD*). The distribution of each variable was examined with the Kolmogorov-Smirnov normality test. Student's unpaired *t*-tests were used to examine differences between groups for baseline and final measurements. Data were first analyzed using a 2-factor repeated-measures analysis of variance with 1 between factor (group; training group vs. CG) and 1 within factor (period; pretraining vs. posttraining). In addition, the standardized difference or effect size (ES) of changes in each variable was calculated using the pooled pretraining *SD*. Threshold values for Cohen ES statistic were >0.2 (small), 0.5 (moderate), and >0.8 (large) (12). Statistical analyses were performed using the SPSS version 17.0 (SPSS, Inc., Chicago, IL, USA) software. The level of significance used was $p \leq 0.05$.

Results

Only players who participated in ≥85% of all training sessions were included in the final analysis. As a result, all subjects participating in the study did not miss any training sessions, demonstrating excellent compliance with the training program. Mean (±*SD*) comparisons between pretest and posttest measurements as well as between training and CGs, respectively, are shown in (Table 1). After training, the training group showed a significant ($p \leq 0.01$) increase in 10-m sprint, CMJ, RSAb, and RSAm, with ES ranging from 0.3 to 0.8, whereas no significant changes were observed in 20-m and 30-m %Dec, and VIFT. No significant changes were observed in the CG after training. Regarding differences between groups, results showed significant differences after training in 10-m sprint ($p \leq 0.05$), CMJ ($p \leq 0.05$), RSAb ($p \leq 0.01$), and RSAm ($p \leq 0.01$).

Discussion

This study compared the effectiveness of the addition of a combined training program (i.e., RS and ExpS training) to normal tennis training sessions on fitness qualities (e.g., linear speed, RSA, jumping ability, and aerobic fitness) of young elite tennis players. The results obtained here show that a combined RS and ExpS training program seems to be an effective training tool to improve neuromuscular performance (i.e., changes in jumping ability and single sprint) as well as RSA in tennis players.

Previous research conducted in other intermittent sports (i.e., soccer and handball) showed the beneficial effects of isolated training programs (i.e., ExpS training or RS training alone), on neuromuscular performance and RS performance (5,6,10,30). These results show different and specific adaptations to both training regimens, with improvements in the RSA test were only observed after RS, whereas neuromuscular performance (i.e., jumping height) was only increased after ExpS (5,25). To the best of our knowledge, no previous study analyzed the combination of both training strategies in tennis players' fitness levels. Results of this study showed that in the training group, single-sprint performance (i.e., acceleration [10 m]) was improved ~3–4%, neuromuscular performance (CMJ) ~2%, and RSA ~1.5% after the 8-week training program, with no significant changes observed in the 20-m and 30-m %Dec during the RSA and in the maximal aerobic performance.

The changes in sprint performance found in this study are similar to those obtained in previous studies conducting speed and agility training programs alone (5,6,39), with moderate to large ESs after training in sprint distances ranging from 10 to 30 m. It seems interesting to highlight that although results showed no significant differences in the training group after training in the 20- and 30-m sprint, ES reported were moderate to large. Because no electromyographic or kinetic data were collected, we can only speculate to the mechanism and specific areas that contributed to the improvement. However, these changes are likely related to improvements in the neural component of speed (e.g., inter-lower limbs muscle coordination, and stride frequency), which have been shown in other studies to provide a short-term improvement in speed components (45,50). Moreover, results also showed improvements in the RSA (1.3 and 1.4% in the mean and the best sprint times, respectively) after the combined training, although the improvement in the RSA observed here is lower than what has been previously reported in tennis players (19), and also in young handball and soccer players after sprint-specific training regimens (6,20). In this regard, the training program conducted here consisted on multidirectional (forward and side to side) shuttles, with 1 or 2 changes of directions, and the involvement of the same muscles during acceleration and deceleration movements (e.g., biceps femoris, rectus femoris, hip adductors, and illiopsoas) could lead players to positive changes in specific coordination and agility during the RSA test (29). Although the RSA performance was improved in this study, there were no changes in the %Dec, suggesting that the combined training used here increased the overall anaerobic performance but not the ability to recover between sprints (20). This conclusion can be supported by the unchanged aerobic performance (e.g., VIFT). Repeated sprint ability is a complex quality, which is believed to be related to neuromuscular (e.g., motor unit activation) and metabolic parameters (e.g., oxidative capacity) (22). In this regard, and consistent with the findings of other authors, the repetition of short bouts of exercise stresses not only many of the physiological or biochemical systems used in aerobic efforts (8,21) but also induces alterations in glycolytic enzymes, muscle buffering, and ionic regulation resulting in improved anaerobic performance (3, 14, 15, 26).

Neuromuscular performance (CMJ) was improved around 2% after 8 weeks of combined training. This was probably because an improvement in the lower limb (e.g., quadriceps and calf muscles) explosive power through improvements in motor unit synchronization, stretch-shortening cycle (SSC) efficiency, together with a better synchronization of body segments (27). Moreover, due to the higher improvements in sprinting ability (>2%) than jumping, it can be suggested that the improvement in the SSC would be accompanied by an enhanced sprinting speed and ability, as suggested by several previous studies (28,30,37). The exercises selected contained many powerful multidirectional movements, which may had an impact on the capacity to change direction faster. Again, although this improvement could be positive for the tennis players' performance, previous research showed higher gains in jump height, with 4.7–15% improvement after explosive power training (i.e., plyometric training) (10,16). This supports the idea that adaptations (e.g., mechanical and physiological) and associated changes in performance after a training intervention are to a certain extent training specific, with the energy system, the muscle group, the contraction force, or the movement patterns engaged, each playing a role in determining the final adaptations (27,43).

Based on previous research, conducting ExpS (9,10,30,37) or RS (10,19,20) alone, one can expect greater effects of ExpS or RS training programs alone than a combined program. These improvements seem to be clearly related to the concept of training specificity (43), highlighting that in complex sports as tennis, fitness qualities (i.e., jumping ability and RSA) might need to be developed independently, and therefore, athletes need specific training sessions, which should be part of the training program. This is similar to data in professional soccer athletes that highlight the distinct differences in development of acceleration, maximal speed, and agility (35). Also, as deceleration is an important aspect of tennis play and performance (32), having the ability to develop these components during both the RS and ExpS is another benefit of this type of training. However, because of technical and tactical skills are predominant factors in tennis, especially during the competitive periods, coaches place their training priorities on technical/tactical contents, and therefore, only just a minimum of specific physical training sessions per week can be programmed (i.e., 2 in this study). Moreover, although this study showed positive results on performance (i.e., jumping ability, sprint, and RSA), the key physical variables linked to performance in tennis are still unclear with contradictory results, suggesting that physical qualities were weak predictors of overall tennis performance (2), and other suggesting that specific qualities such as agility (44) or speed and vertical power (24) were correlated with tennis performance (i.e., ranking).

In conclusion, although this study has limitations, (i.e., low number of subjects analyzed, no electromyographic or kinetic data were collected), results obtained suggest the effectiveness of the addition of a combined training program (i.e., RS and ExpS training) to normal tennis training sessions on fitness qualities (i.e., changes in jumping ability, single sprint, and RSA) of young elite tennis players. It seems important to highlight that training strategies that attempt to stress multiple determinants of performance may not be as effective as targeted training sessions alone (5). Although these training-specific adaptations offer coaches and practitioners the possibility to individualize training content specific to the fitness qualities in tennis, the priority of training goals will depend on the individual needs of the athletes and the relationship between fitness traits and performance (i.e., ranking), which is still unclear. The evaluation of specific conditioning training programs alone and the participation of a higher number of tennis players may warrant further investigation.

Practical Applications

The inclusion, 2 times per week, of a combined training program (i.e., RS and ExpS training) to regular tennis training sessions represents an effective means of increasing performance-related physical fitness traits in high-level tennis players. Coaches can implement their regular training sessions during competitive periods with a combined repetitive sprint training (i.e., 3–4 sets of multidirectional [forwards and side to side shuttles, with 1 or 2 changes of directions] short sprints [5–6 × 15–20 m], sprints, interspersed with short [25 seconds] active recovery periods), and ExpS training (3–4 sets of 4–6 body weight exercises bilateral and unilateral CMJs to 20-cm box [multidirectional], multilateral hops [hurdles], plyometric jumps [hurdles], step multilateral calf jumps, agility drills [ladders], and resisted standing start sprints [multidirectional]), interspersed with at least 45 seconds of passive recovery. It seems important to indicate that training strategies that attempt to stress multiple determinants of performance may not be as effective as targeted training sessions alone (7). Although these training-specific adaptations offer coaches and practitioners the possibility to individualize training content specific to the fitness qualities in tennis, the priority of training goals will depend on the individual needs of the athletes and the relationship between fitness qualities and performance (i.e., ranking), which is still unclear.

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