International Journal of Sports Physiology and Performance, 2017, 12, 90-98
http://dx.doi.org/10.1123/ijspp.2015-0684

Human Kinetics
ORIGINAL INVESTIGATION

The Effects of Sport-Specific Drills Training or High-Intensity Interval Training in Young Tennis Players

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Purpose: To compare the effects of combining high-intensity training (HIT) and sport-specific drill training (MT) versus sport-specific drill training alone (DT) on fitness performance characteristics in young tennis players. ***Methods:*** Twenty young tennis players (14.8 ± 0.1 y) were assigned to either DT (n = 10) or MT (n = 10) for 8 wk. Tennis drills consisted of two 16- to 22-min on-court exercise sessions separated by 3 min of passive rest, while MT consisted of 1 sport-specific DT session and 1 HIT session, using 16–22 min of runs at intensities (90–95%) related to the velocity obtained in the 30–15 Intermittent Fitness Test (V_{IFT}) separated by 3 min of passive rest. Pre- and posttests included peak oxygen uptake (VO_2peak), V_{IFT}, speed (20 m, with 5- and 10-m splits), 505 Agility Test, and countermovement jump (CMJ). ***Results:*** There were significant improvements after the training period in VO_2peak (DT 2.4%, ES = moderate; MT 4.2%, ES = large) and V_{IFT} (DT 2.2%, ES = small; MT 6.3%, ES = large) for both DT and MT, with no differences between training protocols. Results also showed a large increase in the 505 Agility Test after MT, while no changes were reported in the other tests (sprint and CMJ), either for MT or DT. ***Conclusions:*** Even though both training programs resulted in significant improvements in aerobic performance, a mixed program combining tennis drills and runs based on the V_{IFT} led to greater gains and should be considered the preferred training method for improving aerobic power in young athletes.

Keywords: youth, racket sports, aerobic training

Aerobic fitness is an important component of performance for athletes in a wide range of sports.[1,2] During competitive tennis matches, mean heart-rate (HR) values range from 70% to 80% of maximum (HR_{max}), and peak values around 90% to 100% of HR_{max}. Average oxygen uptake (VO_2) values correspond to approximately 50% to 60% of maximum VO_2 (VO_2max), with values above 80% of VO_2max during intensive rallies.[3] Under these circumstances, although the technical and tactical skills are considered the most predominant performance factors,[4] players also need a mixture of fitness qualities such as speed, agility, and power combined with a well-developed aerobic fitness to achieve high levels of performance.[5,6] Therefore, it seems the ability to maintain a high technical efficiency during phases of high-intensity intermittent exercise (which can result in fatigue) is an important feature of successful tennis players.[7]

Training at or near VO_2max is thought to be an effective training stimulus to improve aerobic fitness,[8] with high-intensity-training (HIT) methods (ie, work and rest intervals ranging from 15 s to 4 min, 90–100% velocity at the level of VO_2max, HR values ~90% of HR_{max}, work-to-rest ratios of 1:1–4:1)[8] as an effective way to achieve these intensities and obtain positive effects in aerobic fitness.[9,10] Although HIT has been shown to be effective, such training protocols require high levels of adherence and can be perceived as unpleasant by players along with reducing the time needed to acquire technical and tactical skills during specific training.[11]

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In tennis, since early ages (ie, under-14 players [U14]), players spend a lot of training time mastering their individual sport-specific skills, with technical and tactical training volumes often exceeding 15 to 20 h/wk.[12] Considering that maintaining technical skills is a determinant factor in the sport and training time is at a premium, coaches are increasingly relying on an integrated approach to conditioning and skill-based work, often resulting in the programming of tennis-specific drills that include both technical and tactical assignments as part of sport-specific conditioning.[13,14] The use of these drills has been reported to result in physiological responses that mirrored aspects of both average and maximal match play and can be used as a training method aiming to improve fitness levels in advanced players.[14,15] Despite these findings, to date just a few studies have investigated sport-specific training in young athletes participating in intermittent sports (ie, soccer, team handball), with small-sided games and ball-based drills and activities,[10,13,16–18] and no previous study was conducted in young tennis players.

From a developmental perspective, the use of sport-specific drills would allow the development of both technical/tactical skills and fitness levels (ie, VO_2max), and the level of adherence by young athletes would likely to be high given the inherent enjoyment associated with game-related exercise.[11] However, as high intensities (ie, >90%HR_{max}) are needed to improve aerobic fitness,[8] since the use of sport-specific exercises requiring good levels of technique (ie, to keep the ball in play at the desired intensity) with players who have not yet specialized, aerobic fitness may not always be improved to the desired level.[17] Therefore, the use of HIT at this stage of development by using the final running velocity obtained in a field test such as the 30-15 Intermittent Fitness Test to set individual running distances[19] might be recommended, as individual player workloads can be accurately prescribed and maintained throughout training.[8,13,19]

Thus, the purpose of this study was to compare the effects of combining HIT and sport-specific drill training with sport-specific drill training alone on fitness performance characteristics in young tennis players. We hypothesized that a training program combining HIT and sport-specific drills would lead to higher improvements in fitness levels than sport-specific drill training alone.

Methods

Subjects

Twenty well-trained tennis players (age 14.8 ± 0.1 y, weight 63.8 ± 7.1 kg, height 174.7 ± 4.8 cm; 16 players were right-handed and 4 were left-handed) participated in this study. The players were ranked between 1 and 50 in their respective national singles ranking (U15), trained 15 ± 2 h/wk, and had a training background of 6 ± 1.2 years, which focused on tennis-specific training (ie, technical and tactical skills), aerobic and anaerobic training (ie, on- and off-court exercises), and basic strength training. Before participating in the study, the participants were fully informed about the testing protocol, and written informed consent was obtained from both them and their respective parents/guardians. The participants were free to withdraw from the study without penalty at any time. The procedures were approved by the institutional ethics review committee and conformed to the code of ethics of the World Medical Association (Declaration of Helsinki).

Design

A 2-group, matched, randomized, experimental design was used in this study. Participants were divided into 2 training groups that performed mixed high-intensity intermittent runs and tennis-specific training (MT; n = 10) or tennis-specific drills only (DT; n = 10). Participants in each group were balanced according to their maturation, initial fitness level, and physical and game skills. After an appropriate familiarization period, laboratory tests and a specific range of physical-performance tests were completed 2 weeks before and after an 8-week training period. Physical tests (ie, 30–15 Intermittent Fitness Test [30-15 IFT], 20-m sprint [with 5- and 10-m splits], countermovement jump [CMJ], 505 Agility Test, and a laboratory test to estimate VO_2peak) were conducted before (pretest) and 4 days after the intervention (posttest). Between the last training session and the posttests, only light on-court training combined with injury-prevention sessions (eg, core training, shoulder strengthening, and flexibility) was performed. The investigation was conducted during the preparatory period (October to December). All tests were conducted on an indoor synthetic court. 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. They were told not to exercise on the day before a test and to consume their last (caffeine-free) meal at least 2 hours before the scheduled test time.

Methodology

Tests were scheduled >48 hours after a competition or hard physical training to minimize the influence of fatigue. The program was performed under similar weather, time, and surface conditions (Rebound Ace surface; temperature 24.4–26.4°C, relative humidity 54.4–61.0%; Kestrel 4000 Pocket Weather Tracker, Nielsen Kellerman, Boothwyn, PA, USA) before and 4 days after the 8-week training period. All tests except the laboratory test were administered on the same day (eg, morning session). Investigators were blinded for group allocation during both pretesting and posttesting. Before testing, players performed a standardized warm-up (eg, 10 min including aerobic exercise, general mobilization, and ballistic exercises). In addition, care was taken to allow sufficient rest time between all tests to limit the effects of fatigue on subsequent tests.

Laboratory Test

VO_2peak was determined during an incremental treadmill running test on a motorized treadmill (Technogym Runrace, Italy).[20] After a 3-minute warm-up at 6 km/h and 1% gradient, the treadmill speed was set at 10 km/h for the initial 3-minute stage and increased to 12 km/h for the next stage. Thereafter, treadmill speed was held constant at 12 km/h and the gradient increased by 2.5% every 3 minutes until the participant reached volitional exhaustion. Participants were verbally encouraged to provide maximal effort during the final stages of the test. Gas exchange was continuously measured during the test using a breath-by-breath analyzer (Vmax29, Sensormedics, USA). The gas-analysis system was calibrated before each test using the manufacturer's recommendations. During the incremental test, the breath-by-breath gas samples were averaged every 30 seconds and HR was monitored and recorded at 5-second intervals during the exercise (S610, Polar Electro. Kempele, Finland). VO_2peak and HR_{max} were determined as the highest 30- and 5-second mean values, respectively.

30–15 Intermittent Fitness Test

Supramaximal intermittent performance with changes of direction was assessed using the 30-15 IFT,[19] which consisted of 30-second shuttle runs interspersed with 15-second passive recovery periods. The athletes had to run back and forth between 2 lines set 40 m apart at a pace dictated by an auditory signal. Speed was set at 8 km/h for the first 30-second run and increased by 0.5 km/h every 45-second stage thereafter. The speed during the last completed stage was noted as velocity obtained in the intermittent fitness test (V_{IFT}). The reliability of V_{IFT} has been shown to be good (intraclass correlation coefficient [ICC] .96, typical error [TE] 0.33 km/h).[19,21] HR was monitored and recorded at 5-second intervals during the test (Polar S610, Kempele, Finland).

Speed Test

Time during a 20-m dash (with 5- and 10-m split times) in a straight line was measured by means of single-beam photocell gates placed 1.0 m above ground level (Time It, Eleiko Sport, Halmstad, Sweden). Each sprint was initiated 50 cm behind the photocell gate, which started a digital timer. Each player performed 2 maximal 20-m sprints, separated by at least 2 minutes of passive recovery.[22] The best performance was recorded. The ICC and TE of the 20-m sprint were 0.96 and 0.06 second, respectively

Agility Test

The athletes' ability to perform a single, rapid 180° change of direction over a 5-m distance was measured by using a modified version (stationary start) of the 505 Agility Test.[23] Players assumed a preferred foot behind the starting position and accelerated voluntarily, sprinting with maximal effort without a racquet. One trial pivoting on both left and right foot was completed, with the best time recorded to the nearest 0.01 second (Time It, Eleiko Sport, Halmstad, Sweden). Two minutes of rest were allowed between trials. The ICC and TE for this test were 0.92 and 0.03 second, respectively.

Vertical Jumping

A countermovement jump (CMJ) without arm swing was performed on a contact-time platform (Ergojump, Finland) according to Bosco et al.[24] Each player performed 2 maximal CMJs interspersed with 45 seconds of passive recovery, and the best height for each was recorded. The ICC and TE of the CMJ were .96 and 1 cm, respectively.

Training Program

Participants performed 2 training sessions per week, in addition to their usual training requirements, for 8 weeks. Regular tennis training was designed by coaches to address the specific priorities of each athlete, including more technical/tactical drills (ie, designed to focus on improvements to a specific quality in stroke technique or tactical approach) during the sessions including DT/MT, to avoid a more physical component (ie, more open drills), which could affect the results obtained. The rest of the weekly tennis trainings (ie, 3 sessions) consisted on average of 68.9 ± 12.7-minute sessions generally characterized by an ~10-minute specific warm-up (ie, including general mobility, ground strokes, volleys, and low-intensity smashes), ~10 minutes of technical adjustments (ie, service technique), and ~45 minutes of specific drills (ie, mixed open/closed technical/tactical drills). Together with the tennis-specific sessions, players performed an average of 2 sessions/wk of neuromuscular conditioning. Each session comprised a 10-minute warm-up and approximately 50 minutes of combined core-strength, elastic-tubing, and medicine-ball exercises.

Training programs (DT and MT) followed a periodized plan, including overload, progression, and a short tapering period (ie, 4 d) to maximize final performance. The MT regimen consisted of 1 session/wk of HIT and 1 session/wk of tennis-specific drills, whereas the DT program consisted of 2 sessions/wk of tennis-specific drills (Table 1).

Before all training sessions, subjects performed a standardized dynamic warm-up (~10 min) followed by submaximal 30-m shuttle runs at intensity of 60% to 70% of HR_{max} and 4 acceleration sprints, during the runs based on the V_{IFT}. During the tennis-specific drills sessions the 30-m shuttles and acceleration sprints were substituted by 6 to 8 minutes of tennis-specific activity (eg, ground strokes, volleys). Runs based on the V_{IFT} consisted of 2 sets of 15 to 22 repetitions of 15 seconds work and 15 seconds rest (with 3 min of passive rest between sets) performed over 20- to 30-m shuttles performed at individualized intensities ranging from 90% to 95% of the V_{IFT}. Tennis-specific drills consisted of a combination of different drills (Table 2) selected by 4 qualified coaches with whom the athletes worked, similar to previously described in different studies, with durations of 30 to 60 seconds of work interspersed with 30 to 60 seconds of rest.[25,26] Drills involved specific ground-stroke/open play from the baseline, with repeated strokes from different positions under pressure, but most specifically during baseline play (Figure 1). An experienced professional coach hand-fed new tennis balls, if needed, to the player at a speed determined by the completion of the previous shot (ie, self-selected), at a frequency of approximately 1 ball every 3 seconds, ±5 cm over the net, near a designed landing targets (ie, 60 × 90 cm). All players were required to move as fast as possible, hit with maximal effort, and maintain stroke accuracy.

Table 1 Training Interventions for Tennis-Specific Drills-Training and Mixed-Training Groups

Week	Sessions	Drills training	Mixed training
1		Familiarization and pretests	Familiarization and pretests
2	1–2	S1/S2: 16-min drills (2 × [8 min, 3-min rest])	S1: 16-min drills (2 × [8 min, 3-min rest]) S2: 2 × (16 × 15/15, I:90% V_{IFT} —3-min rest)
3	3–4	S1/S2: 16-min drills (2 × [8 min, 3-min rest])	S1: 16-min drills (2 × [8 min, 3-min rest]) S2: 2 × (16 × 15/15, I:93% V_{IFT} —3-min rest)
4	5–6	S1/S2: 18-min drills (2 × [9 min, 3-min rest])	S1: 18-min drills (2 × [9 min, 3-min rest]) S2: 2 × (20 × 15/15, I:93% V_{IFT} —3-min rest)
5	7–8	S1/S2: 18-min drills (2 × [9 min, 3-min rest])	S1: 18-min drills (2 × [9 min, 3-min rest]) S2: 2 × (20 × 15/15, I:93% V_{IFT} —3-min rest)
6	9–10	S1/S2: 20-min drills (2 × [10 min, 3-min rest])	S1: 20-min drills (2 × [10 min, 3-min rest]) S2: 2 × (20 × 15/15, I:95% V_{IFT} —3-min rest)
7	11–12	S1/S2: 20-min drills (2 × [10 min, 3-min rest])	S1: 20-min drills (2 × [10 min, 3-min rest]) S2: 2 × (20 × 15/15, I:95% V_{IFT} —3-min rest)
8	13–14	S1/S2: 22-min drills (2 × [11 min, 3-min rest])	S1: 22-min drills (2 × [11 min, 3-min rest]) S2: 2 × (22 × 15/15, I:95% V_{IFT} —3-min rest)
9	15–16	S1/S2: 22-min drills (2 × [11 min, 3-min rest])	S1: 22-min drills (2 × [11 min, 3-min rest]) S2: 2 × (22 × 15/15, I:95% V_{IFT} —3-min rest)
10		Tapering and posttests	Tapering and posttests

Abbreviations: S, training session; V_{IFT}, running velocity in the 30-15 IFT; I, intensity.

Table 2 Descriptions of Tennis Training Drills Performed

Drill category	Description	Example
Big X	Diagonal movements inside/outside the court (ie, maximal efforts and jogging) combined with forehand and backhand strokes.	Figure 1.1
Suicide	Movement along the baseline (ie, maximal efforts and jogging) combined with forehand and backhand strokes.	Figure 1.2
Recovery/defensive	2 players, both must hit cross-court strokes, recover past center mark after each stroke, then hit down-the-line strokes.	Figure 1.3
Open pattern	1 player remains in a corner, hits alternating (eg, free) cross-court strokes, then down the line. Other player must return ball to same corner.	Figure 1.4

Drills were performed in 2 or 3 tennis courts, with 1 or 2 players in each court, depending on the drills performed. Players finished the training in a time window of ~40 minutes, including the warm-up and cooldown phases.

During training sessions HR was monitored (Polar S610, Kempele, Finland). The data obtained from the HR monitors were downloaded onto a portable computer using the manufacturer's software. The training load (TL) for each session was calculated using the session rating of perceived exertion (s-RPE) for each subject during the intervention.[27] TL was established postsession through multiplication of s-RPE (Borg CR-10) and duration. For inclusion in posttesting analysis, participants were required to complete >85% of the 16 prescribed training sessions.

Statistical Analysis

Descriptive statistics of the data are presented as mean ± SD. Data normality and homoscedasticity were confirmed before inferential analysis through Kolmogorov-Smirnov and Levene tests, respectively. A 2-way ANOVA (2 × 2) with groups and testing times as factors was used to compare the effects of the applied training regimen on the tested items. A 3-way repeated-measures ANOVA (2 × 4 × 8) with groups, load variables, and training weeks as factors was used to compare the training-session characteristics. When a significant difference was found for either main effect (load variables or group), a Bonferroni post hoc analysis was performed. SPSS version 20 was used for the statistical calculations. Effect sizes were calculated and interpreted according to >0.2 (small), 0.5 (moderate) and >0.8 (large).[28] Statistical significance was set at the level of $P < .05$.

Results

Two players from the MT group and 1 player from the DT group did not meet the inclusion criteria for analysis due to lack of training adherence, resulting in 17 players for final analysis (DT n = 9, MT n = 8; mean ± SD age 14.8 ± 0.1 y, height 175.5 ± 4.2 cm, weight 64.9 ± 6.5 kg, age from peak height velocity 1.13 ± 0.3 y, predicted age at peak height velocity 13.6 ± 0.4 y).

An analysis of a pretest–posttest parallel-groups controlled trial was performed to assess between-groups differences (Table 3). The smallest worthwhile difference or change in means was calculated using standardized units (Cohen). The outcomes were shown as percentages.

Pretests and posttests showed that after the training period there were significant improvements in VO_2peak (DT 2.4%, ES = moderate; MT 4.2%, ES = large) and V_{IFT} (DT 2.2%, ES = small; MT 6.3%, ES = large) in both groups (Table 4). No changes were found after the training period in the rest of analyzed variables (ie, CMJ, 5- to 10- to 20-m sprint, 505). Moreover, there were no differences between groups (ie, DT vs MT) posttraining.

The TL induced by the training protocols used in the study is presented in Figure 2. Results showed no differences between training groups regarding the global TL (127.4 ± 13.4 vs 148 ± 25.5 AU for DT and MT, respectively) and RPE (6.4 ± 1.1 vs 7.2 ± 1.3 for DT and MT, respectively). However, a more detailed analysis showed that there were significant differences in the TL between DT and MT in weeks 3 and 4 (large ES), as well as differences between training weeks 3 and 4 in MT (large ES). Significant differences were also found between tennis-session TL and DT/MT TL (large ES) (Figure 2).

Discussion

The extensive competition demands of tennis athletes, even from young ages, challenges coaches' abilities to ensure that physical, technical, and tactical capacities are sufficiently developed.[29] In this regard, the use of on-court training sessions integrating both technical/tactical and physical components has become a priority for tennis coaches in the last few years.[14,26,30] However, while several previous studies identified the use of sport-specific drills as an effective training method for improving aerobic-fitness characteristics in other intermittent sports (ie, soccer, handball),[13,31] and few tennis-specific studies described the internal and external loads of several different drills,[14,26,29] the current study is the first to investigate the effectiveness of training using sport-specific drills (DT) or a combination of sport-specific drills and HIT runs (MT) to increase the aerobic-fitness qualities of elite young tennis players.

Present results showed that both training interventions were effective to significantly increase aerobic parameters (ie, VO_2peak [DT 2.4%, MT 4.2%] and V_{IFT} [DT 2.2%, MT 6.3%]) in these young tennis players. Results are in accordance with previous studies comparing small-sided games and HIT runs, showing that both are equally effective modes of aerobic interval training in young athletes (ie, soccer, handball players).[13,32,33] However, although there were no differences between groups, greater effects were seen after the combination of sport-specific drills and HIT runs (large effect sizes for both VO_2peak and V_{IFT} in the MT group and small to moderate in the DT). In this regard, Harrison et al[33] recently reported results similar to those in the current study after a similar training intervention (ie, combining small-sided games and HIT was effective at improving aerobic power [~5%], while small-sided games alone did not produce the same benefit) in young soccer players.

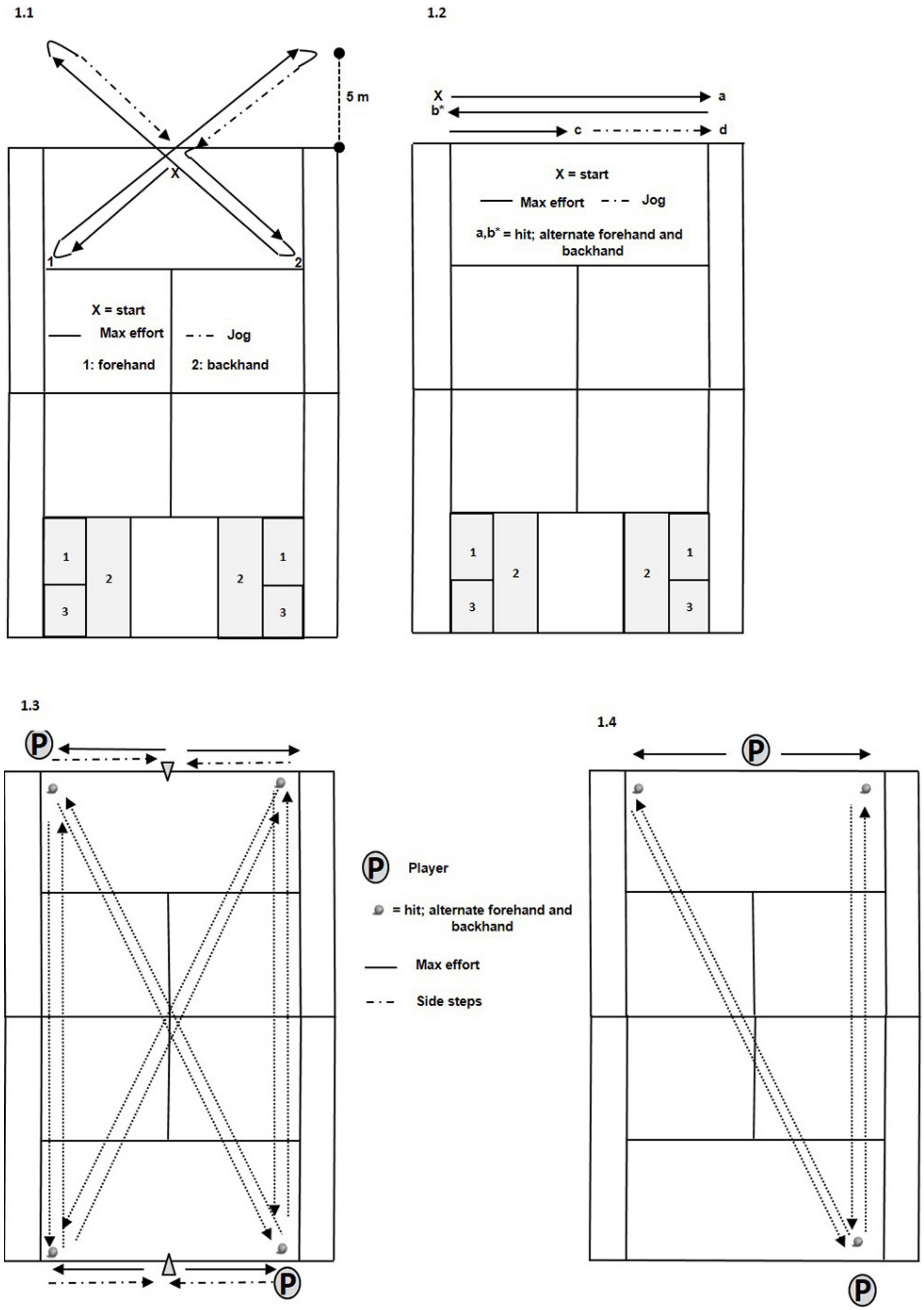

Figure 1 — Schematic representation of the tennis-specific drills. (1.1) Big X. (1.2) Suicide. (1.3) Recovery/defensive. (1.4) Open pattern.

Table 3 Analysis of a Pretest–Posttest Parallel-Groups Controlled Trial Assessing Between-Groups Differences

	Difference in means CI (90%)	Difference in means as percentage CI (90%)
CMJ (cm)	0.9 (–1.1; 2.9)	2.4 (–3.3; 8.4)
5 m (s)	0.0 (–0.1; 0.1)	1.4 (–4.7; 8.0)
10 m (s)	0.0 (–0.1; 0.1)	–1.7 (–6.5; 3.3)
20 m (s)	0.0 (–0.2; 0.2)	–0.3 (–5.4; 5.1)
505 (s)	–0.1 (–0.2; 0.0)	–2.6 (–6.2; 1.2)
VO_2peak	2.0 (0.2; 3.8)	3.5 (0.2; 6.9)
30-15 IFT (km/h)	0.2 (–0.3; 0.7)	1.0 (–1.8; 4.0)

Abbreviations: CI, confident interval; CMJ, countermovement jump; VO_2peak, peak oxygen uptake; IFT, intermittent fitness test.

Table 4 Changes in the Physical-Performance Measurements Obtained During the Pretests and Posttests, Mean ± SD

	Tennis-drills training (n = 9)						Mixed training (n = 8)					
	Pretest	Posttest	*P*	ES (90%CI)	Descriptor	Change	Pretest	Posttest	*P*	ES ± (90%CI)	Descriptor	Change
CMJ (cm)	35.6 ± 3.6	36.5 ± 3.1	.097	–0.25 (–1.01; 0.50)	Trivial	2.8%	35.1 ± 3.4	36.8 ± 3.1	.108	–0.49 (–1.29; 0.30)	Trivial	4.7%
5 m (s)	1.09 ± 0.08	1.08 ± 0.03	.498	0.15 (–0.60; 0.91)	Trivial	–0.5%	1.08 ± 0.08	1.08 ± 0.02	.440	0.00 (–0.78; 0.78)	Trivial	0.6%
10 m (s)	1.86 ± 0.11	1.88 ± 0.07	.761	–0.20 (–0.96; 0.55)	Trivial	1.1%	1.86 ± 0.11	1.86 ± 0.05	.278	0.00 (–0.78; 0.78)	Trivial	0.1%
20 m (s)	3.23 ± 0.19	3.29 ± 0.15	.306	–0.33 (–1.09; 0.43)	Trivial	1.8%	3.22 ± 0.19	3.30 ± 0.09	.095	–0.49 (–1.29; 0.30)	Trivial	2.4%
505 (s)	2.88 ± 0.17	2.86 ± 0.17	.221	0.11 (–0.64; 0.87)	Trivial	–0.6%	3.03 ± 0.08	2.95 ± 0.11	.258	0.81 (0.00; 1.62)	Large	–2.6%
VO_2peak	56.1 ± 2.2	57.3 ± 2.1*	.001	–0.53 (–1.30; 0.24)	Moderate	2.4%	56.2 ± 3.1	59.7 ± 3.3*	.001	–1.05 (–1.88; –0.21)	Large	4.2%
30-15 IFT (km/h)	17.9 ± 1.0	18.3 ±.0*	.003	–0.38 (–1.14; 0.38)	Small	2.2%	18.0 ± 0.9	18.8 ± 0.8*	.001	–0.89 (–1.71; –0.07)	Large	6.3%

Abbreviations: ES, effect size; CI, confident interval; CMJ, countermovement jump; VO_2peak, peak oxygen uptake; IFT, intermittent fitness test. Note: Magnitudes of ESs were assessed using the following criteria: <0.2 = trivial, 0.2–0.49 = small, 0.5–0.79 = moderate, >0.8 = large.

*Significantly different from pretraining.

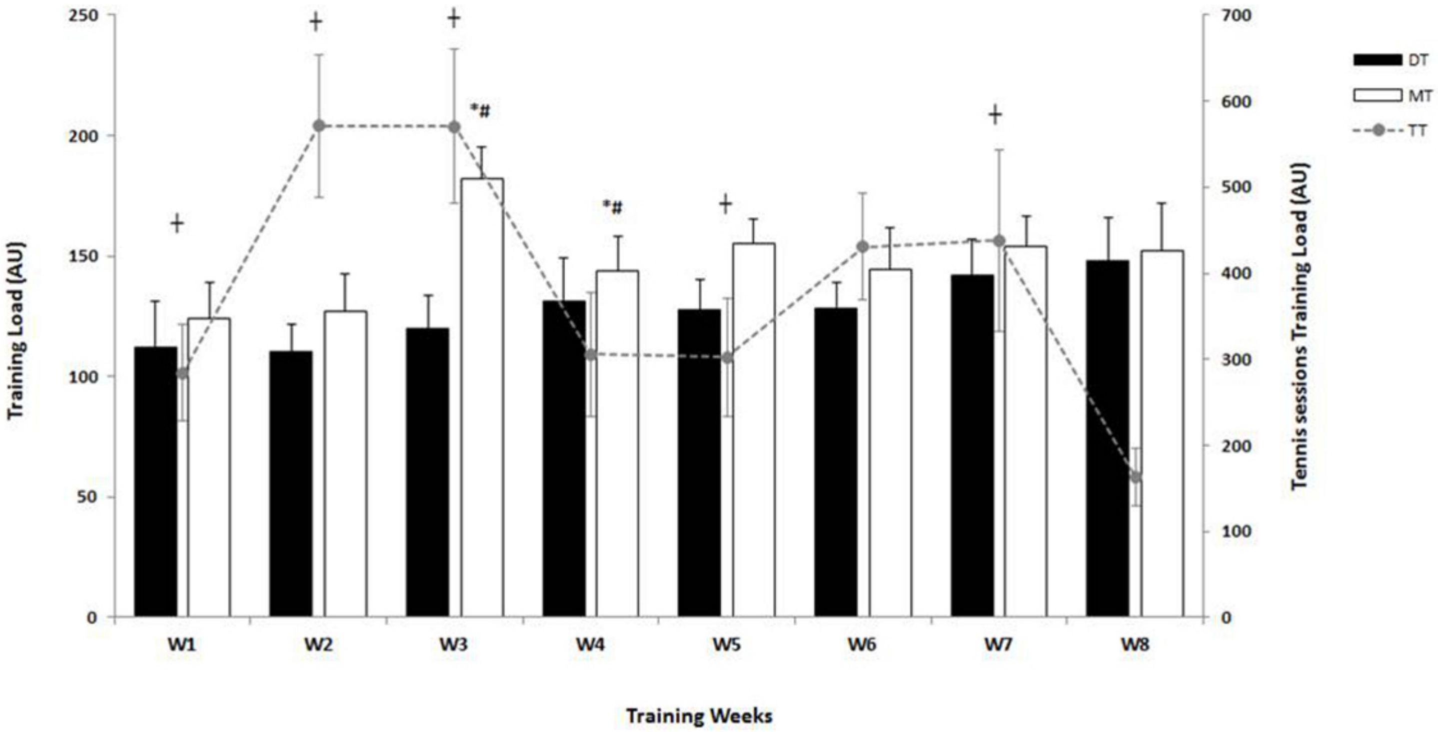

Figure 2 — Schematic representation of the training load induced by the training protocols. Abbreviations: DT, drill training; MT, mixed training; TT, tennis training; W, week; AU, arbitrary units.

It has been shown that the amount of high-intensity exercise (ie, HR >90% of HR_{peak}) accumulated during training has been positively related to changes in aerobic fitness.[34] Analyzing all training sessions separately (ie, on-court drills and runs), results showed that intensity was significantly higher (~5%) during HIT runs than during tennis drills (93.7% ± 1.7% vs 89.0% ± 1.9% HR_{peak}, ES = large), which can be related to a higher amount of time spent at training intensities >90% HR_{peak} by players when performing runs, and therefore differences, although nonsignificant, are reported in the VO_2peak values. These differences could be also related to the fact that runs based on the V_{IFT} can be controlled with much more precision than sport-specific drills,[13] so improvements in maximal aerobic power would be greater in this group.

Analyzing the effects of the 2 training programs on 30-15 IFT performance (ie, V_{IFT}), although both resulted to be effective and there were no differences between them, there was a larger increase in the V_{IFT} after the MT program (6.3%) than with the DT (2.2%). This could be partially explained by the larger increase in VO_2peak after MT (4.2%) than DT (2.4%), leading to a higher metabolic efficiency during recovery and therefore allowing athletes to sustain more high-intensity exercise during the 30-15 IFT.[8,33] However, it is well known that V_{IFT} accounts for multiple physiological variables associated with intermittent shuttle running (ie, VO_2peak, 10 m, CMJ).[19] We can speculate that the larger improvement in the MT may also be explained by the nature of training protocol, as the HIT runs were based on the 30-15 IFT. In this regard, the involvement of the same muscles during acceleration and deceleration movements (eg, biceps femoris, rectus femoris, hip adductors, iliopsoas) could lead players to positive changes in specific coordination and, therefore, in performance.[22]

Results showed that after the 8-week training intervention, neither of the training programs led to significant improvements in speed/agility (5- to 20-m sprint, 505 test) or explosive power (CMJ). These findings are in line with previous research that reported no changes in speed and explosive-power performance after either sport-specific exercises or HIT methods.[13,17] The lack of significant improvements in the CMJ or sprint time (20 m) could be related to the lack of overload and focus on speed and power training. Although this is not surprising, since both training programs were specifically designed to improve aerobic performance, present results also showed a large decrement (–2.6%) in the 505 test after the MT program. This could be related to the previously mentioned muscular involvement in similar actions (ie, decelerate and accelerate) required during both testing (505 test, which includes a change of direction) and training (ie, changes of direction at relatively high speeds during HIT runs).

It is well known that optimal TL is crucial to achieve training outcomes and improve performance. Although the risk of overreaching or even overtraining exists, it seems that intensive sessions are needed to generate adaptations and increases in performance.[27] The present RPE data during DT were similar to previous research analyzing on-court drills, as well as simulated match play (eg, 5–7 AU).[35,36] Regarding TL values, comparisons are difficult since there are no similar studies, and previous research analyzing TL during tennis training used different volumes in their sessions (ie, >1 h), with weekly TL values ranging from ~400 to ~2400 arbitrary units (AU).[35] In our study, weekly TL values (ie, putting together training protocols and tennis training) averaged 638 ± 132.4 AU and 679.2 ± 155 AU for DT and MT, respectively, which is in the range of previous studies and suggests a level of preparation for specific training/tournament demands. Regarding the differences observed in the TL during weeks 3 and 4, we can speculate that this is a normal process of acute fatigue required during training, as players followed a periodized plan including overload and progression, and values returned to be stable after the fourth training week. In this regard, the addition of fatigue-related measures (ie, total quality recovery scale, muscle/joint soreness) could provide specific information about overreaching/overtraining symptoms and warrants future studies, as improved perceptual recovery after training seems an important component of athlete recovery.[25]

Conclusions

In conclusion, this is the first study to report the effects of combining HIT and sport-specific drill training versus sport-specific drill training alone on fitness-performance characteristics in young tennis players. Results demonstrated that while both training programs resulted in significant improvements in aerobic performance, a mixed program combining tennis drills and runs based on the V_{IFT} was associated with greater gains. Based on the amount of time tennis players spend on the court, it seems that the use of tennis-specific drills could be recommended over high-intensity run training due to their higher specificity and valuable impact on tennis-performance-related parameters. However, based on our results, when the training priority is to develop the aerobic component (ie, VO_2peak and intermittent running ability) in young tennis players, a combined training program should be adopted.

Acknowledgments

We would like to thank the athletes and coaches for their enthusiasm and support. There are no conflicts of interest or financial disclosures to report. We would also like to thank Andre Putyera for his help reviewing the manuscript. The results of the current study do not constitute endorsement of the product by the authors or the journal.

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