COACHING & SPORT SCIENCE REVIEW

International Tennis Federation
www.itfcoachingreview.com
December 2017. 25th Year. Issue 73. 27-31
ISSN 2225-4757
https://doi.org/10.52383/itfcoaching.v25i73.303

Towards polarized training in tennis? Usefulness of combining technical and physiological assessments during a new incremental field test

Cyril Brechbuhl, Olivier Girard, Grégoire Millet and Laurent Schmitt

French Tennis Federation

ABSTRACT

Although tennis performance analysis underlines the relationship between physical and technical parameters, scientific or coaching approaches often neglect to develop these two aspects in the same training session. The effectiveness of combining physical and technical factors is reinforced by new results made available through the optimization of new technologies. Here, we discuss how the use of radar and ball machine may offer practical information to improve players' preparation concerning production of optimal ball velocity, ball accuracy and ball frequency..

Key words: Incremental test, ball accuracy, ball velocity, polarized training
Received: 28 Sep 2017
Acepted: 15 Nov 2017
Corresponding author: Cyril Brechbuhl, French Tennis Federation.
Email: cyril.brechbuhl@fft.fr

INTRODUCTION

For the past 30 years, tennis has evolved from a sport in which players' skill proficiency (technique) was the main determinant of performance into a game where physical attributes likely play a more predominant role. Nowadays, tennis is characterized by intense physical demands (Kovacs, 2007; Mendez-Villanueva, FernandezFernandez, Bishop, Fernandez-Garcia, & Terrados, 2007) coupled with rapid perceptual-motor processing (Triolet et al., 2013). Tennis is an explosive sport based on power, strength, and speed, in which serves faster than 200 km.h-1 are common (Kovacs, 2007).

In addition to producing elevated ball velocity (BV, km.h-1), maintaining ball accuracy (BA, i.e., number of errors, %) during intense periods towards a set or match end is also a key component for winning the faster-paced modern game (Kovacs, 2007). Although the sport-specific technical skills and tactical choices are predominant factors, even in the modern game, players require welldeveloped physical conditioning in order to execute advanced shots and maintain stroke efficiency as fatigue develops (Girard, Lattier, Maffiuletti, Micallef, & Millet, 2008).

Evaluation of aerobic fitness is commonly used to characterize training effects, evaluate physical fitness, and identify target training areas (Brechbuhl et al., 2016a). Recently, Baiget et al. highlighted the usefulness of using the Maximal Aerobic Frequency of ball hitting as a new training load parameter in tennis (Baiget et al, 2017), while we introduced analysis of technical alterations with incremental fatigue during a Test to Exhaustion Specific to Tennis (TEST) (Brechbuhl et al., 2017). Considering these two recent articles, we aim to report how they can lead to the integration of combined technical and physical prescription for specific on-court training. Moreover it is possible to assess the implementation of the "polarized training" approach (Seiler & Kjerland, 2006) in tennis by classifying types of sessions. Seiler and Kjerland (2006) refer to this training distribution as a polarized model, where approximately 75% of sessions are performed below the first ventilatory threshold, with 15% above the second ventilatory threshold and < 10% performed between the first and second ventilatory thresholds.

EQUIPMENT AND METHOD

Players

Twenty high-level competitive male tennis players (mean ± SD; age = 18.0 ± 3.2 year, stature = 182.8 ± 7.3 cm, body mass = 72.7 ± 7.2 kg) volunteered to participate in the study. They were all members of the national teams of the French Tennis Federation (International Tennis

Number 1 [elite]). Players were either members of the Association of Tennis Professionals (ATP) (two in top 100, two in top 200, two in top 500, and nine in top 1000) or of the International Tennis Federation (ITF) Juniors ranking (Participating in Grand Slams) at the time of the experiments (2013–2015). Two players have now reached the top 30 ATP.

All players performed the TEST protocol, previously described (Brechbuhl et al., 2016a; Brechbuhl et al., 2016b; Brechbuhl et al., 2017). Both the accuracy and the reliability of this new tennis ball machine appear satisfying enough for field testing and training purposes (Brechbuhl et al. 2016).

Evaluation of ground stroke performance

During TEST, groundstroke production was assessed by the mean of two ''primary'' variables: BV and BA. BV (km.h-1) was measured with a Solstice 2 radar (Hightof®, Echouboulains, France) positioned 50 cm behind the baseline. All shots that were hit out, into the net, and to the wrong spot on the tennis court were excluded. Spots where each ball landed (i.e., hits–errors) were instantaneously recorded by an experienced coach on a dedicated recording sheet. BA (%) was defined as the percentage of correct hits in the defined zones (Baiget et al., 2014). For each stage, BV and BA data have been averaged and expressed for forehands (BVf and BAf) and backhands (BVb and BAb), respectively. Finally, because BV and BA in combination better reflect the overall tennis performance, a TP index was calculated for forehands and backhands separately (TPf and TPb) as the product of these two variables.

Physiological measurements

Expired air was analyzed continuously (breath-by-breath measurements) for oxygen consumption (VO2) using a portable gas analyzer (Metamax II CPX system, Cortex®, Leipzig, Germany). Gas and volume calibration of the measurement device were performed before each test according to manufacturer's instructions. HR was recorded continuously (Suunto Ambit2®, Vantaa, Finland). Furthermore, 25 µL KL capillary blood samples were collected from the fingertip and analyzed for blood lactate concentrations (LT-1710; Arkray®, Kyoto, Japan) at the baseline, during TEST (i.e., during the 30-s recovery periods after every stage until a value of 4 mmol.L-1 was obtained and thereafter every 2 stages), and 15 s after exhaustion.

RESULTS

The players reached on average stage 10.9 ± 1.5 (~26 ± 1 balls.min- 1). At exhaustion, maximal oxygen uptake (VO2max), maximal heart rate (HRmax), and blood lactate concentration values were 61 ± 5 mL.min-1.kg-1, 195.8 ± 1.4 bpm, and 10.5 ± 1.9 mmol.L-1, respectively. At the second ventilatory threshold (VT2), VO2 and HR were 53.8 ± 4.5 mL.min-1.kg-1 (87.7 ± 0.1% VO2max) and 183.7 ± 4.2 bpm (93.8 ± 1.6% HRmax), respectively, corresponding to stage 7.3 ± 2.8 (~22 ± 3 balls.min-1).

Ground stroke performance

BV, BA, and TP (both backhand and forehand) did not differ between 60% and 80% of VO2max (Fig. 1).

We found significant reductions above this later intensity with BV, BA, and TP decreasing from 80% to 100% of VO2max (Table 1) for both strokes.

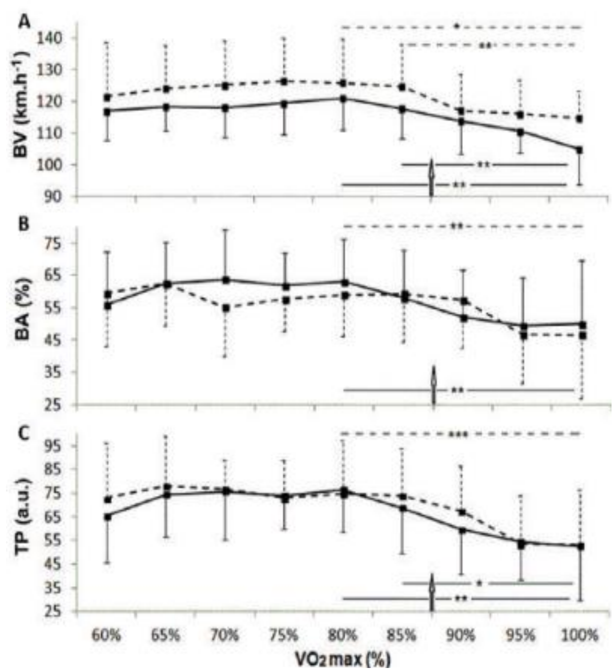

Figure 1: Changes in (A) ball velocity (BV), (B) ball accuracy (BA) and (C) tennis performance (TP) as a function of exercise intensity (% of VO2max) for forehands (white dots) and backhands (black dots). Vertical arrows indicate the second ventilatory threshold. BVf was 5.2% higher than BVb (121.7 ± 4.9 vs 115. 7 ± 8.6 km.h-1).

		Forehand	% change	Backhand	% change
BV	80%	126±13.8	-9.0% *	121±9.9	-13.3 % **
	100%	114.7±8.6		104.9±14.9	
BA	80%	57.7±10.4	-19.4 %***	61.9±10.1	-18.4%***
	100%	46.5±17.1		50.5±19.7	
TP	80%	73.0±16.0	-27.4 %***	74.1±21.8	-29.1 %***
	100%	53.0±14.4		52.5±22.6	

*Table 1: Differences in relative (%) and absolute values of Ball Velocity (BV, in km.h-1), Ball Accuracy (BA, expressed as % in zone) and Tennis Performance (TP), calculated as BA x BV and expressed as arbitrary units) for both forehands and backhands between 80% and 100% of VO2max. Values are presented as mean ± SD. * P < 0.05, ** P < 0.01, *** P < 0.001 significantly different from 80% of VO2max.*

Correlation

Not surprisingly, there were correlations between the players' ranking level and BA in both forehand (r = 0.45 to - 0.47, P < 0.05) and backhands (r = - 0.49, P < 0.05) and with TP (r = - 0.44 to - 0.46, P < 0.05) for forehand only between 80% and 100% of VO2max.

Associations of TP with BV (r = 0.51 and r = 0.49; both P < 0.001) and BA (r = 0.91 and r = 0.96; both P < 0.001) for forehands and backhands were significant. We observed an inverse correlation (r = - 0.51; P = 0.008) between blood lactate concentration and TP.

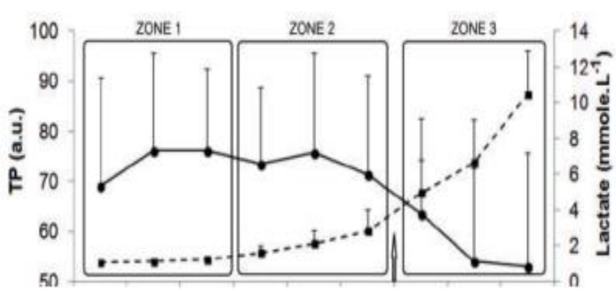

Figure 2: Intensity zones of change in tennis performance (TP) (plain line) and blood lactate concentration (dotted line) as a function of exercise intensity (% of VO2max). Zone 1 below 70% of VO2max, zone 2 between 75% to 87% of VO2max and zone 3 above 87% of VO2max. Vertical arrows indicate the second ventilatory threshold.

DISCUSSION

Elite players were able to maintain technical effectiveness until an intensity of 80% VO2max, which was slightly below VT2 (87% VO2max, and 94% HRmax). Information obtained during TEST can be used to illustrate changes in stroke quality of tested players at different exercise intensities in a context appropriate to the game.

We highlight some practical implications of our findings. First, by using TEST data we propose that technically- or physicallyoriented training sessions can easily be developed, as previously detailed for one elite player (Brechbuhl et al., 2016b). Second, of interest is that the correlation between TP and BA (r = 0.91 and r = 0.96, for forehand and backhand strokes, respectively) is stronger than that with BV (r = 0.51 and r = 0.49), highlighting the prominence of the technical skills in elite tennis. It means that high technical skills but not neither power nor speed are necessary to be classified as a ''technically good'' player. Baiget et al. (2014) also identified a significant and moderate correlation (r = 0.61, P = 0.001) between the competitive level and the accuracy. This highlights that to reach the highest level, players need not only to hit fast strokes but also need to maintain accuracy as fatigue develops. BA has been identified as a key predictor for tennis competitions (Smekal et al., 2000).We showed that TP is affected by the arduousness of the activity (Brechbuhl et al., 2017), so that coaches can carefully adjust training intensity in order to target specific development objectives within the same session (table 2).

	Zone 1	Zone 2	Zone 3
	Stage 16-22 balls.min-1 ≤ 70% VO2max. BA ~70% BV ~ 120 km.h-1 ‹ 80% HRmax. [la-] ‹ 2 mmol.L-1	Stage 22-24 balls.min-1 Between 75%-87% VO2max. BA ‹ 60% ; BV ‹ 120 km.h-1 80%-90% HRmax. 2 mmol.L-1 ‹ [la-] ‹ 4 mmol.L-1	Stage 25-29 balls.min-1 VO2 ≥ 87% VO2max. BA ‹ 60% BV ‹ 120 km.h-1 › 90%HRmax [la-] › 4 mmol.L-1
Technical	Balance, energy transfer, skill of the hand, short footwork	Big footwork, balance, energy transfer, coordination between upper and lower body	Velocity of footwork, balance, coordination between upper and lower body, braking and restarting of the course
Physical	Vascularisation of muscles, number and size of mitochondria, amount of aerobic enzymes and beta-oxydation enzymes (Laursen, 2010)	Use of shuttle systems of transport of hydrogen ions (Nicotinamide Adenine dinucleotide) (White & Schenk, 2012), carbohydrate and fat use (Holloszy, Kohrt, & Hansen, 1998))	Maximal Aerobic Frequency of ball hitting, cardiopulmonary capacity, transport of oxygen, glycolytic enzymes (Phosphofructokinase and Lactate deshydrogenase), muscle buffering capacity, muscle glycogen stores (Laursen & Jenkins, 2002)

Table 2. Sample for specific on-court training protocols for optimizing aerobic fitness and technical effectiveness in elite tennis players. Maximal oxygen uptake (VO2max.), ball accuracy (BA), ball velocity (BV), maximal heart rate (HRmax),

For instance, when targeting improvement in technical skills, we recommend to train at low intensities, in zone 1 (VO2 at or below VT1) (Esteve-Lanao et al., 2005), corresponding to BA of ~70% and BV of ~120 km.h-1 in our cohort of players. Even if it represents a small playing time (3% ± 5%) (Baiget et al., 2015), time in zone 1 brings physiological benefits and will indirectly lead to improved capacity to cope with the higher intensity of competitive tennis (zone 3: VO2 at or above VT2) corresponding to the ''money time'' of the game.

As shown in Figure 1, we can also estimate VT2 from the decline of the technical parameters, and more particularly the decrease in BA. Our proposed model with 3 intensity zones for training the tennis player can also be based on the HR response associated to reproducible metabolic demarcation points (i.e., lactate or ventilatory thresholds), thus allowing to examine the physiological strain during various types of exercise. It has consistently been used in endurance (Esteve-Lanao et al., 2005) and team sports (Akubat et al., 2012). The HR-based model was previously used in tennis and defines three HR zones (Baiget et al., 2015), while we suggest here the following distribution: zone 1 (low intensity, ≤ 80% HRmax), zone 2 (moderate intensity, 80% to 90% HRmax), and zone 3 (high intensity, ≥ 90% HRmax). Second, TEST enables us to easily assess BA, which is a key predictor of tennis performance (Smekal et al., 2000), also supported by significant correlations between stroke production and success in match play (Vergauwen et al., 1998).

CONCLUSIONS

A model (3 intensities) is proposed starting from the realization of an incremental test in which physiological and technical data are measured simultaneously, and then their kinetics of change are compared.

Through TEST and its applications, our aim was to suggest a global approach designed to avoid redundant physiological demands.

Without underestimating the diversity of practices, the combination of physical and technical contents may contribute to more efficient planning and better management of fatigue. Since the present data only concerns elite male players, further investigation on female players is required.

RÉFÉRENCES

Akubat, I., Patel, E., Barrett, S., & Abt, G. (2012). Methods of monitoring the training and match load and their relationship to changes in fitness in professional youth soccer players. J Sports Sci, 30(14), 1473-1480. https://doi.org/10.1080/02640414.2012.712711

Baiget, E., Fernandez-Fernandez, J., Iglesias, X., & Rodriguez, F. A. (2015). Tennis Play Intensity Distribution and Relation with Aerobic Fitness in Competitive Players. PLoS One, 10(6), e0131304. https://doi.org/10.1371/journal.pone.0131304

Baiget, E., Fernandez-Fernandez, J., Iglesias, X., Vallejo, L., & Rodriguez, F. A. (2014). On-court endurance and performance testing in competitive male tennis players. J Strength Cond Res, 28(1), 256-264. https://doi.org/10.1519/JSC.0b013e3182955dad

Baiget, E., Iglesias, X., & Rodriguez, F. A. (2017). Maximal Aerobic Frequency of Ball Hitting: A New Training Load Parameter in Tennis. J Strength Cond Res, 31(1), 106-114. https://doi.org/10.1519/JSC.0000000000001480

Brechbuhl, C., Girard, O., Millet, G. P., & Schmitt, L. (2016a). On the Use of a Test to Exhaustion Specific to Tennis (TEST) with Ball Hitting by Elite Players. PLoS One, 11(4), e0152389. https://doi.org/10.1371/journal.pone.0152389

Brechbuhl, C., Girard, O., Millet, G. P., & Schmitt, L. (2016b). Stress test specific to tennis. ITF Coach Sport Sci Rev(70), 26-29.

Brechbuhl, C., Girard, O., Millet, G. P., & Schmitt, L. (2017). Technical Alterations during an Incremental Field Test in Elite Male Tennis Players. Med Sci Sports Exerc, 49(9), 1917-1926. https://doi.org/10.1249/MSS.0000000000001303

Brechbuhl, C., Millet, G., & Schmitt, L. (2016). Accuracy and Reliability of a New Tennis Ball Machine. J Sports Sci Med, 15(2), 263-267.

Esteve-Lanao, J., San Juan, A. F., Earnest, C. P., Foster, C., & Lucia, A. (2005). How do endurance runners actually train? Relationship with competition performance. Med Sci Sports Exerc, 37(3), 496-504. https://doi.org/10.1249/01.MSS.0000155393.78744.86

Girard, O., Lattier, G., Maffiuletti, N. A., Micallef, J. P., & Millet, G. P. (2008). Neuromuscular fatigue during a prolonged intermittent exercise: Application to tennis. J Electromyogr Kinesiol, 18(6), 1038-1046. https://doi.org/10.1016/j.jelekin.2007.05.005

Holloszy, J. O., Kohrt, W. M., & Hansen, P. A. (1998). The regulation of carbohydrate and fat metabolism during and after exercise. Front Biosci, 3, D1011-1027. https://doi.org/10.2741/A342

Kovacs, M. S. (2007). Tennis physiology: training the competitive athlete. Sports Med, 37(3), 189-198. https://doi.org/10.2165/00007256-200737030-00001

Laursen, P. B. (2010). Training for intense exercise performance: high-intensity or high-volume training? Scand J Med Sci Sports, 20 Suppl 2, 1-10. https://doi.org/10.1111/j.1600-0838.2010.01184.x

Laursen, P. B., & Jenkins, D. G. (2002). The scientific basis for highintensity interval training: optimising training programmes and maximising performance in highly trained endurance athletes. Sports Med, 32(1), 53-73. https://doi.org/10.2165/00007256-200232010-00003

Mendez-Villanueva, A., Fernandez-Fernandez, J., Bishop, D., Fernandez-Garcia, B., & Terrados, N. (2007). Activity patterns, blood lactate concentrations and ratings of perceived exertion during a professional singles tennis tournament. Br J Sports Med, 41(5), 296-300; discussion 300. https://doi.org/10.1136/bjsm.2006.030536

Seiler, K. S., & Kjerland, G. O. (2006). Quantifying training intensity distribution in elite endurance athletes: is there evidence for an "optimal" distribution? Scand J Med Sci Sports, 16(1), 49-56. https://doi.org/10.1111/j.1600-0838.2004.00418.x

Smekal, G., Pokan, R., von Duvillard, S. P., Baron, R., Tschan, H., & Bachl, N. (2000). Comparison of laboratory and "on-court" endurance testing in tennis. Int J Sports Med, 21(4), 242-249. https://doi.org/10.1055/s-2000-310

Triolet, C., Benguigui, N., Le Runigo, C., & Williams, A. M. (2013). Quantifying the nature of anticipation in professional tennis. J Sports Sci, 31(8), 820-830. https://doi.org/10.1080/02640414.2012.759658

Vergauwen, L., Spaepen, A. J., Lefevre, J., & Hespel, P. (1998). Evaluation of stroke performance in tennis. Med Sci Sports Exerc, 30(8), 1281-1288. https://doi.org/10.1097/00005768-199808000-00016 https://doi.org/10.1097/00005768-199808000-00017

White, A. T., & Schenk, S. (2012). NAD(+)/NADH and skeletal muscle mitochondrial adaptations to exercise. Am J Physiol Endocrinol Metab, 303(3), E308-321. https://doi.org/10.1152/ajpendo.00054.2012