

ANALIZA TENIŠKE IGRE

V tej predstavitvi bomo...

Analizirali teniško igro z vidika.

- Časovnih značilnosti
- Gibalnih sposobnosti
- Fizioloških/energijskih procesov
- Psiholoških zahtev/procesov
- Tekmovalnih pogojev
- Taktično/tehničnih/igralnih kompetenc
- ...

Analiza časovnih značilnosti na travi

	1992 Wimbledon	1996 Wimbledon	2001 Wimbledon (Ivanišević – Rafter)	2005 Wimbledon
Štev.tekem	7	14	1	13
Študija	Hughes & Clarke, 1995	O'Donoghue & Liddle, 1998	Zlatoper, 2002	(Morante & Brotherhood, 2005)
Povp.štev.udarce v	3,1	NA	NA	NA
Povp.traj. točke	2,5	3,6	2,7	5,2
Trajanje odmora	11	10,5	10,1	NA
Trajanje odmora med igrami	22,3	18,4	18,7	NA
% aktiv.časa	5	11,5	7,5	17,5

Analiza časovnih značilnosti na trdi podlagi

	1988 US Open (Wilander – Lendl)	1992 Australian Open	1993 US Open (Sampras–Piolin)	2000 US Open (Safin-Sampras)	2001 Australian Open (Agassi – Clement)	2001 US Open (Hewitt-Sampras)	2003 US Open (Roddick–Ferrero)	2005 Australian Open
Štev.tekem	1	5	1	1	1	1	1	13
Študija	Ferjan, 2001	Hughes & Clarke, 1995	Ferjan, 2001	Ferjan, 2001	Ferjan, 2001	Zlatoper, 2002	(Kovacs, 2004)	(Morante & Brotherhood, 2005)
Povp.štev.udarc ev	NA	4,7	NA	NA	NA	NA	NA	NA
Povp.traj.točke	12,2	4,8	6,6	4,7	7,3	3,8	6,0	6,4
Trajanje odmora	12,1	9,6	9,2	9,8	8,7	9,6	7,7	NA
Trajanje odmora med igrami	28,3	23,2	21,2	19,2	19,0	19,9	15,2	NA
% aktiv.časa	22,4	10	11	7,9	12,1	6,3	NA	20,5

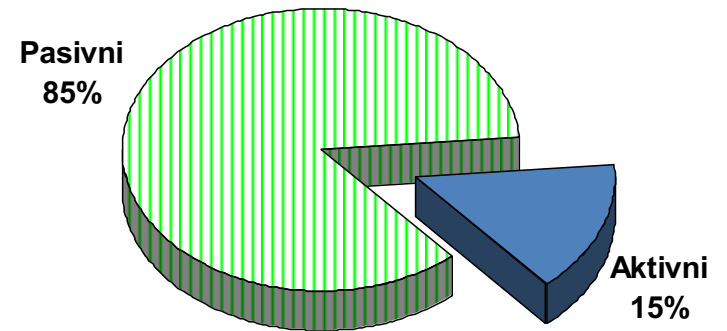
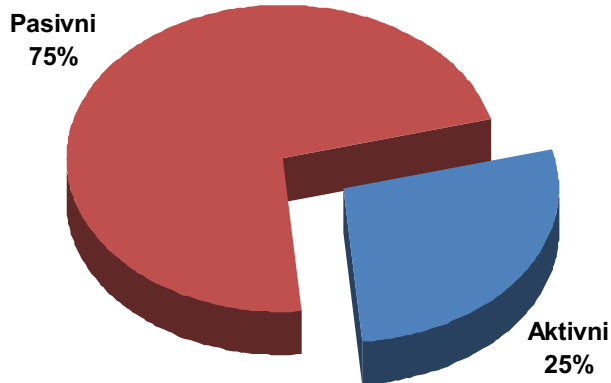
Analiza časovnih značilnosti na pesku

	1993 Roland Garros (Bruguera – Coriuer)	1996 Roland Garros	2001 Roland Garros (Kuerten – Corretja)	2002 Roland Garros (Costa – Ferrero)
Štev.tekem	1	9	1	1
Študija	Ferjan, 2001	O'Donoghue & Liddle, 1998	Pintarič, 2002	Pintarič, 2002
Povpr.štev. udarcev	NA	NA	NA	NA
Povp.traj. točke	8	5,6	6,8	6,1
Trajanje odmora	8,6	10,1	10,6	11,5
Trajanje odmora med igrani	27,3	19,9	23,9	23,8
% aktiv. časa	16,6	14,9	11,4	10,2

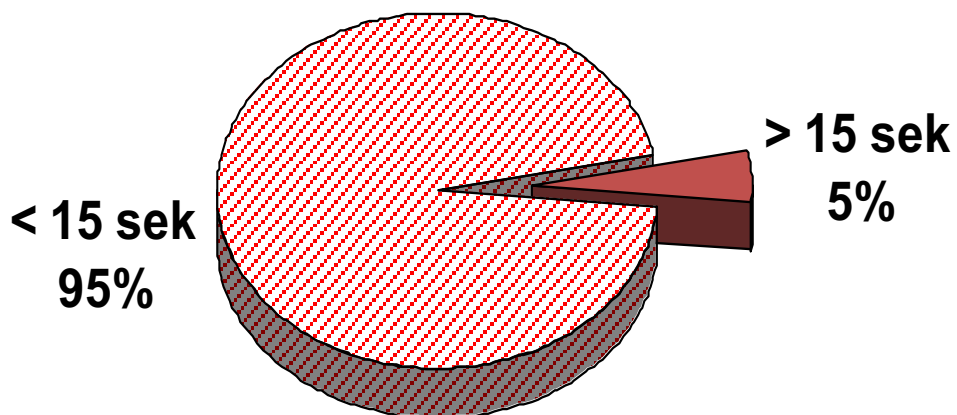
Aktivni/pasivni del igre

Trda podloga

Pesek



Trajanje točk v tekem



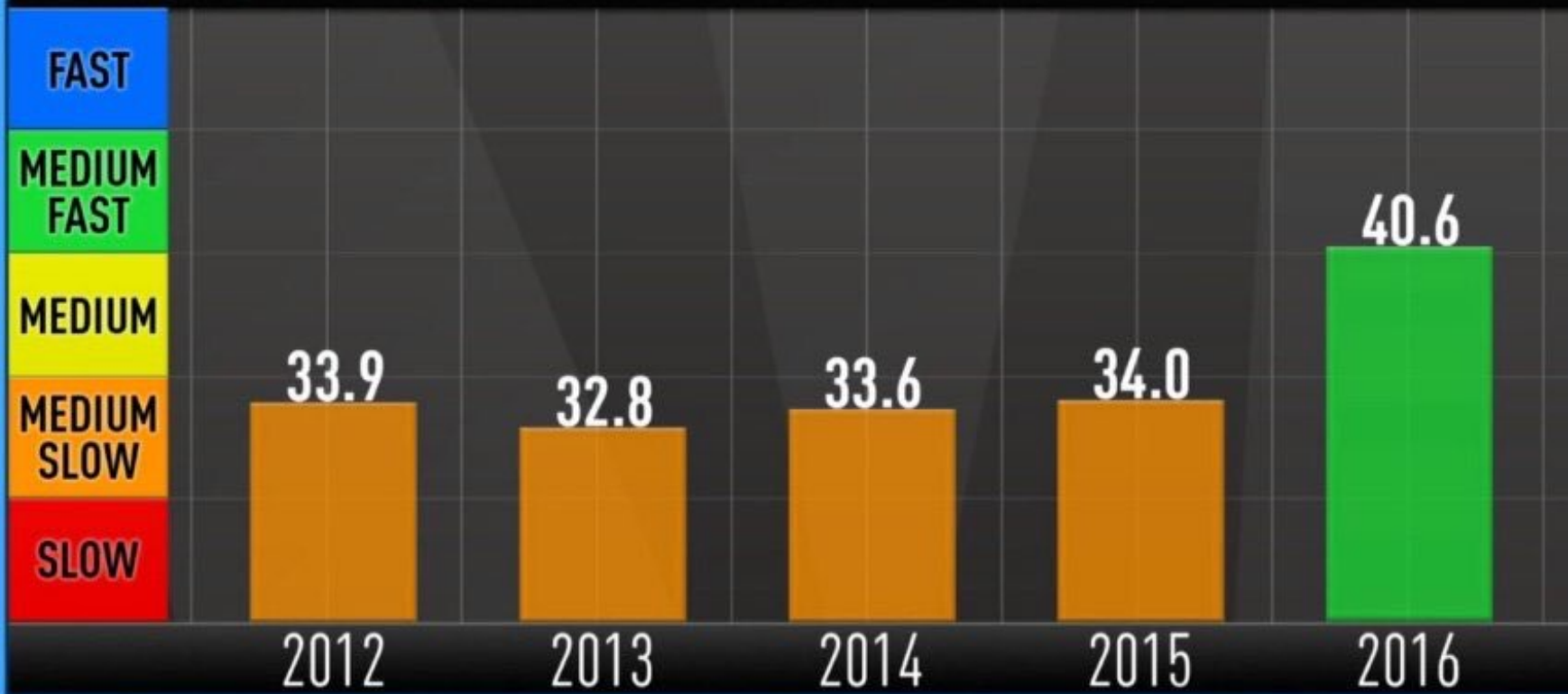
Trajanje točke vs tempo

MOURESMO – MYSKINA

Time, sec Tempo, str/min	Total	< 3"	<5"	< 10"	< 15"	< 20"	> 20"
	100%	18%	23%	36%	9%	9%	4%
< 15							
16-20	1.575		33.3%	33.3%	33.3%		
21-24	15.18%	21.2%	6.9%	27.6%	13.8%	27.6%	13.8
25-26	11.52%	13.6%	4.5%	31.8%	18.2%	18.2%	13.6%
27-28	10.47%	5%	10%	35%	30%	20%	
29-30	7.85%		20%	66.7%	13.3%		
31-35	14.66%	1.7%	17.9%	64.2%	3.6%	3.6%	
36-40	13.09%	4%	60%	36%			
> 40	25.65%	44.9%	34.7%	18.4%	2%		

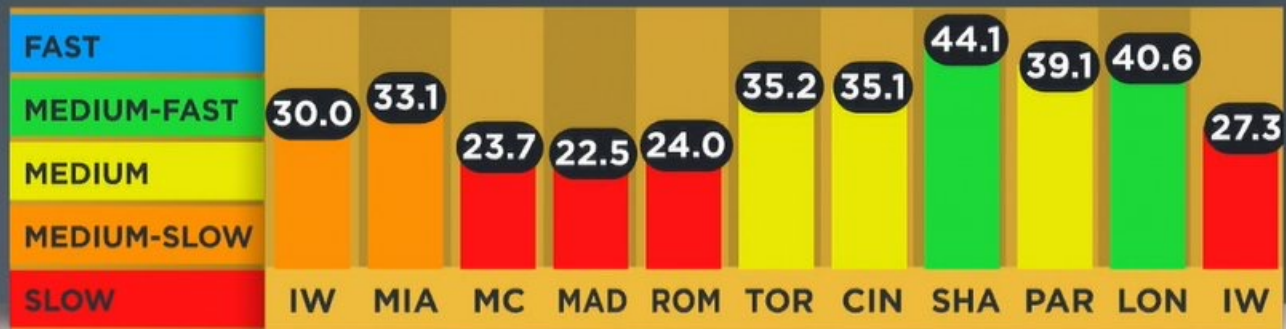
COURT PACE INDEX

BARCLAYS ATP WORLD TOUR FINALS



COURT PACE INDEX

2016/2017 Main Court Averages



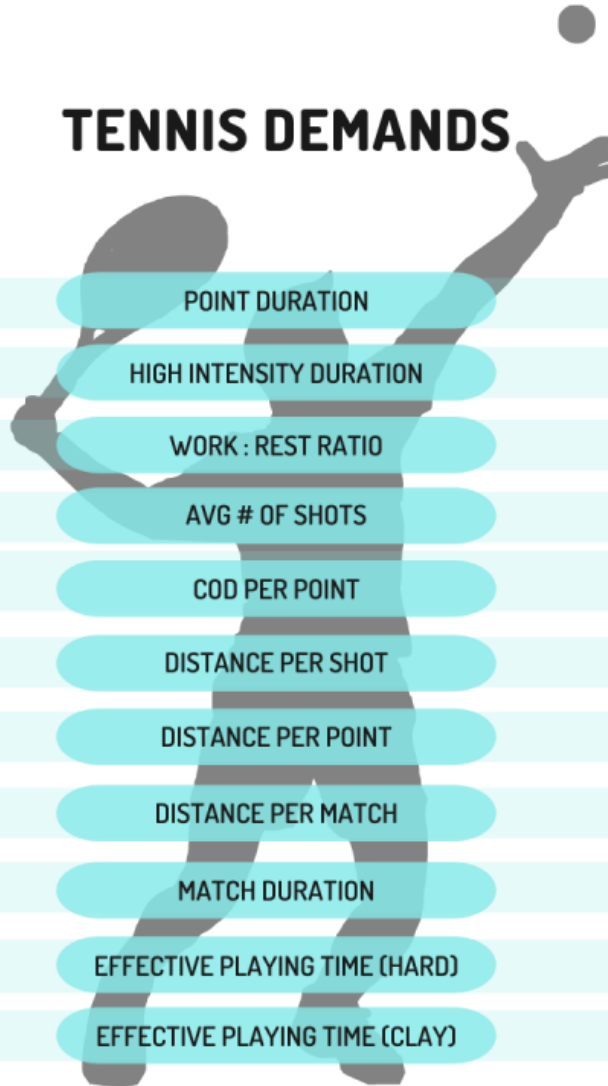


AVERAGE SCENARIO

TENNIS DEMANDS



WORST CASE SCENARIO



8 sec	POINT DURATION	15 sec
4 sec	HIGH INTENSITY DURATION	10 sec
1:2	WORK : REST RATIO	1:5
3	AVG # OF SHOTS	5
4	COD PER POINT	6
3m	DISTANCE PER SHOT	5m
8m	DISTANCE PER POINT	15m
approx. 2600m	DISTANCE PER MATCH	approx. 5200m
1.5h	MATCH DURATION	2.65h
9 min [10%]	EFFECTIVE PLAYING TIME (HARD)	15 min [15%]
18 min [20%]	EFFECTIVE PLAYING TIME (CLAY)	27 min [30%]

TENNIS DEMANDS

REST BETWEEN POINTS	20 sec
REST BETWEEN GAMES	60-90 sec
REST BETWEEN SETS	120-150 sec
STANDING STROKES	in 80% less than 2,5m
SLIDING STROKES	in 10% less than 2,5-4,5m
RUNNING STROKES	in 5% more than 4,5m
PLAYING TIME (ATTACKING)	21%
PLAYING TIME (ALL COURT)	28,60%
PLAYING TIME (BASELINER)	38,50%



V02 MAX
44-69 ml/kg/min

HEART RATE
AVERAGE 145 bpm ± 13 bpm
MAXIMAL 180 + bpm

LACTATE
HARD 1,7-3,8 mmol
CLAY 3,8-6 mmol

EFFORTS
> 6 m/s = 5
> 8 m/s = 10

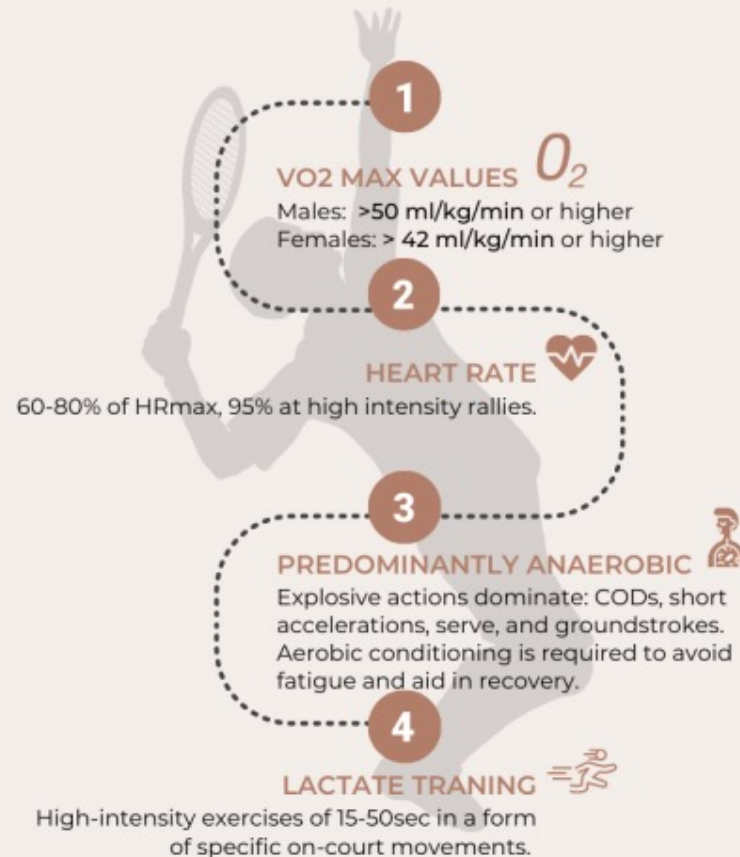
MADE BY @brem3c & b.nasty_13

Fiziološki vidik

Procesi obnove (proizvajanja) ATP temeljijo na treh energijskih sistemih, ki lahko delujejo istočasno:

- Kreatin-fosfatni sistem (CP)
- Sistem anaerobne glikolize
- Aerobni sistem.

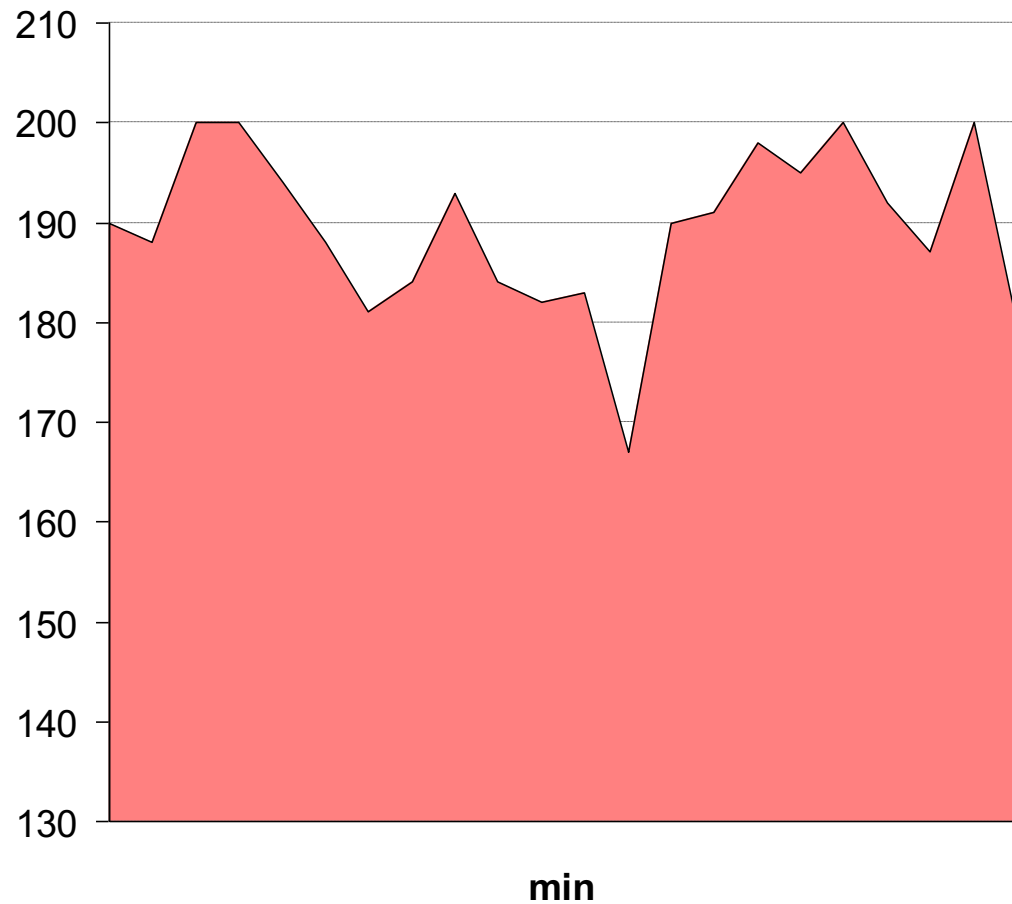
Tennis Demands: Energy Systems



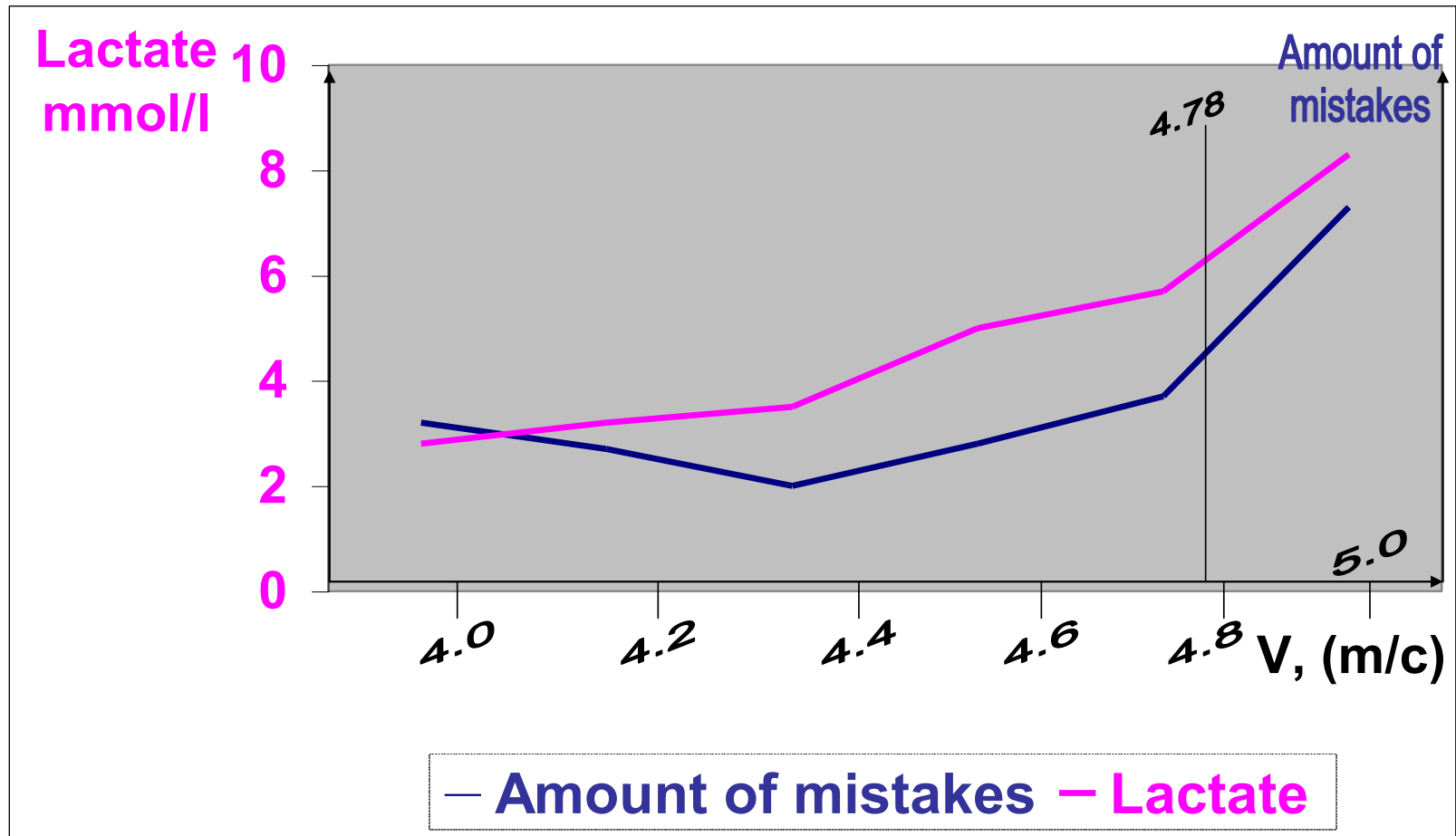
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Srčni utrip v času tekme

ZVEREVA/VANJUKOVA
HB/min.



Laktat in število udarcev



Physiological demands of match-play in elite tennis: A case study

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Abstract

The physiological and perceptual demands together with match notation of a four-set tennis match were studied in two elite professional players during the preparation for the 2008 Davis Cup. The design of this case report is unique in that it is the first to describe the demands of prolonged match-play (197 min) over four sets in ecologically valid conditions. The variables measured before and after each set included blood lactate and glucose concentrations, body mass, and perception of effort. Stroke count for each rally and heart rate were recorded during each set while salivary cortisol concentration was determined before and after the match. The rally length decreased as the match progressed. The results showed significant physiological stress, with each player losing greater than 2.5% of body mass (as fluid) and having elevated salivary cortisol concentrations after the match. Heart rate and perception of effort were also increased following each set indicating increasing stress. However, blood lactate decreased following the fourth set while blood glucose was maintained. The results also suggest that elite players may adjust work rates or tactics to cope with the increased perception of effort. This report shows that four sets of tennis are associated with increasing stress and fatigue.

Keywords: *Racket sports, match analysis, fatigue, physiological demands, perception of effort*

Srčni utrip v tenisu in intenzivnost

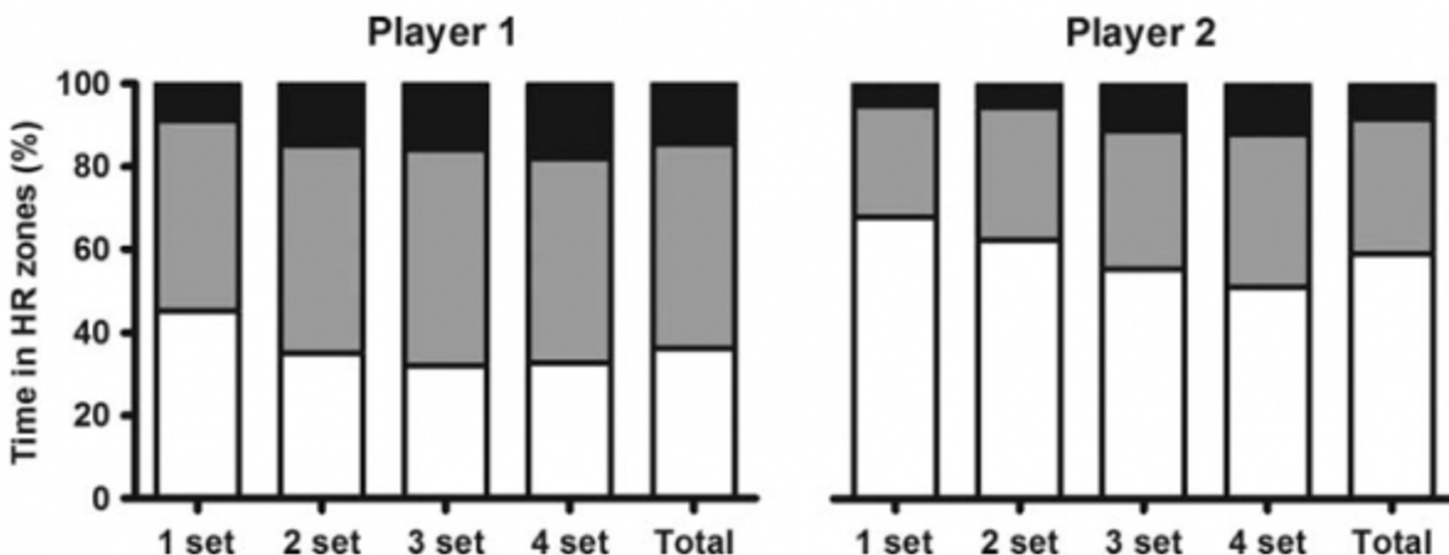


Figure 3: Percentage of time spent in low- (open), moderate- (grey), and high-intensity (black) heart rate (HR) zones for each set, and the overall tennis match (adopted from Gomes et al., 2011).

Število udarcev v nizih

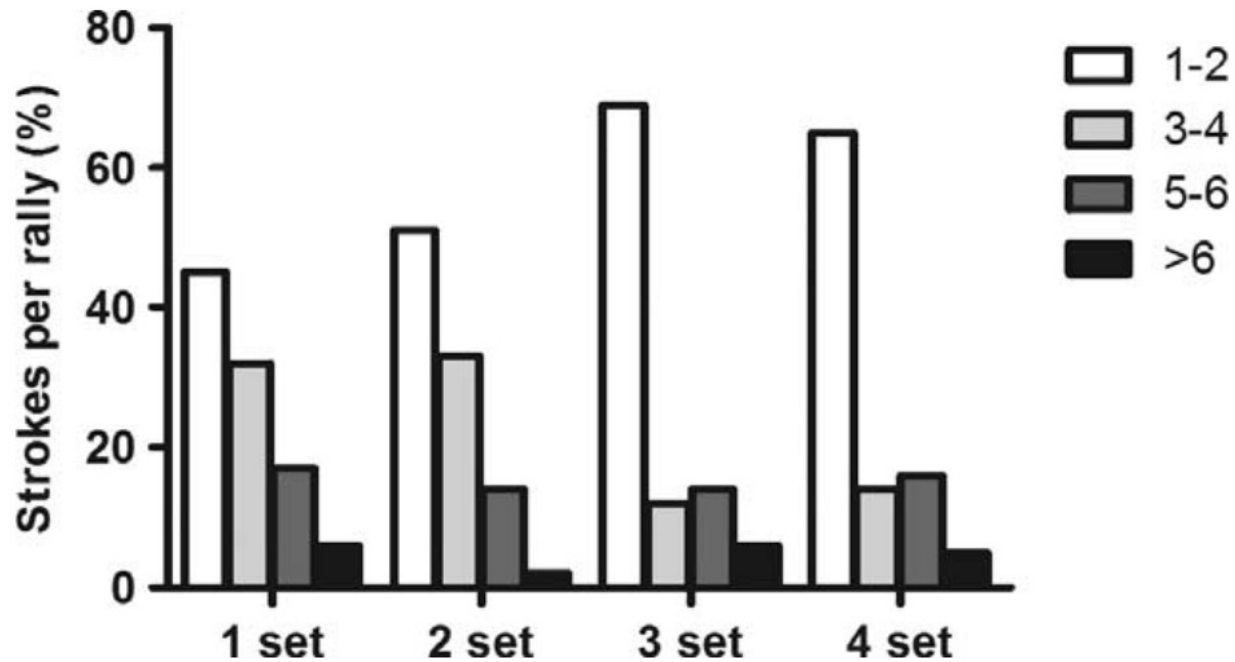


Figure 2. Proportion of strokes per rally during tennis match-play.

The physiological demands of tennis and how to train them

Ava Kerr

ABSTRACT

Tennis is a fast paced sport with specific energy requirements that are dictated by the unpredictable nature of match play. This purpose of this article was to provide a rationale for a specific training program to enhance the energy systems utilised by a female national level tournament player. A review of match play, energy system contributions, associated heart rate and VO2 max values, strength requirements and training loads, and skill based conditioning and injury prevention were explored. The practical application of a sample 4 week mesocycle were presented with associated programs for resistance training, speed, agility and anaerobic circuit training. The overall goals of this program were to increase the intensity of sports specific training as well as improve and maintain game skills. The resistance training program followed an undulating cycle of strength and endurance based sessions incorporating injury prevention exercises. The key finding from this case study was that individualized sport specific training maintained and improved straight line speed and 3RM strength in a sub elite female tennis player. Additionally, this training regime could be increased progressively without causing acute injuries. The athlete reported an increase in confidence in match play in part attributed to undertaking the training program. It is not conclusive that this program design would be appropriate for all tennis players or replicate the same results. Further research is warranted on the tailoring of specific training programs for tennis players that incorporate individual resistance training, speed, agility and anaerobic circuit training.

Table 5: Strength Endurance Training Program

ATHLETE: JK		SPORT: Tennis			
PHASE: Preseason					
Program Purpose: Strength Power		Monitor: Session RPE, Star Excursion Balance			
Warm Up:		Bike 5 min, Med ball toss 2 x 10 Standing trunk rotations with pivot x 10 L & R Internal/External rotations of shoulder			
Training Program 4 WEEKS	1	2	3	4	
Workout A - FRIDAY					
EXERCISE	12-15 RM	12-15 RM	12-15 RM	12-15 RM	Rest
Bench Press	15,15,15	14,14,14	12,12,12	14,14	1-1.5 min
Bent over Row	15,15,15	14,14,14	12,12,12	14,14	between
Bulgarian Split Squats	15,15,15	14,14,14	12,12,12	14,14	sets
Upright Row EZY Curl Bar	15,15	14,14	12,12	14,14	
Hip Thrusts weighted	20,20,20	18,18,18	16,16,16	18,18	
	10-12 RM	10-12 RM	10-12 RM	10-12 RM	Rest
Dumbbell Internal Rotation	12	11,11	10,10	10,10	1.5 - 2 min
Dumbbell External Rotation	12	11,11	10,10	10,10	
Abs/core below					
Session Duration (minutes)	45	45	45	45	
Session RPE (1 -10)	5	6	5	6	
Daily Training Load	225	270	225	270	0

THE PHYSIOLOGICAL DEMANDS OF HITTING AND RUNNING IN TENNIS ON DIFFERENT SURFACES

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ABSTRACT

Fernandez-Fernandez, J, Kinner, V, and Ferrauti, A. The physiological demands of hitting and running in tennis on different surfaces. *J Strength Cond Res* 24(12): 3255–3264, 2010—The aim of the study was to examine how the training surface (i.e., clay or carpet) affects the characteristics (i.e., ball velocity, running pressure, running volume, and physiological responses) of a tennis training session. Ten competitive healthy and nationally ranked male tennis players (mean \pm SD: age 24.2 ± 1.7 years, weight 81.4 ± 7.6 kg, height 1.88 ± 0.05 m, body mass index 23.1 ± 1.8) participated in a maximal treadmill test and a field test (e.g., an on-court tennis training session, which consisted of 4 exercises). Subjects' oxygen uptake ($\dot{V}O_2$) and heart rate (HR) were recorded by portable analyzers, and the ball velocity was measured using a radar gun during the training sessions. We did not find any significant influence of the court surface on any of the variables analyzed under the standardized exercise conditions of the study, as suggested in previous studies conducted under match-play conditions. Moreover, data showed significant differences between maximal forehand and backhand stroke velocities, the forehand stroke being significantly faster ($p = 0.01$) and more energy demanding on both playing surfaces (clay: 122.0 ± 9.1 vs. 111.1 ± 7.5 ; carpet: 120.4 ± 6.0 vs. 111.5 ± 7.0 km·h⁻¹). Comparing the same stroke on the same court surface, but at different stroke velocities, we found significant differences ($p < 0.05$) in all the physiological measurements (e.g., HR, %HRmax; $\dot{V}O_2$; % $\dot{V}O_2$), which significantly increased with hitting velocity.

KEY WORDS tennis, oxygen uptake, heart rate, stroke velocity

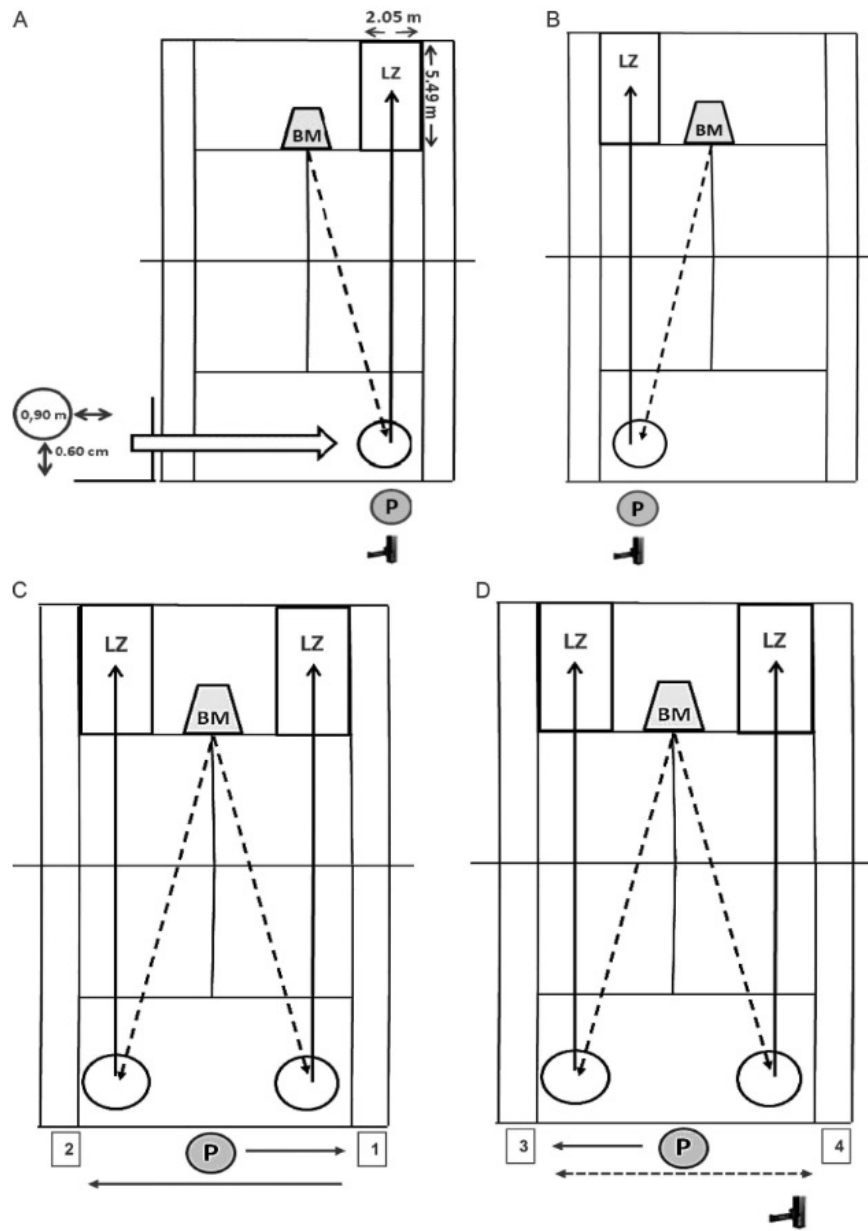


TABLE 3. Physiological and performance demands of exercises A and B.*†

Variables	Exercise A (submaximum)				Exercise B (maximum)				
	Clay		Carpet		Clay		Carpet		
	Stroke	FH	BH	FH	BH	FH	BH	FH	BH
HR (b·min ⁻¹)		129.0 ± 19.3	137.0 ± 19.1	127.4 ± 19.8	131.3 ± 18.1	166.0 ± 13.3‡	171.0 ± 14.0‡	168.0 ± 16.5‡	169.3 ± 16.0‡
%HRmax		66.4 ± 8.9	70.6 ± 9.1	65.5 ± 8.7	67.6 ± 7.9	86.0 ± 5.0‡	88.1 ± 6.5‡	86.3 ± 6.1‡	87.1 ± 5.3‡
$\dot{V}O_2$ (ml·kg ⁻¹ ·min ⁻¹)		29.5 ± 6.9	30.8 ± 7.0	27.8 ± 8.1	29.6 ± 7.8	46.5 ± 11.1‡§	42.5 ± 9.9‡	43.8 ± 9.1‡	42.3 ± 10.0‡
% $\dot{V}O_2$ max		52.7 ± 11.0	55.4 ± 13.0	49.4 ± 12.5	52.6 ± 12.0	83.6 ± 20.3‡§	76.2 ± 17.2‡	78.7 ± 17‡	77.0 ± 17.2‡
Energy expenditure (kcal·min ⁻¹)		11.4 ± 2.3	11.9 ± 2.2	10.8 ± 2.9	11.4 ± 2.8	18.5 ± 4.6‡§	16.8 ± 3.9‡	17.3 ± 3.8‡	16.9 ± 4.1‡
Stroke velocity (km·h ⁻¹)		88.1 ± 6.7	85.1 ± 6.7	86.1 ± 7.0	82.5 ± 8.1	122.0 ± 9.1‡§	111.1 ± 7.5‡	120.4 ± 6.0‡§	111.5 ± 7.0‡

*FH = forehand; BH = backhand; HR = heart rate; %HRmax = percentage of maximum heart rate; $\dot{V}O_2$ = oxygen consumption; % $\dot{V}O_2$ max = percentage of maximum oxygen uptake.

†Values are mean ± SD.

‡Significant differences ($p < 0.05$) between exercises A and B.

§Significant differences ($p < 0.05$) between FH and BH.

A COMPARISON OF THE ACTIVITY PROFILE AND PHYSIOLOGICAL DEMANDS BETWEEN ADVANCED AND RECREATIONAL VETERAN TENNIS PLAYERS

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ABSTRACT

Fernandez-Fernandez, J, Sanz-Rivas, D, Sanchez-Muñoz, C, Pluim, BM, Tiemessen, I, and Mendez-Villanueva, A. A comparison of the activity profile and physiological demands between advanced and recreational veteran tennis players. *J Strength Cond Res* 23(2): 604–610, 2009—The aim of the study was to examine whether differences in playing level influence the activity profile and physiological demands of advanced and recreational veteran men's tennis players during an hour of tennis match play. Ten advanced (International Tennis Number [ITN] 3–5, 45.3 ± 5.1 years) and 10 recreational (ITN 7–9, 44.8 ± 4.7 years) veteran men's tennis players participated in 4 experimental sessions: (1) an ITN on-court assessment, (2) a laboratory incremental treadmill test, (3) an hour of simulated tennis match play, and (4) 30 minutes of tennis match play using a portable gas analyzer. Subjects' $\dot{V}O_2$ and heart rate (HR) were recorded by portable analyzers. Moreover, energy expenditure was evaluated by indirect calorimetry. Temporal structure and distance covered were determined from video recordings. Subjects' $\dot{V}O_2$ (24.5 ± 4.1 vs. 23.3 ± 3 ml·kg⁻¹·min⁻¹), HR (148.3 ± 11.5 vs. 149.8 ± 8.4 bpm), duration of rallies (DR) (6.3 ± 4.1 vs. 7.6 ± 5.5 seconds), and effective playing time (EPT) (21.7 ± 5.0 vs. $23.6 \pm 5.4\%$), HR (148.3 ± 11.5 vs. 149.8 ± 8.4 bpm), and energy expenditure (263.1 ± 49.4 and 281.3 ± 61.8 kcal·min⁻¹) during play did not differ significantly ($p > 0.05$) between advanced and recreational players. The advanced players covered significantly more meters than the recreational players during their 1-hour tennis matches (mean \pm SD: 3568.8 ± 532.2 vs. 3173.8 ± 226 m, $p < 0.01$) at lower

running speeds. The results indicate that, independently of ability, tennis match play satisfies the American College of Sports Medicine recommendations for quantity and quality of exercise for the development and maintenance of cardiovascular fitness in healthy adults and seems to be a viable and highly popular mode of healthy activity.

KEY WORDS energy expenditure, fitness, heart rate, racquet sports, oxygen uptake

TABLE 2. Movement pattern and associated physiological responses during 1 hour of tennis match play.

	Advanced players	Recreational players
DR (s)	6.3 ± 4.1	7.6 ± 5.5
RT (s)	14.5 ± 5.2	13.9 ± 5.5
W:R	1:2.3	1:1.8
EPT (%)	21.7 ± 5	23.6 ± 5.4
SR (no.)	2.1 ± 1.3	2.3 ± 1.6
Distance covered (m)	3568.8 ± 532.2*	3173.8 ± 226.0
HR (bpm)	148.3 ± 11.5	149 ± 8.4
%HRmax	80.4 ± 5.1	80.7 ± 3.5

Values are mean ± SD. DR = duration of rallies; RT = resting time between rallies; W:R = work-to-rest ratio; EPT = effective playing time; SR = indicates strokes per rally; HR = heart rate; %HRmax = percentage of maximal heart rate obtained in the laboratory.

*Significant difference between groups ($p = 0.04$).

A Review of the Activity Profile and Physiological Demands of Tennis Match Play

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S U M M A R Y

THE AIM OF THIS REVIEW IS TO PROVIDE A BRIEF INSIGHT AND UNDERSTANDING OF THE PHYSICAL AND PHYSIOLOGICAL DEMANDS OF COMPETITIVE TENNIS MATCH PLAY. IT ALSO PROVIDES USEFUL INFORMATION THAT MAY HELP STRENGTH AND CONDITIONING COACHES TO IMPLEMENT EFFECTIVE TRAINING PROTOCOLS TO IMPROVE ON-COURT TENNIS PERFORMANCE.

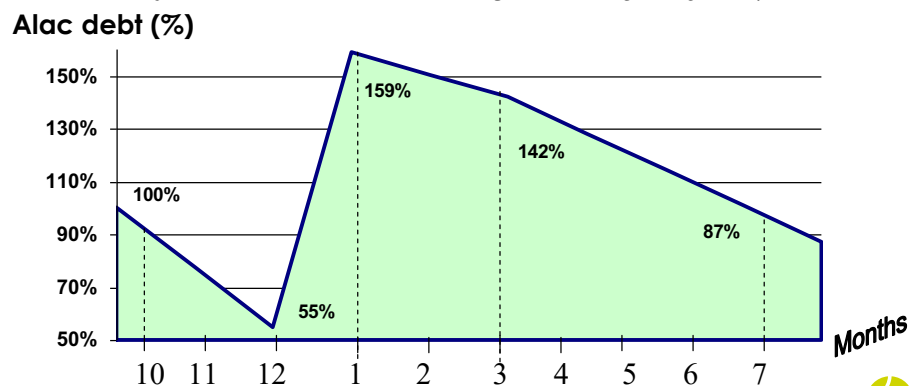
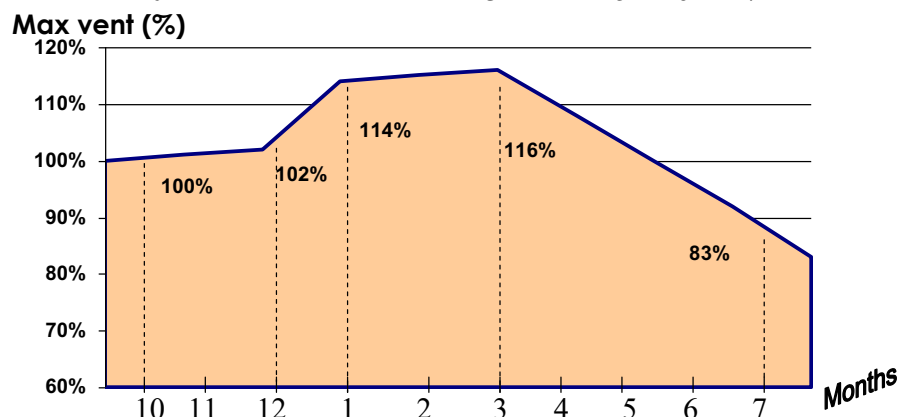
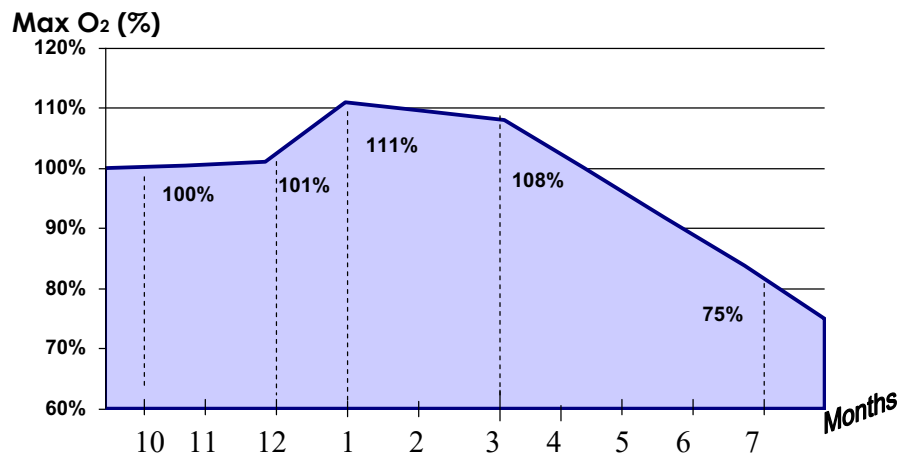
Table 1
Match activity profile reported under real tournament conditions

Reference	Sex	DR (s)	RT (s)	SR (n)	EPT (%)	W:R	Surface
14	M	7.6					Clay
65	M	7.5	16.2	2.7	21.5	1:2.2	Clay
74	M	7.4	19.4				Clay
46	M	7.5	17.2	4.5			Clay
14	F	7.3					Clay
29	F	7.2	15.5	2.5	21	1:2.1	Clay
78	F	9.1	18.2				Clay
78	M	3.8	19.5				Grass
46	M	6.7	25.1	4.7			Hard
14	M	5.5					Grass
78	F	6.2	17.1				Grass
14	F	6.3					Grass
28	F	8.2	17.7	2.8	21.9	1:2.1	Green set

DR = duration of rallies; RT = rest time; SR = strokes per rally; EPT = effective playing time; W:R = work to rest ratio; M = male; F = female.

Sprememba fizioloških parametrov med tekmovalno sezono

CHANGE OF SOME FUNCTIONAL EXPONENTS IN THE YEAR



Running speed loads on clay and hard courts in world class tennis

Sven Pieper, Thomas Exler and Karl Weber

Abstract

Background

Tennis is a complex sport which is characterised by quick starts and stops as well as the involvement of several muscle groups during the different strokes. At elite level, there is a huge number of tournaments on different surfaces each year. So that the players can master the requirements of the game, they must be prepared physically as well as psychologically optimally for the running speed demands of tennis and to protect themselves against overloading damages and injuries. This study shows some important results about the characteristics of running speed demands in elite level tennis, and the implications for training a player's physical working capacity as well as for preventing injuries.

Methods

For the study thirteen clay court and seven hard court men's singles matches were analysed by means of a systematic criterion catalogue. In the foreground this shows all of the playing situations in which a player prepares his next stroke with a running movement under "time pressure". To categorise the running demand profile, several definitions were identified for different match situations. The results of this analysis were taken from a total of 24 ranking list players (ATP 1-50) aged between 20 and 33 years.

Results and conclusions

On hard courts, a top player at international level must operate at approx. 45% (n=1306), as opposed to 29% on clay courts, in all match situations under time pressure, i.e. under a raised running demand. Also the characteristics of the running demand on both these surfaces differ considerably. The rate of stroke errors differs between both tournaments with regard to the runs to each field side (forehand and backhand) as well as to each stroke (forehand and backhand). In the Australian Open substantially longer running ways are evident under high time pressure than, for example, on clay (5.1 ± 2.7 m versus 4.7 ± 1.6 m). We conclude that a match on a hard court is substantially more incriminating and can be therefore more injury-intensive for the tendons and joints. Therefore, it is necessary to train for these particularly high running demands so that adaptations can result in optimum performance and injury prevention.

Key words: running speed loads, time pressure, court surfaces, injury prevention.

Figure 2 Average values and standard deviations to the running distance in time pressure situations in clay and hard court tennis

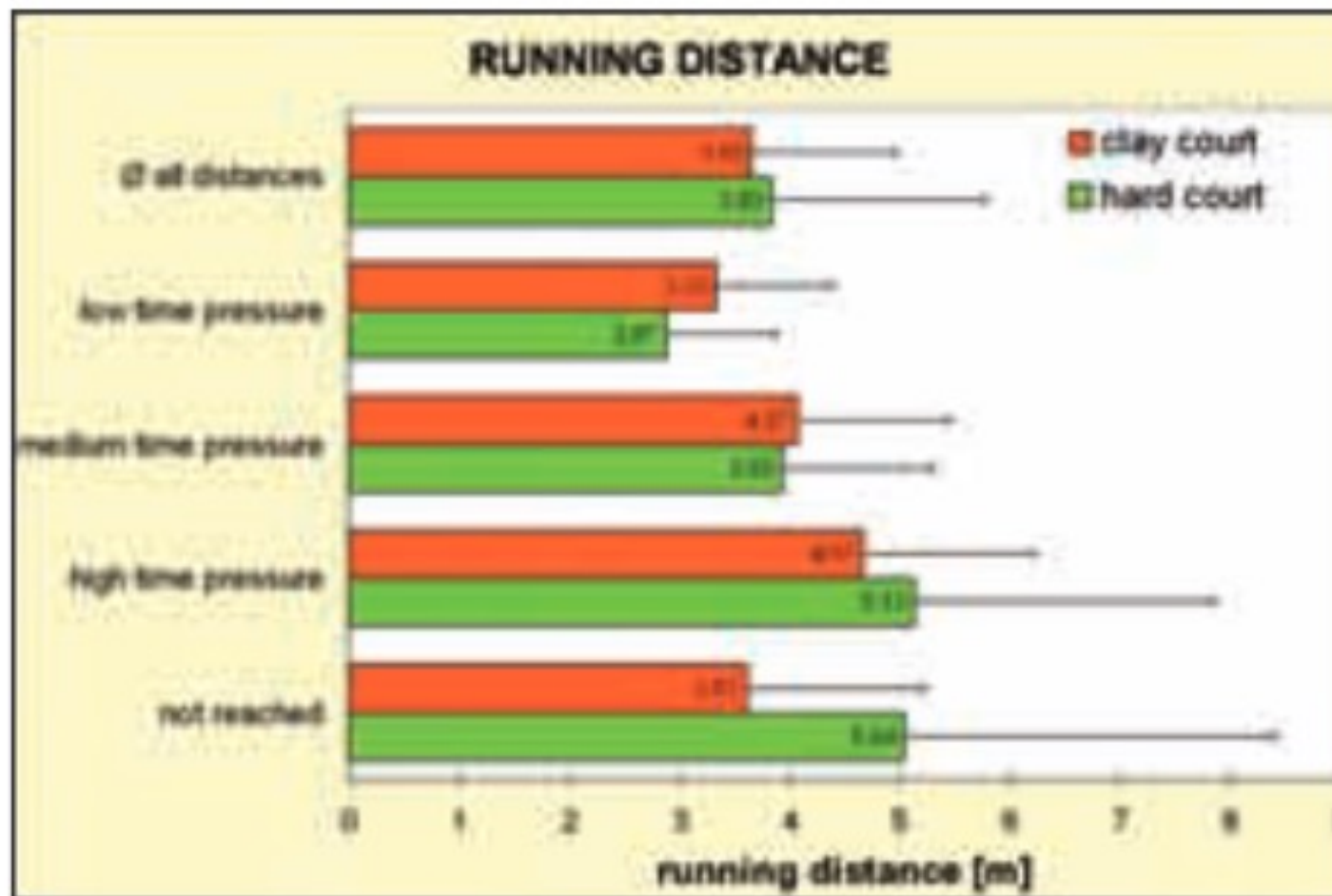


Figure 3 Running distance to the FH and BH sides. Average values and standard deviations to the running distance differentiated for the forehand (FH) and backhand (BH)



Figure 4 Error rate in selected match situations. Progress of the error ratio in selected match situations



Table 3 Percentile error ratio regarding the three time pressure situations for runs to the forehand (FH) and backhand (BH) strokes

ERROR RATIO - RUNS TO STROKE													
Surface		Low time pressure				Medium time pressure				High time pressure			
		out		in		out		in		out		in	
		FH	BH	FH	BH	FH	BH	FH	BH	FH	BH	FH	BH
[n]	Clay court	69	41	267	175	28	20	101	51	17	9	40	29
	Hard court	26	32	163	206	54	34	201	175	34	29	92	87
[%]	Clay court	20,5	19,0	79,5	81,0	21,7	28,2	78,3	71,8	29,8	23,7	70,2	76,3
	Hard court	13,8	13,5	86,2	86,5	21,2	16,3	78,8	83,7	27,0	25,0	73,0	75,0

Table 2 Percentile error ratio regarding the three time pressure situations for runs to the forehand (FH) and backhand (BH) sides.
Error ratio-runs to the side. Low time pressure. Medium time pressure. High time pressure

ERROR RATIO - RUNS TO SIDE													
Surface		Low time pressure				Medium time pressure				High time pressure			
		Out		In		Out		In		Out		In	
		FH	BH	FH	BH	FH	BH	FH	BH	FH	BH	FH	BH
[n]	Clay court	61	49	202	240	28	20	98	54	16	10	40	29
	Hard court	17	41	107	262	50	38	188	188	32	31	89	90
[%]	Clay court	23,2	17,0	76,8	83,0	22,2	27,0	77,8	73,0	28,6	25,6	71,4	74,4
	Hard court	13,7	13,5	86,3	86,5	21,0	16,8	79,0	83,2	26,4	25,6	73,6	74,4

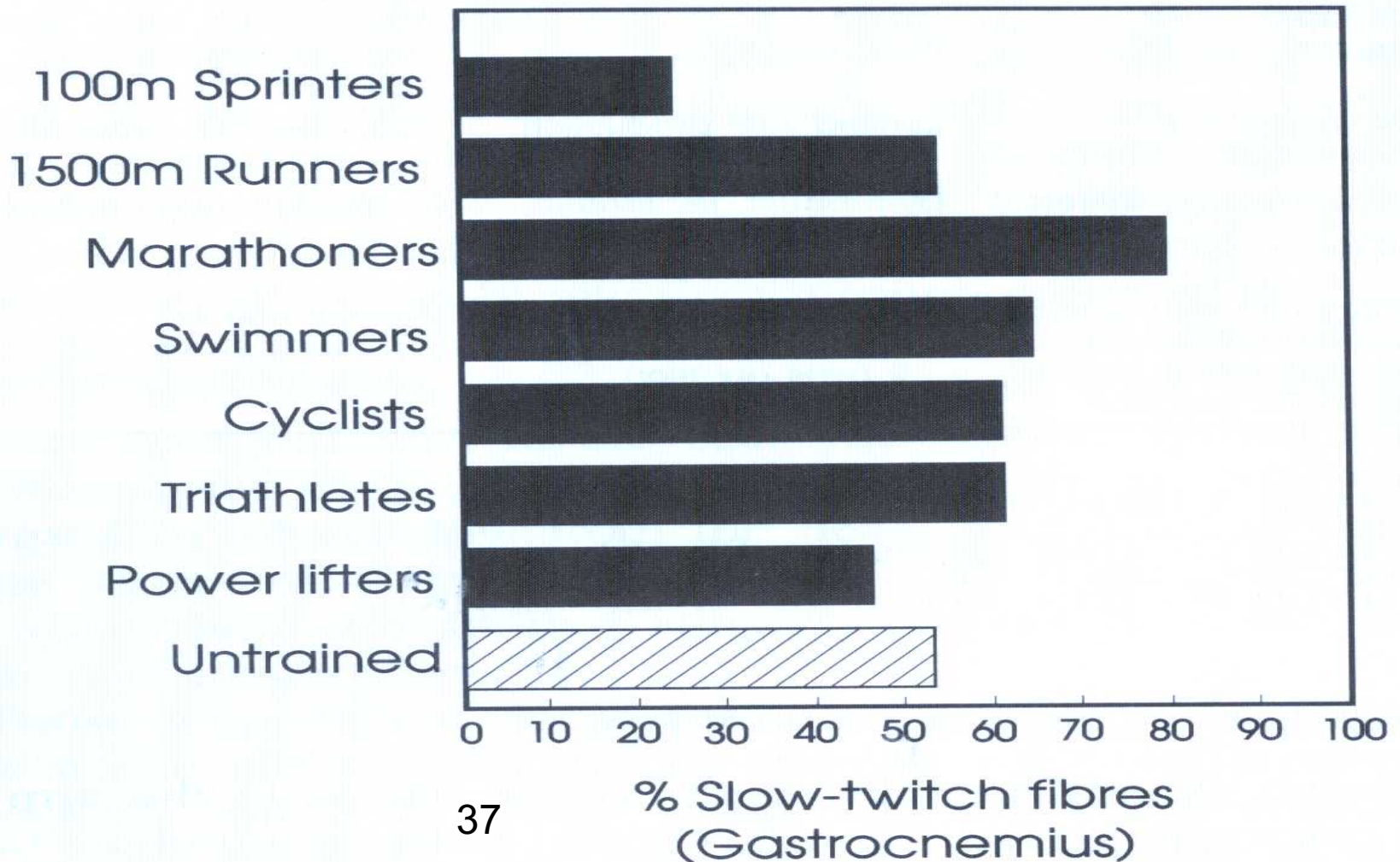
Tennis Demands: Speed & Agility



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Vrste mišičnih vlaken

Figure 1.6: Percentage of slow twitch (Type I) fibres sampled from the gastrocnemius muscle of various elite athletes. The percentage Type I fibres in an untrained population is also shown



Movement Characteristics of Elite Tennis Players on Hard Courts with Respect to the Direction of Ground Strokes

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Abstract

Previous studies of movement characteristics in tennis have considered the effect of playing surface but have assumed that playing strategies are simply determined by the surface as opposed to being under an individual's control. This study considered the selection of cross court or down the line ground strokes as being indicative of playing strategy and measured the outcome of playing these shots in terms of the opponent's movements. Matches (N = 8) at the 2011 ATP tournament 500 Valencia were recorded and analysed using SAGIT, a computer vision tracking system that allowed both players' movements to be tracked automatically, albeit with operator supervision. The data was split into (N = 188) games for analysis purposes and these lasted a median 174.24 seconds with active time (ball in play) a median proportion of 34.89% (IQR = 10.64%) of total time. During the active time losers of games tended to cover less distance (median = 80.17 m), move quicker (median = 1.38 m·s⁻¹), spend more time in the defensive zones (median = 14.24 s) and less in the offensive zones (median = 44.74 s). These results suggested that game winners tended to dominate game losers, forcing them to exhibit behaviors typically associated with a defensive strategy. Defensive and offensive strategy are not well defined currently and future investigations should consider movements in relation to individual shots, in particular their velocities, at the rally level and by different individuals to better understand successful performance.

Key words: Motion analysis, tactics, winners, losers, differences.

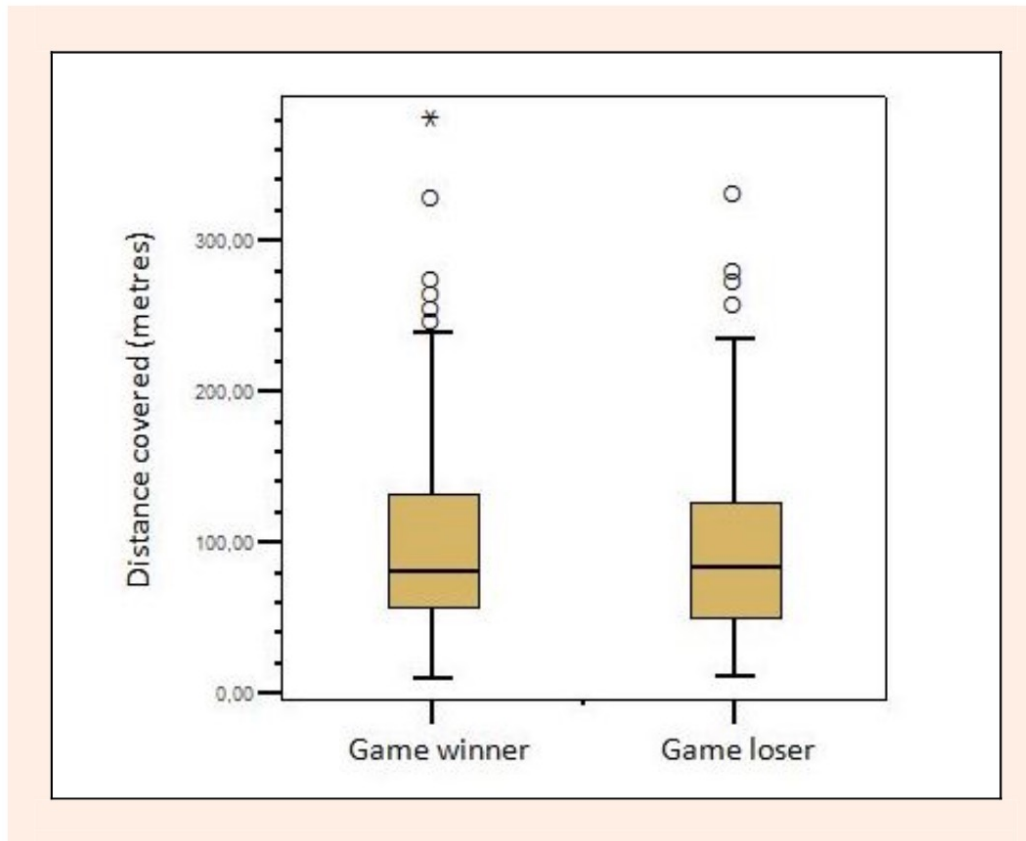
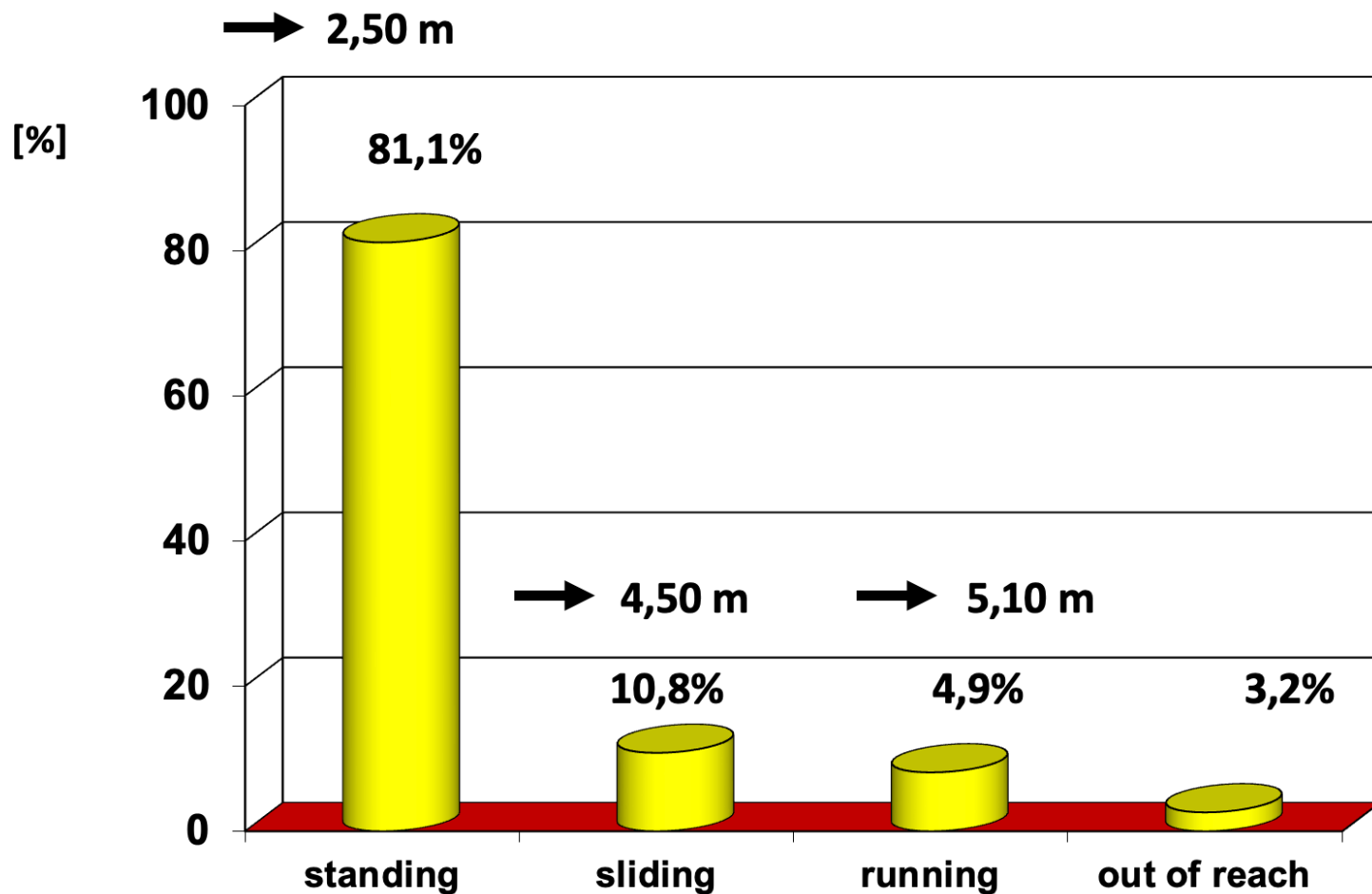


Figure 3. Distance covered during active (ball in play) period of a game.

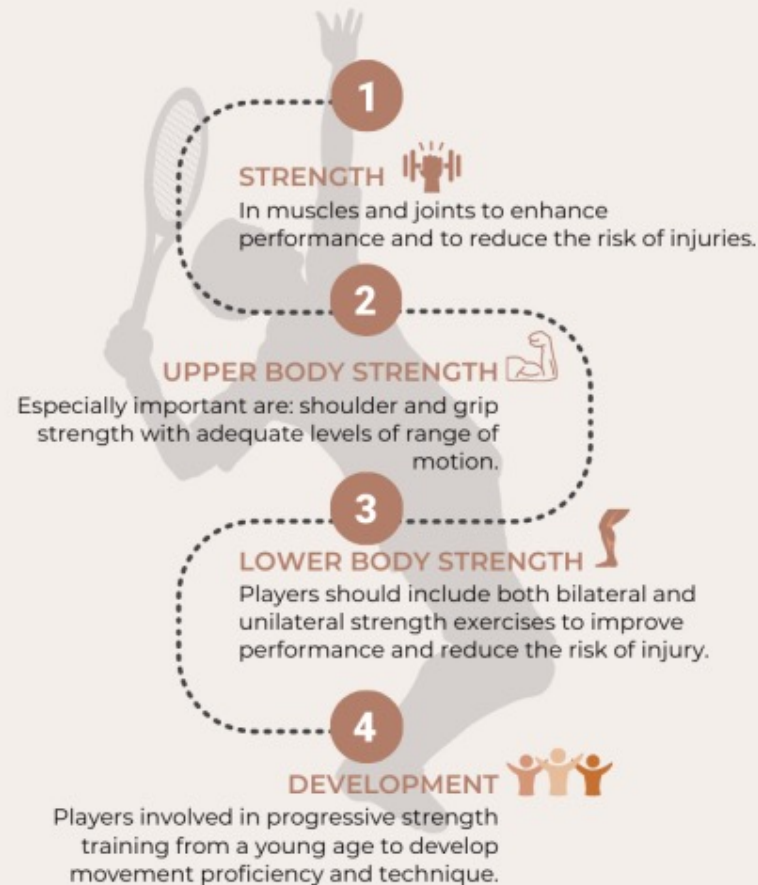
Udarci in gibanja

Ferrauti & Weber, 2008.

(Roland Garros, 1993, n=1540 strokes)

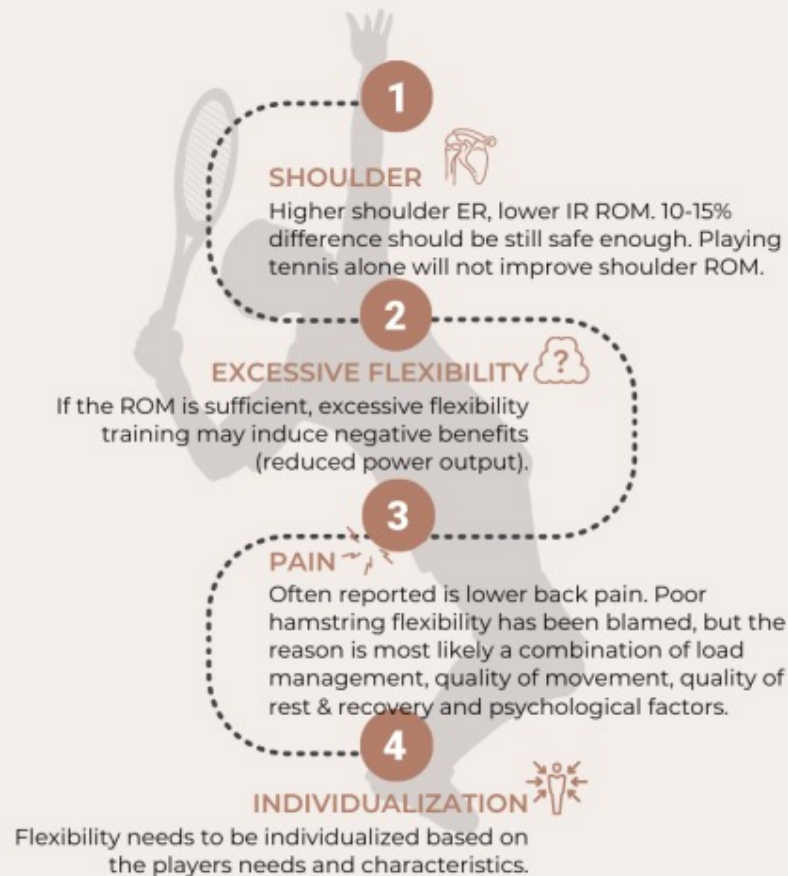


Tennis Demands: Strength & Power



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Tennis Demands: Flexibility



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Kondicijske sposobnosti in ocena vpliva na uspeh



Performance demands of professional male tennis players

C D Johnson, M P McHugh

Br J Sports Med 2006;**40**:696–699. doi: 10.1136/bjism.2005.021253

Objective: To quantify the performance demands in professional male tennis.

Methods: Games from three grand slam tournaments were analysed by an elite tennis player from video recordings. Game related data were collected on 22 players (French Open, 8 (186 games); Wimbledon, 11 (206 games); US Open, 9 (224 games)). Total number of strokes per game was quantified separately for service and return games. Strokes were categorised by type and designated as forehand or backhand. Differences in the types of strokes in a game were analysed using one factor (type of stroke) repeated measures analysis of variance. Differences in total strokes and stroke distributions between playing surfaces were analysed by analysis of variance (surface type) with Tukey's post hoc pairwise comparisons.

Results: For service games there were more serves per game than any other type of stroke ($p < 0.001$), with topspin forehand and topspin backhand the only other strokes averaging more than one per service game. For return games there were more forehand and backhand returns and topspin forehands and backhands than other types of stroke ($p < 0.01$). Total number of strokes per game was greater in the French Open than Wimbledon ($p < 0.01$), with more topspin forehands ($p < 0.01$) and more topspin backhands ($p < 0.01$). Total strokes per game in the US Open were not different from the other two tournaments.

Conclusions: The serve was the predominant stroke accounting for 45% (French Open) to 60% (Wimbledon) of strokes during service games. The greater number of strokes per game on clay v grass may contribute to earlier fatigue.

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Accepted 11 October 2005

Serviranje

Table 1 Data on the number of strokes and stroke distribution for service games in the three tournaments: service games

Stroke type		US Open	French Open	Wimbledon
Total strokes		17.9 (12.1)	21.0 (10.2)	16.0 (8.9)
Serves	First	6.4 (3.2)	6.5 (2.3)	6.4 (2.9)
	Second	2.5 (2.1)	2.4 (1.7)	2.6 (2.0)
Top spin	Fore	4.3 (4.3)	6.0 (4.2)	2.9 (3.4)
	Back	3.4 (3.8)	4.2 (4.0)	1.3 (1.9)
Slice	Fore	0.1 (0.3)	0.4 (1.3)	0.1 (0.3)
	Back	0.5 (1.0)	0.7 (1.1)	0.3 (0.7)
Half volley	Fore	0.1 (0.2)	0.1 (0.5)	0.3 (0.6)
	Back	0.1 (0.3)	0.03 (0.2)	0.2 (0.5)
Volley	Fore	0.2 (0.4)	0.2 (0.4)	0.6 (0.9)
	Back	0.3 (0.7)	0.1 (0.4)	0.9 (1.5)
Overhead		0.1 (0.4)	0.2 (0.6)	0.2 (0.6)

See results section for statistical analysis. Values are mean (SD).

Reterniranje

Table 2 Data on the number of strokes and stroke distribution for return games in the three tournaments: return games

Stroke type		US Open	French Open	Wimbledon
Total strokes		12.2 (10.0)	14.8 (9.2)	10.4 (6.0)
Returns	Fore	2.0 (1.5)	2.8 (1.9)	2.3 (1.5)
	Back	3.2 (2.3)	3.0 (1.7)	2.9 (1.6)
Topspin	Fore	3.2 (3.8)	3.2 (3.8)	2.0 (2.2)
	Back	2.5 (3.5)	3.7 (3.7)	1.8 (1.8)
Slice	Fore	0.2 (0.5)	0.4 (1.1)	0.1 (0.4)
	Back	0.9 (1.4)	0.7 (0.9)	0.8 (1.2)
Half volley	Fore	0.03 (0.2)	0.06 (0.2)	0.1 (0.3)
	Back	0.05 (0.3)	0.02 (0.2)	0.08 (0.3)
Volley	Fore	0.04 (0.2)	0.09 (0.3)	0.09 (0.3)
	Back	0.09 (0.3)	0.07 (0.3)	0.1 (0.5)
Overhead		0.0 (0.0)	0.03 (0.2)	0.04 (0.2)

See results section for statistical analysis. Values are mean (SD).

Serviranje + reterniranje

Table 3 Combined data from all three tournaments on the number of strokes and stroke distribution (see results section for statistical analysis). Service and return games

Service games			Return games		
Stroke type			Stroke type		
Serves	First	6.4 (2.9)	Returns	Fore	2.3 (1.7)
	Second	2.5 (1.9)		Back	3.0 (1.9)
Topspin	Fore	4.4 (4.2)	Topspin	Fore	3.0 (3.4)
	Back	3.0 (3.6)		Back	2.6 (3.1)
Slice	Fore	0.2 (0.8)	Slice	Fore	0.2 (0.7)
	Back	0.5 (1.0)		Back	0.8 (1.2)
Half volley	Fore	0.2 (0.5)	Half volley	Fore	0.1 (0.3)
	Back	0.1 (0.4)		Back	0.1 (0.2)
Volley	Fore	0.3 (0.7)	Volley	Fore	0.1 (0.3)
	Back	0.4 (1.0)		Back	0.1 (0.4)
Overhead		0.2 (0.5)	Overhead		0.02 (0.2)

See results section for statistical analysis. Values are mean (SD).

1-4 strokes depending on age/level

Age/Level	Men	Women
12&under	55 %	57 %
14&under	59 %	59 %
16&under	56 %	57 %
18&under	61 %	61 %
College	62 %	61 %
Pro	70 %	66 %

Length of rally

Age category/player	1-4 strokes	5-8 strokes	9+ strokes
Men/Women	70%	20%	10%
Roger Federer	75%	19%	8%
Novak Djokovic	55%	26%	19%

% of serves / total number of strokes

	Boys		Girls		Men		Women	
Serve	72	21,8%	64	23,6%	134	22,7%	75	24,6%
Forehand	140	42,3	118	43,5	237	40,2	120	39,3
Backhand	119	36,0	89	32,8	219	37,1	110	36,1
Total	331	100	271	100	590	100	305	100

Comparing Matchplay Characteristics and Physical Demands of Junior and Professional Tennis Athletes in the Era of Big Data

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Abstract

Differences in the competitive performance characteristics of junior and professional tennis players are not well understood. The present study provides a comprehensive comparative analysis of junior and professional matchplay. The study utilized multiple large-scale datasets covering match, point, and shot outcomes over multiple years of competition. Regression analysis was used to identify differences between junior and professional matchplay. Top professional men and women were found to play significantly more matches, sets, and games compared to junior players of an equivalent ranking. Professional players had a greater serve advantage, men winning 4 and women winning 2 additional percentage points on serve compared to juniors. Clutch ability in break point conversion was 6 to 8 percentage points greater for junior players. In general, shots were more powerful and more accurate at the professional level with the largest differences observed for male players on serve. Serving to the center of the court was more than two times more common for junior players on first serve. While male professionals performed 50% more total work in a Grand Slam match than juniors, junior girls performed 50% more work than professional women. Understanding how competitiveness, play demands, and the physical characteristics of shots differ between junior and professional tennis players can help set realistic expectations and developmentally appropriate training for transitioning players.

Table 1. Median (IQR) of competitive singles activity of junior and professional tennis players between 2000-2015.

Activity	Junior Boys	Professional Men	Junior Girls	Professional Women
Sample Size (matches)	1.8 million	0.8 million	1.5 million	0.6 million
Sample Size (players)	34,986	14,033	26,189	11,727
Events Per Season^{a,b}				
1-250	21 (17-25)	24 (21-27)	18 (15-22)	23 (19-26)
251-500	16 (12-21)	21 (18-24)	14 (11-18)	17 (13-21)
501-750	13 (8-18)	16 (13-20)	12 (8-16)	11 (8-15)
751-1000	10 (6-15)	11 (8-15)	9 (6-13)	7 (4-10)
Matches Per Season^{a,b}				
1-250	56 (47-65)	60 (54-67)	48 (41-56)	54 (47-61)
251-500	40 (29-47)	45 (40-49)	34 (26-40)	34 (28-41)
501-750	30 (20-37)	31 (26-36)	26 (18-32)	20 (16-25)
751-1000	23 (14-30)	19 (15-24)	20 (12-26)	12 (8-15)
Sets Per Season^{a,b}				
1-250	129 (106-150)	142 (126-160)	109 (91-126)	123 (107-140)
251-500	90 (65-108)	104 (91-117)	76 (59-90)	78 (65-93)
501-750	68 (45-85)	72 (59-84)	59 (41-72)	46 (36-57)
751-1000	52 (31-68)	44 (34-54)	45 (27-58)	26 (18-35)
Games Per Season^{a,b}				
1-250	652 (532-759)	711 (632-811)	535 (452-625)	590 (514-686)
251-500	440 (315-529)	503 (444-567)	364 (279-426)	359 (301-422)
501-750	325 (208-406)	334 (278-390)	273 (184-332)	203 (159-250)
751-1000	240 (139-314)	190 (150-238)	205 (121-262)	107 (76-142)
Win Percentage Per Season^{a,b}				
1-250	64.2 (59.4-69.2)	63.5 (59.2-67.8)	65.1 (60.0-70.8)	60.8 (55.7-66.7)
251-500	57.9 (52.4-63.6)	54.7 (50.0-59.2)	57.8 (52.1-64.9)	52.6 (46.7-59.5)
501-750	54.5 (47.7-61.5)	48.0 (42.9-54.2)	53.6 (46.9-60.7)	46.9 (40.0-55.6)
751-1000	51.5 (44.4-60.0)	41.2 (35.3-50.0)	50.0 (42.9-57.9)	40.0 (33.3-50.0)

^a Indicates a difference between junior boys and professional men at the 5% level or less

^b Indicates a difference between junior girls and professional women at the 5% level or less

Table 2. Median (IQR) of match statistics for junior and professional tennis players at the 2017 Australian Open.

Match Statistic	Junior Boys	Professional Men	Junior Girls	Professional Women
Sample Size (matches)	62	124	63	127
Service Points Won				
Percentage ^a	59.3 (51.1-66.0)	63.7 (59.2-69.0)	55.0 (50.2-61.4)	57.1 (51.2-63.9)
Clutch	55.8 (31.2-74.7)	56.5 (0.0-70.2)	57.0 (45.1-66.0)	56.9 (44.7-68.2)
First Service Points				
Percentage ^b	61.6 (55.1-65.5)	59.6 (56.1-65.3)	58.0 (52.1-63.5)	60.3 (55.7-65.9)
Clutch	61.9 (46.3-71.8)	58.5 (0.0-69.0)	59.8 (47.8-69.0)	62.2 (51.7-70.5)
First Service Points Won				
Percentage ^a	66.7 (59.3-74.2)	72.1 (66.7-78.4)	64.1 (55.6-72.8)	64.2 (57.8-72.7)
Clutch	62.6 (33.1-77.6)	63.0 (0.0-77.7)	61.9 (50.6-72.7)	63.2 (48.8-74.0)
Second Service Points Won				
Percentage ^a	47.3 (41.0-55.1)	50.4 (44.1-56.8)	44.3 (39.7-52.4)	45.6 (38.5-53.3)
Clutch	41.6 (15.8-57.2)	42.1 (0.0-56.9)	44.2 (30.3-56.8)	42.8 (28.9-54.9)
Aces				
Percentage ^{a,b}	3.6 (1.5-6.6)	8.0 (4.7-12.1)	2.8 (0.0-4.5)	3.8 (1.8-6.9)
Clutch ^{a,b}	0.0 (0.0-5.2)	2.9 (0.0-9.5)	1.0 (0.0-4.0)	2.9 (0.0-7.1)
Double Faults				
Percentage ^a	4.9 (2.7-7.5)	3.8 (2.3-5.3)	5.4 (3.2-8.4)	5.0 (3.2-7.9)
Clutch ^a	3.0 (0.0-7.1)	1.6 (0.0-4.7)	4.1 (0.2-8.1)	4.0 (0.0-7.5)
Break Points				
Percentage ^b	8.8 (3.5-12.7)	7.5 (4.6-10.7)	9.7 (4.9-14.1)	10.4 (6.5-14.3)
Clutch ^a	20.5 (0.0-35.8)	14.6 (0.0-26.2)	11.9 (0.0-19.8)	13.2 (0.0-20.5)
Break Points Won				
Percentage	42.9 (25.0-57.1)	37.5 (25.0-50.0)	44.4 (33.3-55.6)	42.9 (33.3-54.2)
Clutch ^{a,b}	42.2 (11.0-66.3)	34.1 (6.7-53.2)	46.1 (28.2-63.0)	39.8 (19.5-56.3)
Net Points				
Percentage ^{a,b}	7.9 (4.7-12.4)	10.1 (7.1-13.6)	4.9 (1.7-7.8)	6.3 (4.1-9.9)
Clutch	4.9 (0.0-11.1)	4.8 (0.0-13.8)	3.5 (0.0-7.4)	4.7 (0.0-9.3)
Net Points Won				
Percentage ^{a,b}	62.5 (50.0-75.0)	65.3 (57.1-72.7)	63.6 (50.0-77.8)	66.7 (55.3-80.0)
Clutch ^b	47.2 (0.0-73.6)	53.8 (0.0-72.5)	51.7 (0.0-73.1)	64.0 (3.6-81.2)
Total Winners				
Percentage	39.0 (29.6-48.7)	49.7 (41.6-57.2)	34.0 (25.2-42.3)	42.9 (35.7-50.0)
Clutch ^{a,b}	30.3 (0.0-47.5)	35.9 (0.0-55.1)	30.1 (1.0-39.8)	38.5 (18.2-48.6)
Total Unforced Errors				
Percentage ^{a,b}	61.0 (51.3-70.4)	50.3 (42.8-58.4)	65.8 (57.5-73.9)	57.1 (50.0-64.3)
Clutch	52.7 (0.0-71.8)	38.1 (0.0-55.9)	64.6 (44.0-76.3)	54.1 (34.4-64.6)
Total Points Won				
Percentage ^{a,b}	53.0 (45.3-60.8)	50.8 (45.8-55.4)	52.7 (46.5-60.2)	51.0 (45.0-56.6)
Clutch ^b	49.8 (25.9-65.4)	42.8 (0.0-57.3)	49.2 (39.7-60.5)	48.0 (36.3-59.3)

^a Indicates a difference between junior boys and professional men at the 5% level or less

^b Indicates a difference between junior girls and professional women at the 5% level or less

Table 3. Median (IQR) of competitive singles game characteristics of junior and professional tennis players for four Grand Slams*

Game Characteristic	Junior Boys	Professional Men	Junior Girls	Professional Women
Sample Size (matches)	246	1,089	250	1,126
Points Per Match^a				
Clay	131 (112-158)	213 (174-258)	122 (104-150)	133 (108-170)
Grass	137 (118-162)	221 (180-275)	115 (100-177)	130 (111-169)
Hard	130 (104-167)	216 (177-265)	122 (105-175)	129 (108-171)
Serve Percentage Won Per Match^{a,b}				
Clay	58.3 (52.4-65.4)	62.7 (56.5-68.3)	52.8 (46.8-59.1)	56.1 (49.4-62.0)
Grass	63.6 (58.0-67.8)	66.4 (61.2-71.8)	57.2 (49.6-64.1)	59.0 (52.7-64.7)
Hard	58.7 (52.5-65.9)	63.8 (58.4-69.2)	55.0 (50.0-62.1)	57.1 (50.5-63.6)
Point Spread Per Match^{a,b}				
Clay	4.0 (3.1-4.7)	3.6 (2.9-4.4)	4.0 (2.9-5.0)	3.9 (3.0-4.9)
Grass	3.2 (2.3-4.0)	3.4 (2.8-4.1)	3.9 (3.0-4.9)	3.6 (3.0-4.8)
Hard	3.8 (3.0-4.9)	3.6 (2.9-4.3)	3.5 (2.8-4.5)	3.8 (2.9-4.7)
Break Point Chances Per Match^{a,b}				
Clay	6 (4-8)	5 (3-8)	8 (6-10)	7 (5-9)
Grass	5 (3-8)	4 (2-6)	7 (4-10)	6 (4-8)
Hard	6 (4-8)	5 (3-7)	7 (4.5-9)	7 (5-9)
Tiebreaks Per Match^a, Mean				
Clay	11.6	14.1	5.7	9.2
Grass	18.2	20.2	10.5	12.1
Hard	9.3	17.1	7.3	9.0

* The data include the 2017 Australian Open for juniors and the 2016 Majors for all other junior Grand Slams; the professional data included matches from the 2016-2016 Grand Slams

^a Indicates a difference between junior boys and professional men at the 5% level or less

^b Indicates a difference between junior girls and professional women at the 5% level or less

Table 4. Median (IQR) of shot and movement characteristics of junior and professional tennis players at the 2012-2017 Australian Opens.

Activity	Junior Boys	Professional Men	Junior Girls	Professional Women
Sample Size (matches)	12	21 [†]	6	21 [*]
Sample Size (shots)	8,282	25,906	3,361	13,281
Rally Length	4.8 (1-13)	5.0 (1-14)	4.4 (1-10)	4.6 (1-12)
Shot Production^{a,b}				
Serve	72 (49-103)	134 (91-168)	64 (48-81)	75 (51-114)
Forehand	140 (84-227)	237 (138-367)	118 (84-147)	120 (74-173)
Backhand	119 (61-185)	219 (122-344)	89 (57-112)	110 (56-206)
Shot Speed^{a,b} (kph)				
Serve	158 (119-193)	179 (140-213)	146 (116-176)	153 (122-186)
Forehand	113 (75-142)	119 (77-148)	110 (75-134)	111 (76-135)
Backhand	105 (68-131)	108 (70-137)	103 (69-128)	106 (68-129)
Speed at Baseline^{a,b} (kph)				
Forehand	56 (47-65)	60 (54-67)	48 (41-56)	54 (47-61)
Backhand	40 (29-47)	45 (40-49)	34 (26-40)	34 (28-41)
Net Clearance^{a,b} (m)				
Serve	129 (106-150)	142 (126-160)	109 (91-126)	123 (107-140)
Forehand	90 (65-108)	104 (91-117)	76 (59-90)	78 (65-93)
Backhand	68 (45-85)	72 (59-84)	59 (41-72)	46 (36-57)
First Serve Patterns^{a,b} (%)				
Wide	37.8	45.7	36.2	36.3
T	43.2	46.9	35.9	47.7
Body	19.0	7.4	27.9	16.0
Second Serve Patterns^{a,b} (%)				
Wide	21.9	32.0	21.0	23.8
T	30.7	36.7	21.7	41.0
Body	47.5	31.3	57.3	35.1
First Serve Patterns^{a,b} (%)				
Wide	37.8	45.7	36.2	36.3
T	43.2	46.9	35.9	47.7
Body	19.0	7.4	27.9	16.0
Serve Return Time ^b (s)	0.54 (0.38-0.80)	0.55 (0.37-0.81)	0.52 (0.38-0.76)	0.48 (0.35-0.75)
Serve Return Reaction Time ^{a,b} (s)	0.73 (0.56-0.95)	0.66 (0.52-0.87)	0.78 (0.63-0.97)	0.73 (0.58-0.92)
Serve + 1 Stretch ^b (m)	4.99 (1.46-8.77)	5.10 (1.65-8.77)	4.92 (1.42-8.67)	5.25 (1.68-9.25)
Sideline Distance^{a,b} (m)				
Forehand	1.94 (0.35-3.68)	1.77 (0.38-3.56)	1.93 (0.32-3.67)	1.89 (0.37-3.66)
Backhand	2.27 (0.53-3.81)	2.09 (0.47-3.71)	2.30 (0.48-3.84)	2.14 (0.45-3.78)
Distance from Baseline^a (m)				
Forehand	3.05 (0.54-5.19)	3.11 (0.59-5.17)	2.98 (0.55-5.15)	3.03 (0.57-5.18)
Backhand	3.11 (0.58-5.17)	3.00 (0.59-5.17)	3.06 (0.46-5.19)	3.04 (0.57-5.30)
Inside Out Forehand ^a (%)	9	10	8	8
Down the line Backhand ^{a,b} (%)	9	11	9	11
Distance travelled per point ^{a,b} (m)	6.9 (0.3-19.9)	7.4 (0.3-24.2)	6.3 (0.2-18.4)	5.9 (0.2-19.6)
Distance travelled per match ^{a,b} (m)	993 (562-1,610)	1,990 (1,243-2,916)	798 (549-1,012)	881 (556-1,504)
Peak foot speed ^{a,b} (kph)	12.0 (5.1-21.6)	10.5 (4.7-18.2)	11.9 (4.9-21.1)	9.1 (3.7-16.3)
Changes of direction per point ^{a,b}	6.0 (0-18)	5.0 (0-22)	6.0 (0-18)	4.5 (0-18)
Work per point ^{a,b}	2,236 (36-7,335)	1,761 (27-6,257)	1,690 (30-5,462)	917 (17-3,342)
Work per match ^{a,b} (per 1000 units)	320 (168-641)	475 (290-695)	216 (166-278)	138 (85-248)

^{*} Professional matches were matched on the round of junior matches

[†] Indicates a difference between junior boys and professional men at the 5% level or less

^b Indicates a difference between junior girls and professional women at the 5% level or less

Table 5. Relative influence* of the association of match statistics for match wins at the 2017 Australian Open.

Player Group	Type	Match Statistic	Relative Influence
Junior Boys	Simple Percentage	Total Points Won	66
		First Serve Points Won	30
		Winners vs Unforced Errors	2
		Second Serve Point Won	2
Junior Boys	Clutch Average	Total Points Won	87
		Break Points Won	10
		Winners vs Unforced Errors	2
		First Serve Points Won	1
Professional Men	Simple Percentage	Total Points Won	100
Professional Men	Clutch Average	Total Points Won	68
		Break Points Won	16
		First Serve Points Won	10
		Winners vs Unforced Errors	6
Junior Girls	Simple Percentage	First Serve Points Won	85
		Total Points Won	15
Junior Girls	Clutch Average	Total Points Won	74
		First Serve Points Won	26
Professional Women	Simple Percentage	Total Points Won	93
		Winners vs Unforced Errors	4
		First Serve Points Won	3
Professional Women	Clutch Average	Total Points Won	88
		First Serve Points Won	10
		Winners vs Unforced Errors	2

* The frequency factor was selected across models in a generalized boosted regression

Matchplay characteristics and performance indicators of male junior and entry professional tennis players

International Journal of Sports Science
& Coaching
0(0) 1–9
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DOI: 10.1177/1747954120988002
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Abstract

Performance analysis during match play is vital for the long-term development of tennis players. The primary goal of this study was to establish the differences between junior and entry professional tennis player's selected performance indicators in five-game situations. Data were collected using the Sagit/Tennis tracking system during six junior and four professional tennis matches. Eight boys performed 3,112 strokes, while eight male professional players hit 1,631 strokes. The results showed slight differences in the distance covered by the two observed groups in the specific game situations. Professional players performed faster shots in all game situations, except when playing at the net. They played at a significantly faster tempo than the juniors. This difference was also affected by the higher shots speed and shorter distance between the two players during the rallies. When playing from the baseline, the entry professional players performed shots at a smaller angle than the juniors; and when serving, receiving and playing at the net, they hit shots at a greater angle than the juniors. Our findings may assist coaches and players in improving the effectiveness of their tactical and technical training to enhance their competitive performance.

Keywords

Performance analysis, racket sport, youth sport

Table 1. Descriptive statistics and differences in matchplay characteristics of junior boys and male entry professional tennis players.

Matchplay characteristics	Junior boys	Professional men	<i>p</i> (<i>t</i>)	<i>d</i> * [#]
Match (no.)	6	4		
Time				
Match time (min)	65.4 (±18.3)	81 (±28)	1.79	-0.66
Rally time (s)	7.3 (±1.7)	4.4 (±0.5)	0.00	2.31#
Resting time per rally (s)	19.5 (±3)	20.5 (±2.4)	1.53	-0.37
Rally time (%)	27.5 (±5.8)	17.9 (±3.4)	0.00	2.02#
Rallies range				
Rally 0-5 s (%)	51.5 (±8.7)	67 (±5.5)	2.00	-2.13
Rally 5-10 s (%)	22.7 (±4.9)	23.3 (±2.4)	1.24	-0.16
Rally 10-20 s (%)	18.9 (±4.9)	8.6 (±2.6)	0.00	2.63#
Rally 20+ s (%)	6.7 (±4)	0.8 (±0.7)	0.00	2.05#
Rallies and shots				
Rally (no.)	145.2 (±22.7)	193 (±52)	1.96	-1.19
Shots (no.)	1327.3 (±425.5)	1316.5 (±199.7)	0.95	0.03
Rally length (shots)	4.7 (±1.8)	3.4 (±0.3)	0.08	1.01
Shots production				
First serve	47.3 (±9.5)	66.5 (±11.1)	2.00	-1.86
Second serve	20.2 (±2.3)	32.5 (±9.6)	1.99	-1.76
Forehand return on first serve	20 (±12.2)	13.5 (±5.1)	0.20	0.70
Backhand return on first serve	14.8 (±4.9)	16 (±6.8)	1.31	-0.20
Forehand return on second serve	5.2 (±2.4)	1.8 (±1.7)	0.01	1.63#
Backhand return on second serve	4.5 (±4.7)	22.5 (±8.9)	2.00	-2.53
Forehand	131.8 (±50.1)	68 (±8.7)	0.01	1.77#
Backhand	97.5 (±38.1)	83.3 (±11.6)	0.34	0.50
Net shots	5.3 (±5.4)	6.8 (±3.0)	1.49	-0.34
Other shots (slice and drop shots)	55.2 (±19.1)	40.8 (±19.3)	0.16	0.75
Distance travelled				
Distance per match (m)	2208 (±645.7)	1776.2 (±281.4)	0.12	0.87
Distance per rally (m)	15 (±2.8)	9.4 (±0.9)	0.00	2.69#
Distance per shot (m)	4.8 (±1.7)	4.3 (±1.4)	0.53	0.32
Movement speed				
Average movement speed (kph)	4.5 (±0.3)	4.9 (±0.5)	1.92	-0.97
Peak movement speed	1. (±1.5)	21.3 (±3.4)	1.18	-0.11

#Indicates a difference between junior boys and professional men at the 5% level or less.

*Cohen's *d*.

Table 2. Mean, SD, N, and Cohen's *d* of matchplay performance indicators of junior boys and male entry professional tennis players.

	Junior boys			Professional men			<i>p</i> (<i>t</i>)	<i>d</i> *
	Mean	Std. deviation	N	Mean	Std. deviation	N		
Distance covered by player between shots (m)								
Serving	3.4	1.3	479	3.0	1.2	348	0.00	-0.37#
Receiving	5.1	1.6	400	5.4	1.6	247	1.99	0.22
Baseline game	4.7	1.9	1559	4.4	1.8	465	0.00	-0.14#
Net game	4.2	1.3	11	3.5	0.4	5	1.24	-0.64
Other shots	6.5	2.5	79	5.3	2.0	119	0.00	-0.57#
Distance between the player's and the opponent's shots (m)								
Serving	25.4	1.2	583	25.2	0.9	447	0.04	-0.12#
Receiving	26.4	1.8	479	25.2	1.8	348	0.00	-0.66#
Baseline game	27.2	2.5	1906	26.6	2.2	638	0.00	-0.23#
Net game	18.3	4.2	19	17.3	3.5	16	0.45	-0.26
Other shots	23.3	3.7	124	24.4	3.1	182	1.99	0.31
Time between player's and opponent's shots (s)								
Serving	1.2	0.2	583	0.9	0.2	447	0.00	-2.02#
Receiving	1.6	0.4	479	1.4	0.3	348	0.00	-0.65#
Baseline game	1.7	0.5	1906	1.3	0.3	638	0.00	-0.94#
Net game	1.4	0.4	19	1.6	0.4	16	1.75	0.38
Other shots	2.0	0.6	124	1.7	0.4	182	0.00	-0.85#
Average shot speed (km/h)								
Serving	75.9	13.4	583	104.0	17.4	447	2.00	1.85
Receiving	61.7	12.0	479	68.7	14.5	348	2.00	0.53
Baseline game	60.5	12.2	1906	75.4	12.4	638	2.00	1.21
Net game	50.5	17.3	19	45.2	20.8	16	0.43	-0.28
Other shots	43.3	10.1	124	54.9	11.2	182	2.00	1.08
Rally tempo (number of shots per minute)								
Serving	51.8	10.2	104	72.4	11.8	99	2.00	1.87
Receiving	32.2	4.6	79	40.7	6.0	101	2.00	1.54
Baseline game	23.3	4.0	347	29.8	4.0	173	2.00	1.61
Net game	22.0	3.6	8	27.7	3.5	11	1.99	1.61
Other shots	21.5	3.3	45	27.3	3.2	63	2.00	1.8
Angle between two successive shots (degrees)								
Serving	9.4	2.7	461	11.0	2.7	447	2.00	0.58
Receiving	10.2	4.2	509	10.4	5.1	348	1.39	0.04
Baseline game	7.3	4.4	1984	6.0	4.2	638	0.00	-0.3#
Net game	7.1	4.4	26	8.9	6.3	16	1.66	0.34
Other shots	8.9	4.9	132	8.4	4.7	182	0.36	-0.11

#Indicates a difference between junior boys and professional men at the 5% level or less.

*Cohen's *d*.

Practice and match workload of a female tennis player in two annual seasons: A single-case study

International Journal of Sports Science
& Coaching

1–8

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DOI: 10.1177/17479541221088836

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Abstract

The aim of this single case study was to monitor the external workload of a professional female tennis player between 314 training sessions and 115 matches. A wearable device was used during two fully consecutive tennis seasons (24 months). External workload was determined using time indicators (total and active session times), shots indicators (shots per week, session, hour, rally and minute) and frequency distribution of rallies. This case study showed that the workload during practice sessions was higher compared to matches in terms of active time, percentage of active time, shots per hour and rally, and frequency distribution of rallies with more than nine shots. The number of shots executed per minute was lower in the practice sessions than in the match. It is concluded that the recommended number of shots per hour in a 90-min practice session is for the player to perform 400 to 800 shots. The recommended average number of rallies in practice sessions is 144 and 70% of the rallies should consist of four shots. The pace of rallies in open match situations in the practice sessions should reach the level of official matches. These conclusions could be useful guidelines for determining the workload of female tennis players participating in entry-level professional tournaments.

Keywords

Performance analysis, periodization, racket sport, wearable technology

Table 2. Descriptive statistics on practice and match workload data.

	Practice (n = 314)		Match (n = 115)	
	Mean \pm s	Range	Mean \pm s	Range
Total session time (min.)	86.7 \pm 24.9	32–189	96.1 \pm 34.2	28.8–197.5
Active session time (min.)	29.8 \pm 8.6	8.7–51	19.8 \pm 8.4	4.4–49.2
Active session time (%)	35.5 \pm 8.9	13.5–61.8	20.7 \pm 6.2	9.7–45.8
Shots per week (no.)	3023.9 \pm 1294.7	428–7698	2749.8 \pm 1446.5	749–4703
Shots per session (no.)	672.3 \pm 187	225–1154	552.4 \pm 195.8	171–1146
Shots per hour (no.)	461.9 \pm 94.3	196–787	325.5 \pm 64.7	185–600
Shots per rally (no.)	5.3 \pm 2.2	1.7–15.5	2.8 \pm 1	1.6–7.7
Shots per minute (no.)	22.9 \pm 2.3	17.6–32.9	27.1 \pm 3.3	18.3–41.9
Rallies (no.)	144.9 \pm 59.5	29–405	192.8 \pm 67.5	70–391
Rallies 1–2 shots (%)	52.5 \pm 14.5	11.8–95.7	64.9 \pm 10.4	38.7–92.8
Rallies 3–4 shots (%)	17.6 \pm 6.3	1.2–40.4	20.7 \pm 5.1	6.5–30.8
Rallies 5–6 shots (%)	9.4 \pm 5.1	0–43.5	8.4 \pm 3.7	0–17.5
Rallies 7–8 shots (%)	4.8 \pm 3.4	9–27.5	3 \pm 2.3	0–13.7
Rallies 9 or more shots (%)	15.6 \pm 11.6	0–62.1	3 \pm 6	0–29.5

Real-Life Application of a Wearable Device towards Injury Prevention in Tennis: A Single-Case Study

Iztok Kramberger ^{1,*} , Aleš Filipčič ², Aleš Germič ² and Marko Kos ¹

Abstract: The purpose of this article is to present the use of a previously validated wearable sensor device, Armbeep, in a real-life application, to enhance a tennis player's training by monitoring and analysis of the time, physiological, movement, and tennis-specific workload and recovery indicators, based on fused sensor data acquired by the wearable sensor—a miniature wearable sensor device, designed to be worn on a wrist, that can detect and record movement and biometric information, where the basic signal processing is performed directly on the device, while the more complex signal analysis is performed in the cloud. The inertial measurements and pulse-rate detection of the wearable device were validated previously, showing acceptability for monitoring workload and recovery during tennis practice and matches. This study is one of the first attempts to monitor the daily workload and recovery of tennis players under real conditions. Based on these data, we can instruct the coach and the player to adjust the daily workload. This optimizes the level of an athlete's training load, increases the effectiveness of training, enables an individual approach, and reduces the possibility of overuse or injuries. This study is a practical example of the use of modern technology in the return of injured athletes to normal training and competition. This information will help tennis coaches and players to objectify their workloads during training and competitions, as this is usually only an intuitive assessment.

Keywords: tennis; training; data-based coaching; shot recognition; wearable device; workload; recovery

Table 1. Practice and match data for the observed athlete gathered in a period of six months.

Variable ID	Description (Unit)	Practice		Match	
		Mean	SD	Mean	SD
SessionTime	Session time (s)	5805.67	1662.91	5247.24	1520.75
ActiveTime	Active time (s)	1961.66	516.67	1252.65	538.12
ActiveTimePercentage	Active time (%)	34.86	7.68	24.03	8.68
AvgRallyTime	Average rally time (s)	17.79	5.11	11.81	4.33
AvgRestTime	Average rest time (s)	34.69	17.04	37.86	7.06
AvgHR	Average HR	129.78	9.29	135.19	9.63
MinHR	Min HR	79.40	8.97	83.80	13.07
MaxHR	Max HR	175.88	13.43	179.35	12.20
HighHR	Time in high-HR zone (%)	5.94	8.71	8.49	10.91
ModerateHR	Time in moderate-HR zone (%)	32.64	13.2	40.8	14.23
LowHR	Time in low-HR zone (%)	61.37	18.1	50.63	20.38
TotalRecoveries	Total recoveries after max or submax HR value	3.01	3.05	67	5.09
Recovery20Count	Number of recoveries after 20 s	3.01	3.05	8.67	5.09
Recovery60Count	Number of recoveries after 60 s	0.82	1.31	1.51	1.26
Recovery120Count	Number of recoveries after 120 s	0.00	0.00	0.00	0.00
Recovery20BPM	HR value after 20 s	3.31	3.11	4.25	2.38
Recovery60BPM	HR value after 60 s	15.93	10.95	17.54	8.43
Recovery120BPM	HR value after 120 s	0.00	0.00	0.00	0.00
CardioLoad	Cardio load index (algorithm)	55.75	43.77	73.76	66.02

Movement	Movement index (Valencell data)	1.66	0.11	1.65	0.08
Sprinting	Number of values in sprinting (%)	13.46	1.56	13.80	2.12
Running	Number of values in running (%)	46.05	7.21	39.88	8.80
Walking	Number of values in walking (%)	33.66	5.99	43.63	9.10
Standing	Number of values in standing (%)	6.70	3.53	2.69	1.99
Shots	Number of shots	780.40	203.69	542.86	205.67
ShotsOverhead	Number of overheads	88.16	37.59	98.18	39.51
POverhead	Percentage of overheads (%)	11.18	4.16	18.20	4.51
ShotsForehand	Number of forehands	258.63	86.20	166.18	87.70
Pforehand	Percentage of forehands (%)	32.56	5.74	29.14	7.16
ShotsBackhand	Number of backhands	334.44	101.43	186.80	93.84
Pbackhand	Percentage of backhands (%)	42.32	7.15	33.22	9.41
ShotsOther	Number of other shots	99.17	34.42	91.69	64.10
pOther	Percentage of other shots (%)	13.94	10.48	19.43	16.93
ShotsPerHour	Shots per hour	492.54	88.26	371.00	99.45
ShotsPerRally	Shots per rally	7.02	1.64	5.11	1.40
ShotsPerRallyLow	Rallies with 1–2 shots (%)	28.96	10.33	38.96	9.65
ShotsPerRallyModerate	Rallies with 3–4 shots (%)	38.96	10.11	36.37	8.80
ShotsPerRallyHigh	Rallies with 5+ shots (%)	42.40	13.88	24.65	12.28
ShotsPerRallyMin	Shots per rally—minimum value in session	2.00	0.00	2.00	0.00
ShotsPerRallyMax	Shots per rally—maximum value in session	50.47	21.53	23.12	23.05
RalliesTotal	Rallies number	117.46	39.45	107.67	34.93

Table 1. Cont.

Variable ID	Description (Unit)	Practice		Match	
		Mean	SD	Mean	SD
Tempo	Shots per minute	24.02	1.86	26.60	2.24
TempoLow	Shots per minute (1–10 shots per minute) (%)	0.00	0.00	0.00	0.00
TempoModerate	Shots per minute (11–19 shots per minute) (%)	16.59	7.54	11.69	7.28
TempoHigh	Shots per minute (20+ shots per minute) (%)	83.42	7.55	88.33	7.28
TempoMin	Shots per minute minimum value in session	14.47	1.77	15.36	1.98
TempoMax	Shots per minute maximum value in session	176.76	78.73	200.39	59.21
ShotsPower	Shots acceleration (g)	13.40	1.79	14.72	2.40
ShotsPowerLow	Shots acceleration (1–10 g) (%)	32.89	12.50	32.94	15.01
ShotsPowerModerate	Shots acceleration (11–19 g) (%)	55.14	11.02	48.20	11.90
ShotsPowerHigh	Shots acceleration (20+ g) (%)	11.87	5.52	18.69	5.57
HittingLoad	Hitting load (algorithm) (%)	215.18	110.34	87.82	87.27

Note: numbers in bold represent higher average value for individual indicator for easier comparison between practice and match sessions.

Full Title: Macro periodisation of competition in international women's tennis: insights for long-term athlete development

Submission Type: Original Investigation

Authors: Thomas Perri^{1,2}, Rob Duffield¹, Alistair Murphy², Tom Mabon² and Machar Reid²

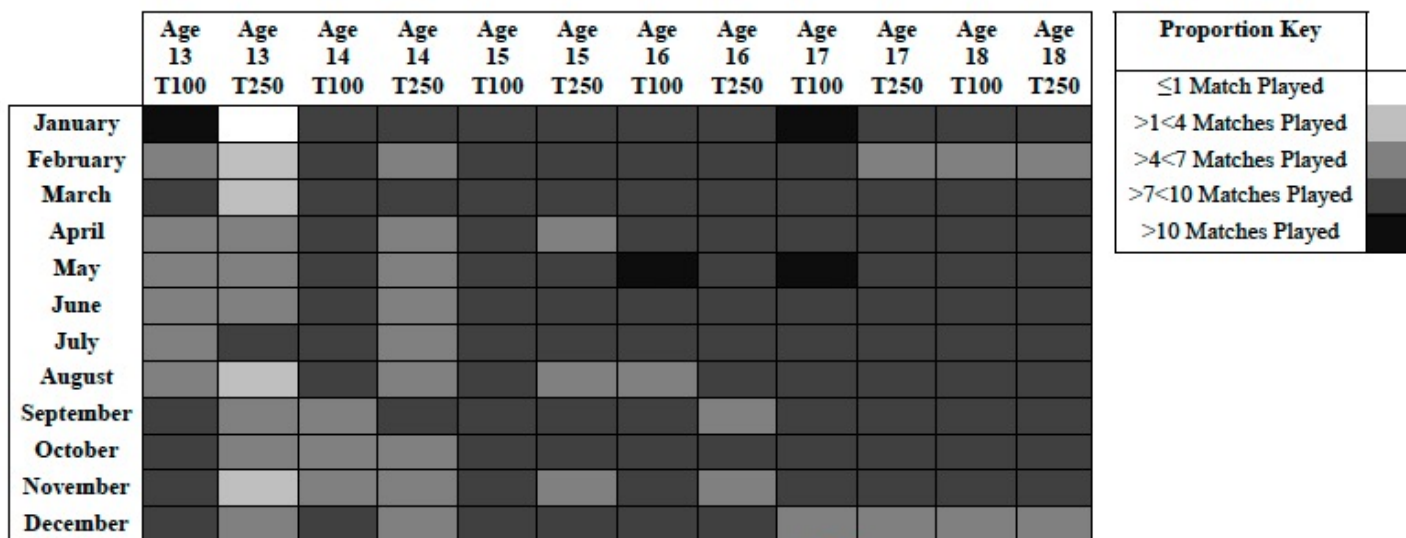


Figure 1. Average matches played per month by future top 100 (T100) and top 250 (T250) female tennis players

Table 1. Annual Matches Played and Tournament Distribution Variables

A.				B.			
Age	Group			Age	Group		
	T100-F	T100-S	T250		T100-F	T100-S	T250
13	7 ± 14	8 ± 18	2 ± 5	13	7 ± 14	8 ± 18	2 ± 5
14*	31 ± 27 ^(T250)	30 ± 29 ^(T250)	14 ± 19	14*	28 ± 25 ^(T250)	26 ± 26	13 ± 18
15*	63 ± 33 ^(T250)	53 ± 31	41 ± 30	15*	49 ± 29	37 ± 27	32 ± 27
16*	80 ± 33 ^(T250)	66 ± 32	60 ± 34	16	50 ± 29	38 ± 28	42 ± 31
17	80 ± 29	75 ± 33	71 ± 30	17*	29 ± 25	27 ± 29	31 ± 28
18	76 ± 23	78 ± 31	69 ± 24	18*	7 ± 12	10 ± 17	8 ± 12

C.				D.			
Age	Group			Age	Group		
	T100-F	T100-S	T250		T100-F ^(T250)	T100-S	T250
13	0 ± 0	0 ± 0	0 ± 0	13	35 ± 36	34 ± 48	45 ± 61
14*	2 ± 5 ^(T100-S)	5 ± 7	2 ± 5	14	38 ± 51	34 ± 60	46 ± 70
15*	14 ± 14	16 ± 13 ^(T250)	10 ± 11	15*	27 ± 36	25 ± 37	33 ± 55
16*	30 ± 20 ^(T250)	28 ± 17	18 ± 14	16*	23 ± 27	25 ± 37	26 ± 38
17*	50 ± 21	48 ± 20	40 ± 18	17*	20 ± 21	20 ± 27	22 ± 30
18*	69 ± 22	68 ± 25	61 ± 22	18	18 ± 19	19 ± 24	20 ± 26

All data presented as mean ± standard deviation.

(A) Annual Professional and Junior Tour Matches Played (B) Annual Junior Tour Matches Played (C) Annual Professional Tour Matches Played (D) Days Between Tournaments

Groups

T100-F. Players who made the top 100 ≤4 years of first professional ranking point

T100-S. Players who made the top 100 more than >4 years after first professional ranking point

T250. Players who achieved a ranking inside 101-250

* significantly different from previous age ($p < 0.05$)

^(T100-S) significantly different from T100-S ($p < 0.05$)

^(T250) significantly different from T250 ($p < 0.05$)

Table 2. Annual Consecutive[^] Tournaments Played

Age	Group		
	T100-F	T100-S	T250
13	1 ± 1	2 ± 4	0 ± 1
14*	2 ± 3	3 ± 3 ^(T250)	2 ± 2
15*	5 ± 3	5 ± 3	4 ± 3
16*	6 ± 3	6 ± 3	5 ± 4
17*	6 ± 3	8 ± 4	8 ± 3
18*	9 ± 4	9 ± 4	9 ± 4

All data presented as mean ± standard deviation

[^]Consecutive tournament defined as those occurring less than 8 days apart of each other

Groups

T100-F. Players who made the top 100 ≤4 years of first professional ranking point

T100-S. Players who made the top 100 more than >4 years after first professional ranking point

T250. Players who achieved a ranking inside 101-250

* significantly different from previous age ($p < 0.05$)

^(T250) significantly different from T250 ($p < 0.05$)

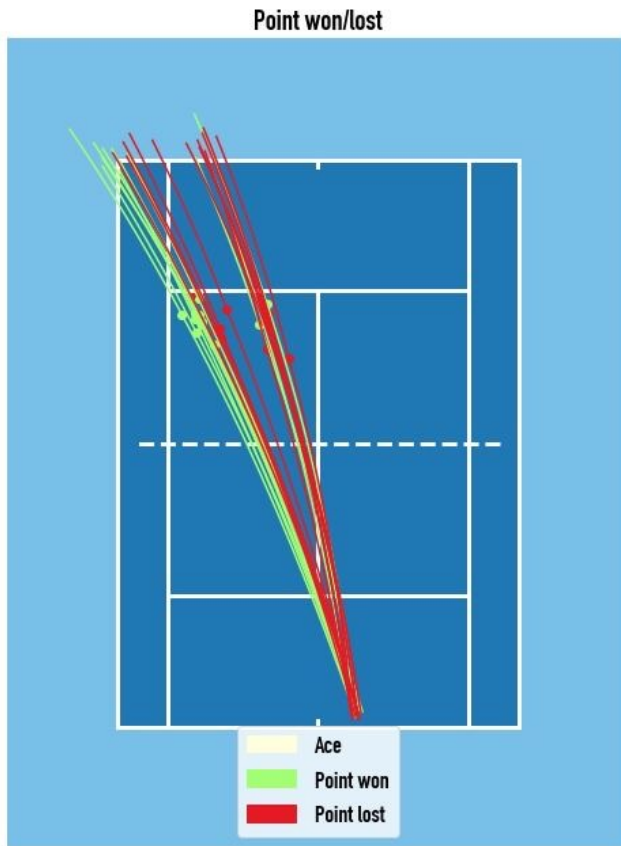
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MUGURUZA		Opponents
4.9/4.0	Average rally length when serving (1st/2nd)	6.1/6.3
1.23	Average contact point height [m]	1.03
24/114.0	Number of rally forehands / average speed [km/h]	22/102.8
17/114.2	Number of rally backhands / average speed [km/h]	22/104.6
178	Distance run [m]	448
4	Rally winners	3
2	Rally unforced errors	5
36/2	Topspin / slice	39/6
23/17	Cross-court / Down the line	19/25
112.9	FH DTL average speed [km/h]	84.1
116.5	BH DTL average speed [km/h]	102.0
117.6	BH CC average speed [km/h]	104.5
9.21	BH DTL average depth [m]	10.1
8.42	BH CC average depth [m]	8.67
1.6	Average net clearance	2.4
1.7/1.5	Average net clearance (FH/BH)	2.3/2.5
90	% shots deep of service line	82

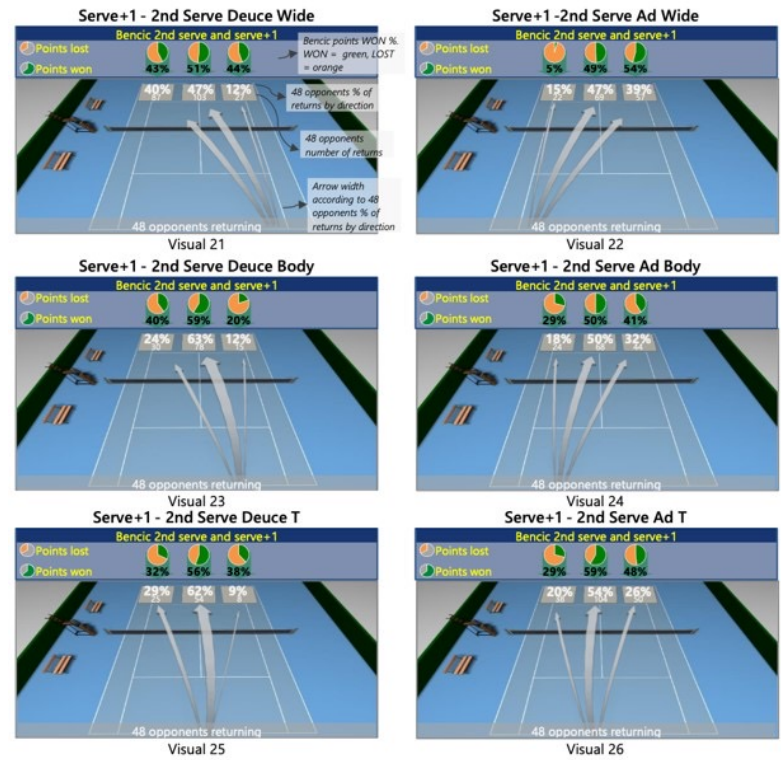
MUGURUZA		Opponents
5.0/5.0	Average rally length when serving (1st/2nd)	5.0/4.5
1.19	Average contact point height [m]	1.04
57/115.7	Number of rally forehands / average speed [km/h]	52/108.2
38/110.1	Number of rally backhands / average speed [km/h]	36/105.7
718	Distance run [m]	580
8	Rally winners	10
14	Rally unforced errors	7
86/3	Topspin / slice	75/10
56/32	Cross-court / Down the line	45/37
110.5	FH DTL average speed [km/h]	101.7
116.7	BH DTL average speed [km/h]	105.4
114.5	BH CC average speed [km/h]	102.0
9.57	BH DTL average depth [m]	8.64
9.59	BH CC average depth [m]	8.63
1.9	Average net clearance	1.8
2.0/1.7	Average net clearance (FH/BH)	1.8/2.0
85	% shots deep of service line	83

Analiza servisa

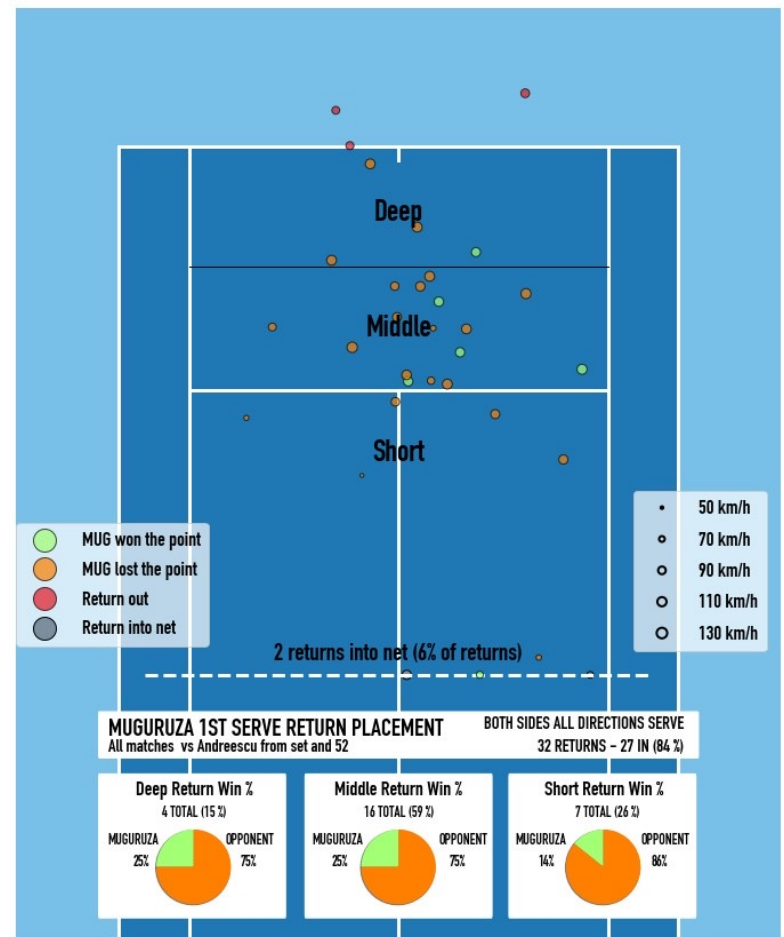
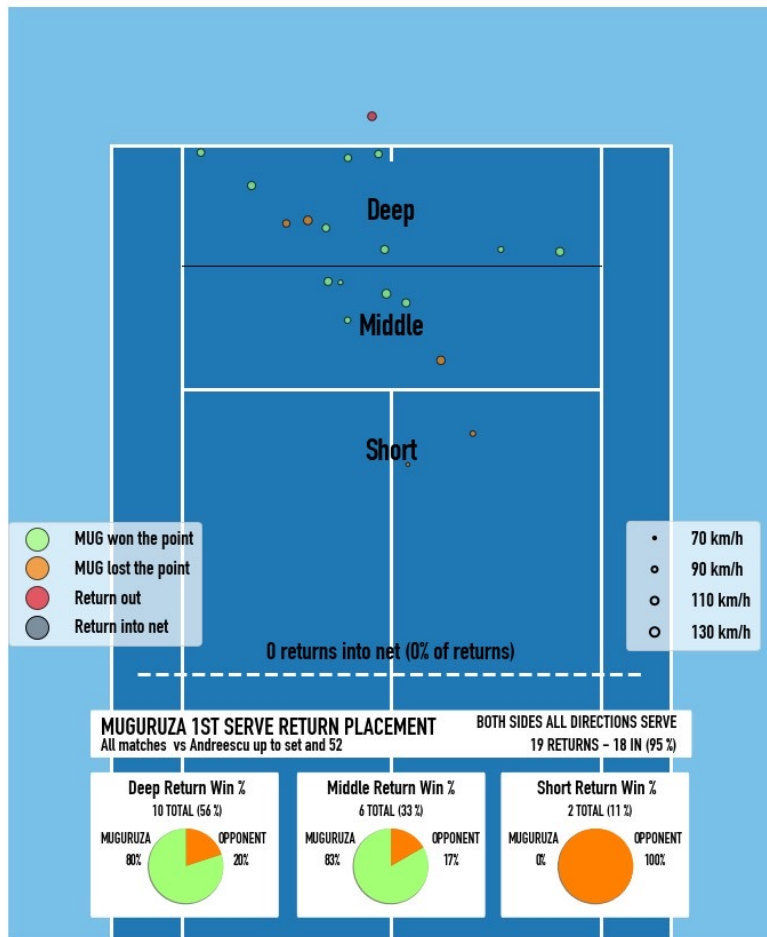
BENCIC 2nd serve



IT IS IMPORTANT TO TAKE THE INITIATIVE AND CRUCIAL TO **AVOID NEUTRAL RETURNS TO THE MIDDLE**, AS MUCH AS POSSIBLE (OPPONENT RETURNS V BENCIC)



Analiza reterna



Vprašanja?