ACTIVITY PROFILE AND PHYSIOLOGICAL DEMAND OF PADEL MATCH PLAY: A SYSTEMATIC REVIEW

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Review
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Abstract:

Padel is a complex sport within which performance relies on the interrelation of multiple factors such as physiological and physical capacities, psychological skills, and tactical and technical knowledge. Padel match involves intermittent whole-body efforts, evidenced by a large number of strokes and repeated high-intensity running actions such as accelerations, decelerations and changes of direction. Due to its recent creation, little is known about the activity and energy demands of padel match play. The purpose of the present study was to systematically review physiological demands of padel match play by assessing parameters related to external load, such as notational analysis or time-motion studies, and internal load through the analysis of physiological responses during the match. The systematic review process was conducted in accordance with the PRISMA guidelines. The electronic databases PubMed, Scopus and SportDiscus were searched using: ("padel" OR "pádel" OR "paddle tennis"). Twelve papers matched the inclusion criteria, from which four addressed internal load, six external load, and two analyzed both. A total of 203 padel players across all competition levels participated in the 12 selected studies. Study outcomes have probed prevalence of moderate physiological responses, low contribution of anaerobic glycolytic processes to supply energy, $\dot{V}O_2$ not being a limiting factor, and moderate to relatively high perceived effort rate. The highest game durations were found in professional players. Work-to-rest ratios reaffirm the intermittent nature of padel. Distance covered per set and match as well as speed are reciprocally proportional to player's standard level.

***Key words**: physiology, training load, paddle tennis, PRISMA*

Introduction

Padel is a court-based racket sport, played on a 10 x 20 m synthetic grass court enclosed in a structure covered with glass walls and a metallic mesh (FIP, 2017; Garcia-Benitez, Courel-Ibáñez, Perez-Bilbao, & Felipe, 2018). Game rules and scoring system are based on tennis, excepting those which affect walls and fence (Courel-Ibáñez, Sánchez-Alcaraz, & Cañas, 2017b) and the fact that padel is always played in doubles, so collaborative aspects are prominently important.

Over the last decade, padel has experienced an important growth in the number of players (Courel-Ibáñez, Sánchez-Alcaraz, García, & Echegaray, 2017a; Ruiz Barquín & Lorenzo García, 2008). By way of example, licenses in Spain has increased from 13,698 in the year 2005 to 96,872 in 2021 (FEP, 2021). After being very popular in Spain and South America, padel is now beginning to spread rapidly across Europe and other continents, having presence in 78 countries with more than 12,000,000 active players and 300,000 federated players among 44 national federations (FIP, 2021). However, this sport is still not a major racket sport such as tennis, badminton, squash, or table tennis (Lupo, et al., 2018).

Padel is a complex sport within which performance relies on the interrelation of multiple factors such as physiological and physical capacities, psychological skills, and tactical and technical knowledge (Courel-Ibáñez, et al., 2017a). The padel match involves intermittent whole-body efforts evidenced by a large number of strokes and repeated high-intensity running actions such as accelerations, decelerations and changes of direction (Priego, et al., 2013). These actions are executed in a short period of time using maximal or submaximal force with the predominance of eccentric and concentric muscle actions in stretch-shortening cycles (SSC) requiring power in a lot of cases

(Elliott, 2006) and implying anaerobic metabolism capacities (i.e., speed, agility, and power). Short periods of anaerobic actions are followed by long periods of recovery between points (Pradas de la Fuente, Zagalaz, Benedí, Quintas-Hijós, Arraco-Castellar, & Castellar-Otín, 2014). Therefore, moderate to high intensity interval efforts are damped down by aerobic activity in resting periods, which helps players recover from anaerobic peaks that occur in rallies.

Over the last decade, match activity profile and physical demands have been widely investigated in racket sports (i.e., tennis and badminton) (Baiget, Fernandez-Fernandez, Iglesias, & Rodriguez, 2015; Cabello Manrique & González-Badillo, 2003; Galé-Ansodi, Castellano, & Usabiaga, 2016; Hoppe, et al., 2014; Kilit & Arslan, 2017; Smekal, et al., 2001). Research in these areas provide essential information that can help coaches and physical trainers in the design of specific programs to improve players' performance. In this regard, the development of new training methods and load parameters have been the subject of in-depth studies in other racket sports such as tennis and badminton (Baiget, Iglesias, Fuentes, & Rodríguez, 2019; Baiget, Iglesias, & Rodríguez, 2017; Fernandez-Fernandez, Sanz-Rivas, & Mendez-Villanueva, 2009; Hülsdünker, et al., 2019). However, owing to the recent creation of padel (Navarro, 2014; Sánchez-Alcaraz, Courel-Ibáñez, & Cañas, 2018), little is known about the match activity and energy demands of padel match play. Research studies have been carried out analyzing external and internal load of padel match play such as heart rate (HR), blood lactate concentration (LA), rate of perceived exertion (RPE), oxygen uptake ($\dot{V}$O2), stroke distribution and time-motion parameters (Amieba & Salinero, 2013; Carbonell Martínez, Ferrándiz Moreno, & Pascual Verdú, 2017; Carrasco, Romero, Sañudo, & de Hoyo, 2011; Castillo-Rodríguez, Alvero-Cruz, Hernández-Mendo, & Fernández-García, 2014; Courel-Ibáñez, et al., 2017b; Díaz García, Grijota Pérez, Robles Gil, Maynar Mariño, & Muñoz Marín, 2017; García-Benítez, Pérez-Bilbao, Echegaray, & Felipe, 2016; Llin Mas, Guzmán Luján, & Martínez Gallego, 2018; Muñoz Marín, et al., 2016; Navarro, 2014; Pradas de la Fuente, et al., 2014; Sánchez-Alcaraz, 2014; Torres-Luque, Ramirez, Cabello-Manrique, Nikolaidis, & Alvero-Cruz, 2015).

Given the lack of reliable and accurate systematic reviews about this subject, the purpose of the present study was to analyze physiological demands of padel match play, reviewing and summarizing publications assessing any parameter related to external load, such as notational analysis or time-motion studies, and also investigations addressing internal load through analysis of physiological responses during the match.

Methods

Experimental approach to the problem

The systematic review process was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Liberati, et al., 2009; Moher, et al., 1999; Moher, Liberati, Tetzlaff, Altman, & PRISMA group, 2009; Shamseer, et al., 2015; Urrútia & Bonfill, 2010).

Subjects

Articles published in any language in peer-reviewed journals were screened for eligibility. No restrictions in terms of study design or time frame were established. Studies were considered for inclusion in the present review if they met all of the following criteria: (1) studies published in scientific journals with either JCR or SJR impact factor index, (2) male or female padel players of any age or competitive were included, (3) quantifiable measures of internal and/or external load of padel match were recorded and analyzed.

Procedures

The electronic databases PubMed, Scopus and SportDiscus were searched from their inception to December 2018.

Title, abstract, and keyword fields were searched in each of the aforementioned databases using the following search terms and syntax: ("padel" OR "pádel" OR "paddle tennis").

Records were exported to a local database using Thomson Reuters EndNote X7 software (2013). After eliminating duplicates, search results were screened against the eligibility criteria. The studies that could not be eliminated according to title or abstract were retrieved and in-depth evaluated as shown in Figure 1. Finally, studies were included in the present review if they matched the eligibility criteria and contained enough detailed information to allow for a comprehensive appraisal of methodological quality. Reference lists of all retrieved studies were manually searched for other potentially eligible studies.

Statistical analyses

A standardized data extraction template was developed and used to record data from the included studies. Data relating to study characteristics (sample size), players' characteristics (level of competition and gender) and parameters related to internal and/or external load were registered. Regarding internal load, the following variables were extracted: maximal and mean HR (HR_{max} and HR_{mean}), percentage of HR_{mean} with respect to theoretical HR_{max} and to HR_{max} registered in laboratory (%HR_{max}), LA, RPE, mean $\dot{V}O_2$ ($\dot{V}O_{2mean}$),

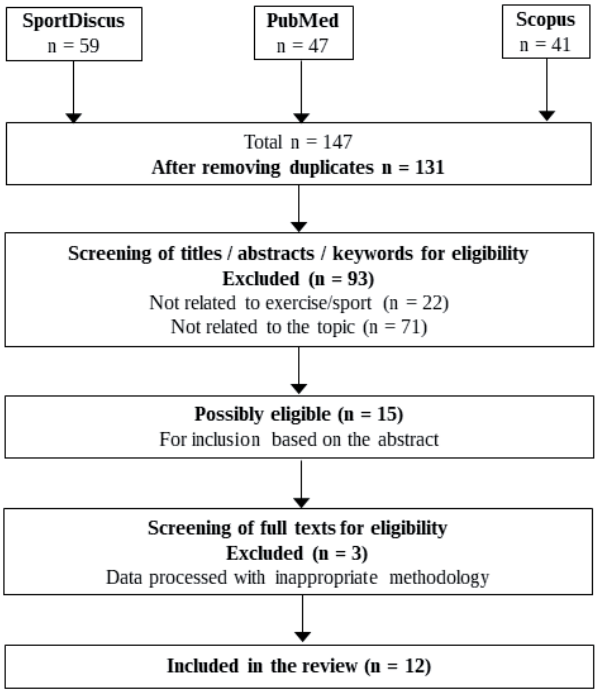

Figure 1. Flow chart of studies identification and their eligibility for the systematic review.

percentage of $\dot{V}O_{2max}$ (% $\dot{V}O_{2max}$) and percentage of $\dot{V}O_{2mean}$ with respect to oxygen uptake corresponding to the second ventilatory threshold ($\dot{V}O_{2mean}$:VT2). Concerning external load, the parameters collected from the studies were: rally duration (RD), rest time interval between rallies (RT), strokes per rally (SR), effective playing time (recorded from the time the server hits the ball to the end of the point as specified in the rules) and total duration corresponding to game (GD), set (SD) and match (MD), strokes per match (SM), strokes per rally (SR), work-to-rest ratio (W:R), distance covered per match (DCM), distance covered per set (DCS), distance covered per game (DCG), maximal registered speed (MS), average speed per rally (AS) and time spent at various speed zones.

Results

Search outcome

A total of 147 studies were retrieved from the aforementioned databases. After removal of duplicates, screening of titles, abstracts, and keywords for eligibility, 93 studies were excluded. Subsequently, the full text of 15 remaining papers was retrieved and revised; three were excluded after the full-text examination. As a result, 12 studies ended up matching the inclusion criteria. All 12 selected papers were original journal articles published between the years 2011 and 2018, out of which four regarded internal load, six external load, and two analyzed both of them. All collected data were summarized in Tables 1, 2 and 3.

Study characteristics

A total of 203 padel players, males (n = 145) and females (n = 58) across all competition levels participated in the 12 selected studies. They were of the following competition levels: international ranking (n = 96) (Courel-Ibáñez, et al., 2017b; García-Benítez, et al., 2016; Llin Mas, et al., 2018; Lupo, et al., 2018; Pradas de la Fuente, et al., 2014; Torres-Luque, et al., 2015), national ranking (n

Table 1. Physiological demands of padel match play

Study	Subjects			HR_{mean} (beats·min^{-1})	HR_{max} (beats·min^{-1})	% HR_{max}	LA (mmol·l^{-1})	RPE (Borg CR-10)	$\dot{V}O_{2mean}$ (ml·kg^{-1}·min^{-1})	%$\dot{V}O_{2max}$ max	$\dot{V}O_{2mean}$: VT2 (%)
	Level	Sex	Age (y)								
Carrasco et al. (2011)	Nat U18	12 M	16.6 ± 1.5	148.3 ± 13.6	169.7 ± 18.4	74.0 ± 4.7$^{\&}$	NR	NR	24.1 ± 7.0	43.7 ± 11.0	52.5 ± 15.5
Castillo-Rodríguez et al. (2014)	Nat 1st Cat	8M		131.7 ± 16.3	NR	68.8 ± 6.9*	2.6 ± 1.3	3.2 ± 2.0	NR	NR	NR
	Nat 2nd Cat	8 M	28.7 ± 6.8	156.4 ± 15.6	NR	81.3 ± 7.7*	2.7 ± 1.4	5.9 ± 1.7	NR	NR	NR
	Nat 3rd Cat	8M		150.8 ± 14.4	NR	78.0 ± 7.1*	3.4 ± 1.8	5.1 ± 1.7	NR	NR	NR
Pradas et al. (2014)	Int (PPT)	6 F	28.2 ± 0.6	151 ± 8.1	177 ± 9.3	76.3$^{\&}$	2.4 ± 0.7	NR	NR	NR	NR
Carbonell et al. (2017)	Nat (1st to 3rd Cat)	9 F	32.8 ± 12.3	150 ± 8.6	179 ± 9.4	78.6 ± 3.6*	NR	NR	NR	NR	NR
Díaz et al. (2017)	Rec	8 M	22.5 ± 1.1	126.8 ± 10.4	154.8 ± 7.3	65.7$^{\&}$	NR	NR	NR	NR	NR
Llin et al. (2018)	Int (PPT)	7 M	31.1 ± 5.9	153.7 ± 14.6	186.6 ± 15.2	85.9*	NR	NR	NR	NR	NR
	Nat 1st Cat	7 M	25.4 ± 3.8	159.1 ± 13.8	188.6 ± 5.9	86.4*	NR	NR	NR	NR	NR

Note. HR_{mean}: mean heart rate; HR_{max}: maximal heart rate registered on the court; %HR_{max}: percentage of mean heart rate with respect to maximal heart rate; LA: blood lactate concentration; RPE: rate of perceived exertion; VO_{2mean}: mean oxygen uptake; VO_{2max}:VT2: maximal oxygen uptake over the second ventilatory threshold ratio; %VO_{2max}: percentage of maximum oxygen uptake; *%HR_{mean} with respect to theoretical HR_{max}; $^{\&}$%HR_{mean} with respect to HR_{max} registered in laboratory; M: male; F: female; NR: not registered; PPT: padel pro tour; Nat: national; Cat: category; Int: international; Rec: recreational.

Table 2. Notational analysis of padel match play

Study	Subjects			RD (s)	SR (n)	RT (s)	GD		SD		MD		SM (n)	W:R
	Level	Sex	Age (y)				Total (s)	Effective (s)	Total (s)	Effective (s)	Total (s)	Effective (s)		
Muñoz et al. (2016)	Reg	15 M	25.4 ± 4.2	12.7 ± 10.1	NR	14.0 ± 6.3	NR	69.6 ± 35.7	NR	684.9 ± 118.2	NR	1484 ± 174.6	NR	NR
Lupo et al. (2018)	Int (WPT)	14 M	NR	12.6 ± 2.1	9.6 ± 1.5	NR	NR	NR	NR	NR	NR	NR	NR	NR
		9 F	NR	16.8 ± 2.8	12.2 ± 2.0	NR	NR	NR	NR	NR	NR	NR	NR	NR
García-Benítez et al. (2016)	Int (PPT)	18 M	32.6 ± 5.1	10.8 ± 7.7	7.7 ± 6.3	17.2 ± 7.7	159.6 ± 104.4	66 ± 34.8	2111.4 ± 606	633 ± 183.6	5029.2 ± 1848.6	1441.8 ± 521.4	1178.9 ± 443.1	1:1.54
		10 F	31.3 ± 4.1	15.8 ± 12.7	9.7 ± 8.3	20.3 ± 7.2	216.6 ± 126.6	103.8 ± 66	2296.8 ± 708.6	867 ± 316.8	5355.6 ± 1569.6	1950 ± 690	1338.8 ± 480.7	1:1.28
Torres-Luque et al. (2015)	Int (PPT)	8 M	NR	9.30 ± 4.0	9.3 ± 1.1	19.3 ± 10.2	NR	NR	NR	NR	3041.8 ± 263.3	1050.2 ± 170.0	NR	1:2.31
		8 F	NR	9.67 ± 4.76	9.5 ± 2.2	21.8 ± 12.3	NR	NR	NR	NR	3721.3 ± 774.8	1453.1 ± 260.5	NR	1:2.51
Carrasco et al. (2011)	Nat U18	12 M	16.6 ± 1.5	7.24 ± 0.0	NR	9.1 ± 0.0	163.1 ± 3.0	71.43 ± 0.0	NR	NR	NR	NR	NR	1:1.26
Courel et al. (2017)	Int (WPT)	16 M	NR	9.4 ± 7.2	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
García-Benítez et al. (2018)	Nat U16	8 M	15.5 ± 1.1	8.9 ± 6.1	6.1 ± 5.0	14.3 ± 7.9	142 ± 89	61.6 ± 6.9*	2017 ± 455	31.1 ± 2.4*	4866 ± 954	29.0 ± 0.9*	995 ± 194	1:1.41
		8 F		11.3 ± 9.2	6.9 ± 6.4	15.6 ± 6.1	167 ± 86	44.4 ± 8.7*	2035 ± 599	33.4 ± 3.5*	4926 ± 1380	32.4 ± 3.6*	986 ± 349	1:1.31
	Nat U18	8 M		12.0 ± 8.7	8.0 ± 6.2	15.5 ± 6.4	163 ± 84	46.9 ± 7.3*	2166 ± 600	35.5 ± 2.1*	5214 ± 2145	34.7 ± 1.4*	1185 ± 760	1:1.20
		8 F		11.7 ± 9.1	7.2 ± 6.1	14.1 ± 5.2	168 ± 107	41.7 ± 12.6*	1535 ± 650	30.4 ± 6.9*	3168 ± 1002	34.8 ± 4.3*	713 ± 281	1:1.13

Note. RD: rally duration; RT: rest time interval between rallies; GD: game duration; SD: set duration; MD: match duration; SM: strokes per match; SR: strokes per rally; WR: work-to-rest ratio; Reg: regional; Int: international; Nat: national; M: male; F: female; NR: not registered; WPT: world padel tour; PPT: padel pro tour; *Effective (s): calculated from percentages in the original article.

Table 3. Distance covered and running speed during padel match play

Study	Subjects			DCM (m)	DCS (m)	AS (km·h^{-1})	Time spent at various speed zones (%)				
	Level	Sex	Age (y)				Z1 0-2 Km·h^{-1}	Z2 2.1-7 km·h^{-1}	Z3 7.1-9 km·h^{-1}	Z4 9.1-13.5 km·h^{-1}	Z5 13.6-18 km·h^{-1}
Castillo-Rodríguez et al. (2014)	Nat 1st Cat	8 M		1117.2 ± 252.7	609 ± 113.2	1.9 ± 0.3	55.3 ± 5.5	42.8 ± 4.9	1.4 ± 0.5	0.6 ± 0.3	0.0 ± 0.0
	Nat 2nd Cat	8 M	28.7 ± 6.8	1922.5 ± 641.4	886.6 ± 214.0	2.1 ± 0.3	48.9 ± 5.6	48.0 ± 4.7	2.2 ± 0.8	1.0 ± 0.9	0.0 ± 0.1
	Nat 3rd Cat	8 M		2319.7 ± 755.3	1043.4 ± 548.7	2.2 ± 0.3	48.1 ± 6.5	48.9 ± 5.5	2.2 ± 0.9	0.8 ± 0.4	0.0 ± 0.1

Note. DCM: distance covered per match; DCS: distance covered per set; AS: average speed per rally; Z: zone; M: male; Nat: national; Cat: category.

= 40) (Carbonell Martínez, et al., 2017; Castillo-Rodríguez, et al., 2014; Llin Mas, et al., 2018), national U18 ranking (n = 28) (Carrasco, et al., 2011; Garcia-Benitez, et al., 2018), national U16 ranking (n = 16) (Garcia-Benitez, et al., 2018), regional ranking (n = 15) (Muñoz Marín, et al., 2016), and recreational (n = 8) (Díaz García, et al., 2017).

Finding outcomes

Two out of the twelve studies investigated both the internal and external load of padel match play (Carrasco, et al., 2011; Castillo-Rodríguez, et al., 2014), six aimed at analyzing the external load (Courel-Ibáñez, et al., 2017b; Garcia-Benitez, et al., 2018; Lupo, et al., 2018; Muñoz Marín, et al., 2016; Sánchez-Alcaraz Martínez, et al., 2018; Torres-Luque, et al., 2015) (Table 2 and 3), and four the internal one (Carbonell Martínez, et al., 2017; Díaz García, et al., 2017; Llin Mas, et al., 2018; Pradas de la Fuente, et al., 2014) (Table 1).

Discussion and conclusions

This systematic review sought to evaluate physiological internal and external load parameters involved in the game of padel: time-motion characteristics, notational analysis and physiological responses. Studies have probed prevalence of moderate physiological responses, low contribution of anaerobic glycolytic processes to energy supply, $\dot{V}O_2$ not being a limiting factor, and moderate to relatively high perceived effort rate. Registered RD were close to those found in single tennis and slightly lower than in single badminton. Effective GD varies according to players' level and gender; the highest GD were set by professional players. DCS and DCM is reciprocally proportional to players' level, so more distance is covered at lower speeds by top level players. Analyzed data have been compared with other racket sports that share common characteristics such as tennis and badminton.

Internal load

Six studies investigated the physiological demands of padel match play (Carbonell Martínez, et al., 2017; Carrasco, et al., 2011; Castillo-Rodríguez, et al., 2014; Díaz García, et al., 2017; Llin Mas, et al., 2018; Pradas de la Fuente, et al., 2014). HR_{max} was assessed in all the six included studies and HR_{mean} in five. Similar HR_{max} values have been reported for professional players in other racket sports such as tennis and badminton (Cabello Manrique & González-Badillo, 2003; Fernandez-Fernandez, et al., 2009; Fernandez, Mendez-Villanueva, & Pluim, 2006; Kovacs, 2007). However, HR_{mean} during match play has been probed higher in professional badminton players compared to padel (Cabello Manrique & González-Badillo, 2003; Faude, et al., 2007). $\%HR_{max}$ with respect to either theoretical or HR_{max} registered in laboratory, ranging from 65.73 to 86.39%, probed submaximal and moderate intensity efforts during padel match play. International and national first category players exhibited higher values than recreational players in both HR_{max} (188.6 ± 5.9 and 186.6 ± 15.2 vs. 154.75 ± 7.25 beats·min^{-1}) and HR_{mean} (159.1 ± 13.8 and 153.7 ± 14.6 vs. 126.78 ± 10.4 beats·min^{-1}), respectively (Kilit, Arslan, & Soylu, 2018; Torres-Luque, Cabello, Raquel, & Garatachea, 2011). These differences may be due to a longer point duration and higher moving speeds, accelerations, decelerations, and stroke velocities in top level players compared to recreational ones.

LA concentration was assessed in two investigations including international and national category players (Carrasco, et al., 2011; Castillo-Rodríguez, et al., 2014). Mean LA concentration values are low in all player levels (2.4 ± 0.66 to 3.38 ± 1.83 mmol·l^{-1}) and suggests moderate anaerobic glycolytic processes to supply energy. Even though padel match play implies high intensity game actions, we may hypothesize that low LA concentrations may be due to short point duration and low W:R ratios. However, game characteristics lead to hypothesize that LA concentrations may be increased in punctual moments of the match such as longer and more intense rallies as shown in single tennis (Fernandez-Fernandez, et al., 2006; Kovacs, 2007). All registered values agree to mean LA concentrations studied in single tennis and badminton during match play, which range from 1.53 to 4.0 mmol·l^{-1} (Faude, et al., 2007; Fernandez-Fernandez, Mendez-Villanueva, Pluim, & Terrados, 2007; Ferrauti, Bergeron, Pluim, & Weber, 2001; Hornery, Farrow, Mujika, & Young, 2007; Phomsoupha & Laffaye, 2015; Smekal, et al., 2001).

One investigation studied the subjective intensity of effort trough the RPE scale, exhibiting values ranging from 3.21 ± 2.04 to 5.85 ± 1.71 (Borg CR-10 scale) in national category players (Castillo-Rodríguez, et al., 2014). These values correspond to moderate to relatively high perceived effort. Similar RPE values have been reported in tennis matches (Fernandez-Fernandez, Mendez-Villanueva, Pluim, et al., 2007; Fernandez-Fernandez, Sanz-Rivas, Fernandez-Garcia, & Mendez-Villanueva, 2008; Mendez-Villanueva, Fernandez-Fernández, Bishop, & Fernandez-Garcia, 2010) and higher values have been found in badminton match play (15.7 ± 1.7; 6-20 Scale) (Duncan, Chan, Clarke, Cox, & Smith, 2017).

Although continuous measurement of $\dot{V}O_2$ using portable gas analyzers has been considered a valid tool to determine the match play internal load in racquet sports (Baiget, et al., 2015; Faude, et al., 2007), the average and peak $\dot{V}O_2$ intensities were studied in only one investigation (Carrasco, et al., 2011). Players in the national under 18 category

exhibited 24.06 ± 6.95 ml·kg^{-1}·min^{-1} $\dot{V}O_{2mean}$, 43.73 ± 11.04% $\dot{V}O_{2max}$ and 52.52 ± 15.50% $\dot{V}O_{2mean}$:VT2, probing the moderate and clearly submaximal average intensities and that $\dot{V}O_2$ is probably not a limiting factor during padel match play. $\dot{V}O_{2mean}$ registered values in padel are close to those reported previously in tennis (Christmass, Richmond, Cable, Arthur, & Hartmann, 1998; Ferrauti, et al., 2001) and lower than that observed in badminton (46.0 ± 4.5 ml·kg^{-1}·min^{-1}) (Faude, et al., 2007). Regarding the %$\dot{V}O_{2max}$, numbers are lower than those previously found in single tennis and badminton (Comellas & López de Viñaspre, 2011; Faude, et al., 2007; Fernandez-Fernandez, et al., 2009; Ferrauti, et al., 2001) probably due to smaller padel court dimensions and also because padel tennis is always played in doubles.

External load

Eight publications studied external load of padel match play throughout notational analysis. RD was assessed in seven studies. Values ranging from 7.24 ± 0.0 to 16.8 ± 2.8 s were found. The lowest RD was registered in young players (Carrasco, et al., 2011; Garcia-Benitez, et al., 2018), suggesting that age has an impact on this variable through less control of the ball and a higher number of errors committed during the point. In addition, significant differences were found in male and female players (10.8 ± 7.70 vs. 15.8 ± 12.70 s) (García-Benítez, et al., 2016). Women exhibit longer RD, probably due to a higher number of lobs, which slow down the game (García-Benítez, et al., 2016; Torres-Luque, et al., 2015) and a higher number of SR (Garcia-Benitez, et al., 2018). RD has been widely studied in tennis (Fernandez-Fernandez, et al., 2006; Kilit, et al., 2018; Kovacs, 2007), probing similar values to those registered in padel (Pradas de la Fuente, et al., 2014). Regarding badminton, lower values have been registered in singles (6.40 ± 1.25 s) (Cabello Manrique & González-Badillo, 2003). Six investigations studied the RT. Values are in the range 9.11 ± 0.0 s in male national U18 players (Carrasco, et al., 2011) to 21.82 ± 12.32 s in female international Padel Pro Tour players (Torres-Luque, et al., 2015). Rules of padel establish a maximal time interval between points of 20 s (Federación Internacional de Pádel, 2017). According to García-Benítez et al. (2016), this limitation justifies the lack of investigations probing significant differences in RT between different players' gender or level. Finally, other racket sports such as tennis and badminton reported average resting times in professional players about 10-20 s (Cabello Manrique & González-Badillo, 2003; Christmass, et al., 1998; Fernandez-Fernandez, et al., 2009a; Fernandez-Fernandez, Mendez-Villanueva, Fernandez-Garcia, & Terrados, 2007; Fernandez-Fernandez, et al., 2008; Hoppe, et al., 2014; Hornery, et al., 2007; Kilit, Şenel, Arslan, & Can, 2016; Mendez-Villanueva, Fernandez-Fernandez, Bishop, Fernandez-Garcia, & Terrados, 2007; Mendez-Villanueva, et al., 2010; Smekal, et al., 2001; Torres-Luque, Cabello, et al., 2011), which are close to those registered in padel studies.

SR was assessed in four investigations. Values ranging from 6.1 ± 5.0 to 12.2 ± 2.0 were registered. The lowest SR numbers were registered in young players (Garcia-Benitez, et al., 2018), suggesting, as in RD, that age has an impact on this variable through less control of the ball and a higher number of errors that lead to shorten the point. The highest number of SR were found in professional female players, probing significant differences from professional male players (12.2 ± 2.0 vs. 9.6 ± 1.5).

GD was studied in four studies. Total GD ranges from 142 ± 89 s in male national U16 category players (Garcia-Benitez, et al., 2018) to 216.6 ± 126.6 s in female international Padel Pro Tour players (García-Benítez, et al., 2016). This difference may be justified by higher resting times between rallies in professional players (17.2 ± 7.70 and 20.3 ± 7.20 vs. 14.95 ± 6.32 s) (García-Benítez, et al., 2016; Muñoz Marín, et al., 2016) and by RD times among different categories and player's level. Concerning GD effective time, male national category U16 players exhibit the lowest numbers at 61.62 ± 6.85 s (Garcia-Benitez, et al., 2018) and female Padel Pro Tour players set the highest (103.8 ± 66 s) (García-Benítez, et al., 2016). Differences in effective GD are caused by differences in RD. These differences are due to errors committed during the point, number of lobs and number of SR (Garcia-Benitez, et al., 2016, 2018; Torres-Luque, et al., 2015).

Three investigations studied SD among different player categories. Concerning total SD, the longest values were found in female international Padel Pro Tour players (2296.8 ± 708.6 s) (García-Benítez, et al., 2016) and male U18 national players (2166 ± 600 s) (Garcia-Benitez, et al., 2018). When effective set playing times were isolated, female international Padel Pro Tour players kept setting the longest durations (867 ± 316.8 s) (García-Benítez, et al., 2016) and female U18 national players recorded the shortest ones (30.4 ± 6.9%) of effective SD, which was equivalent to 466 s (Garcia-Benitez, et al., 2018). Significant differences between international Padel Pro Tour male and female players were found in total and effective set playing times. Females set higher values in both parameters, in SD (2111.4 ± 606 s vs. 2296.8 ± 708.6 s) and in set effective playing time (633 ± 183.6 vs. 867 ± 316.8 s) (García-Benítez, et al., 2016). As mentioned in previous analyzed time variables, these numbers are mainly explained by RD times among different categories and player's level.

Four investigations assessed MD (Garcia-Benitez, et al., 2016, 2018; Muñoz Marín, et al., 2016; Torres-Luque, et al., 2015). Female international Padel Pro Tour players registered the longest total match average times (5356.6 ± 1569.6 s) and match effective playing time (1950 ± 690 s) (García-Benítez, et al., 2016). The shortest values were found in national U18 female players with the 3168 ± 1002 s total match average time and 34.8 ± 4.3% of effective match playing time, which was equivalent to 1102 s. (Muñoz Marín, et al., 2016). Significant differences concerning MD were found in international players, where female players set longer total and effective match times as a consequence of a higher use of lobs during the match that slowed down the game and number of SR (Garcia-Benitez, et al., 2016).

SM was investigated in two studies (Garcia-Benitez, et al., 2016, 2018). In international Padel Pro Tour players, a total of 1178.93 ± 443.05 and 1338.75 ± 480.65 SM were registered for women and men, respectively (García-Benítez, et al., 2016), probing significant differences between two genders. A higher number in SR may explain these differences (7.67 ± 6.34 vs. 9.71 ± 8.32). By contrast, national U18 and U16 players showed values ranging from 713 ± 281 in female U18 players to 1185 ± 760 in male U18 category where no significant differences between gender or category were found (Garcia-Benitez, et al., 2018). As mentioned in SR discussion, age might have an impact on this variable through a poorer control of the ball and a higher number of errors that lead to shorten the points.

Work:rest ratio (W:R) was assessed in five studies (Carrasco, et al., 2011; Garcia-Benitez, et al., 2016, 2018; Muñoz Marín, et al., 2016; Torres-Luque, et al., 2015). Values ranged from 1:1.19 in regional category male players (Muñoz Marín, et al., 2016) to 1:2.25 in international female Padel Pro Tour players (Torres-Luque, et al., 2015). Lower W:R ratios were found in younger players, which is likely to be a direct consequence of a shorter RD (Garcia-Benitez, et al., 2018). Similar studies on other racket sports such as tennis and badminton have shown smaller W:R ratios 1:2–4 and 1:2, respectively (Abdullahi & Coetzee, 2017; Cabello Manrique, & González-Badillo, 2003; Reid & Duffield, 2014; Torres-Luque, Cabello, et al., 2011; Torres-Luque, Sanchez-Pay, Jesús, Belmonte, & Moya, 2011). This difference may be due to a shorter RD in tennis and equal rules in both sports concerning resting times between points (20 s). In the case of badminton, which presents similar SR values to those registered in padel, a smaller W:R ratio is justified by a shorter RT, even if there is no quantitative restriction about this subject in badminton rules. W:R ratio reaffirms the intermittent nature of this discipline (Torres-Luque, et al., 2015). Low W:R ratios and short RD may have a significant impact on the moderate physiological responses during padel match play such as LA concentration, HR values and $\dot{V}O_2$.

One study investigated DCM, DCS, AS and the amount of time spent at various speed ranges (Castillo-Rodríguez, et al., 2014). Regarding DCM and DCS, national first category male players showed statistical differences compared to the second and third category, registering lower values per match (1117.2 ± 252.7 m) and set (609 ± 113.2 m). No justifications to these differences have been provided by authors in the original publication. However, we may hypothesize that better players tend to cover less distance because of their ability to anticipate ball trajectories and better positioning or, in other words, a better tactical understanding of the game. AS was also studied in the aforementioned publication. Low registered speeds, ranging from 1.93 ± 0.31 to 2.18 ± 0.31 km·h^{-1} (Castillo-Rodríguez, et al., 2014), are due to the nature of padel, which is a discipline where accelerations and changes of directions seem to prevail over linear speed due to the lack of long distances to be covered in addition to complex technical, tactical and coordinative skills that are involved in the game. No statistical differences have been found among the male national first, second and third category (1.93 ± 0.31, 2.13 ± 0.25 and 2.18 ± 0.31 km·h^{-1}) (Castillo-Rodríguez, et al., 2014). Greater AS have been found in tennis (2.2 – 11.5 km·h^{-1}) (Kilit, et al., 2018; Smekal, et al., 2001), probably due to smaller padel court dimensions that limits reaching higher speeds and also because padel tennis is always played in doubles. Regarding the amount of time spent at various speed intervals, the researchers found statistical differences in the first category players compared to the second and third, who spent more time in zones 1 and 2, meaning that they covered more distance at lower speeds (0-7 km·h^{-1} range). In addition, less DCS and DCM, so efficiency of the first category players' movements can justify registered values showing less physical and physiological responses also (Castillo-Rodríguez, et al., 2014). Similar results have been found in tennis, in which a major part of the covered distance have been generally showed between 0 and 7 km·h^{-1} (Galé-Ansodi, et al., 2016; Hoppe, et al., 2014; Kilit & Arslan, 2017). Nevertheless, further studies investigating DCM, DCS and AS during padel match play are needed in order to corroborate the aforementioned findings.

In conclusion, study outcomes have probed the prevalence of moderate physiological responses, low contribution of anaerobic glycolytic processes to supply energy, $\dot{V}O_2$ not being a limiting factor, and moderate to relatively high perceived effort rate. RD in padel ranges from 7.24 ± 0.0 to 16.8 ± 2.8 s. The lowest RD, registered in young players, and

the longest points duration were set by women. The highest GD, that may be justified by higher RT, were found in professional players. Effective game duration varies among players' level and gender, extrapolating these differences to set and match total and effective times. Work-to-rest ratio reaffirms the intermittent nature of padel. Low W:R ratios and short RD may have a significant impact on the moderate physiological responses during padel match play such as LA concentration, HR values and $\dot{V}O_2$. DCS and DCM is reciprocally proportional to players' level. The higher the player's level, the more distance is covered at lower speeds that may be due to efficiency in the first category players' movements.

These findings provide practical insights for coaches and conditioning professionals prescribing padel specific training programs. Regarding physical conditioning coaches, a major enhance in training load quantification may be achieved based on the evidence extracted from both the internal and external load during competitive match play. In addition, as coaches increasingly rely on an integrated approach to conditioning and skill-based training, internal and external load quantification in competitive match play context seems to play an essential role in training prescription. In order to design training programs based on padel specific internal and external workloads, it is recommended that sessions may have duration around 50 to 90 minutes. Players should cover a total distance per training session from 1000 to 2000 meters. The number of strokes per drill should be set between 10-12 with 10-20s resting time intervals between them. Regarding internal load, LA concentration may be maintained between 2.4 and 3.4 $mmol \cdot l^{-1}$, $\dot{V}O_2$ around 24 $ml \cdot kg^{-1} \cdot min^{-1}$ and rate of perceived exertion should be between 3 and 6 on the CR10-Borg scale.

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