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Match activity profile analysis during professional men's double pickleball tournaments

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ABSTRACT
The aim of this study was to analyse the activity profile of professional men's doubles pickleball tournaments. A total of 6839 shots from eight men's doubles matches, corresponding to the final stages of two Professional Pickleball Association (PPA) Tour tournaments were analysed. The match activity analysis included technical-tactical (shots per player, hitting locations, type of shots, ball trajectory and action and shot outcomes) as well as playing and resting time parameters (rally duration, effective playing time, resting time, work-to-rest ratio). Match duration averaged 36 ± 15.9 min, with a work-to-rest of 1:1.6 ± 0.3, while actual playing time averaged 14.0 ± 5.0 min (39% of total match time). Most points lasted between 3–9 s (67.4%) with rest times of 9–15 s (84.3%). In 60.5% of the cases, rallies involved 3–10 shots, with the forehand being the most frequent shot (40.2%). Indirect shots were more common than direct ones, with most shots being played from the transition zone (71.3%). Cross-court play (54%) dominated over parallel play and 90.8% of shots were intercepted. Winning pairs' left-side players performed more shots per game (27.3%). This analysis provides valuable insights into the activity profile of doubles pickleball, offering guidance for improving sports' performance.

1. Introduction

Pickleball is a sport that combines elements from other racket-sports (i.e. tennis, padel, badminton and table tennis) (Steinaker, 2023). In recent years, its popularity has been growing significantly, particularly in the United States, leading to a significant increase in the number of players, clubs, and courts across the country (U.S.A. Pickleball, 2023). It can be played in both singles and doubles formats, with doubles being the most common. Several professional leagues have emerged, including the Professional Pickleball Association (PPA) Tour, the APP Tour, and Major League Pickleball. More specifically, the 2024 PPA Tour schedule includes 26 tournaments in 16 different U.S. states, with events classified as a Slam (2000), Cup (1500) or Open (1000), based on the PPA points awarded to first-place winners. These tournaments cover categories such as men's and women's professional singles, men's and women's professional doubles, and professional mixed doubles (Tour, 2024).
A review of the scientific literature on pickleball reveals a growing number of publications addressing topics such as injuries (Vitale & Liu, 2020) and the mental health benefits of the sport (Cerezuela et al., 2023). Among the research on physiological demands, the acute and chronic physiological responses in middle-aged adults were examined, investigating variables such as heart rate, game intensity and steps counts (Smith et al., 2018; Webber et al., 2023). Training strategies to enhance on-court performance in older players were also explored, analysing sport-specific needs based on movement demands, physiological demands, and injury risk assessment (Terrell & Ficquette, 2023). Additionally, research suggests that pickleball matches, whether singles or multiple doubles matches, do not induce significant neuromuscular fatigue (Martin et al., 2024). However, there is a paucity of studies focusing on performance and competitive demands. Specifically, there is limited research on the specific movement patterns and physical demands and physiological variables in pickleball, such as heart rate, lactate levels and the activity profile of the sport. A better understanding of the sport-specific competitive demands and activity profile can help guide training and optimise athlete performance in competition (Halson, 2014). In contrast, other racket- sports have been extensively studied and analysed by researchers. For instance, in tennis, player activity profiles and physiological demands have been well-documented, buting to enhanced preparation and performance optimisation (Baiget et al., 2015; Borderias et al., 2021; Fernandez-Fernandez et al., 2009; Pluim et al., 2023; Smekal et al., 2001; Torres-Luque et al., 2011). Similarly, in padel, key parameters such as physiological responses, activity profiles, and technical-tactical playing actions have also been examined (Ampuero et al., 2023; Mellado-Arbelo & Baiget, 2022; Mellado- Arbelo et al., 2019). In pickleball, however, there is a notable lack of studies addressing these sport-specific factors, leaving gaps in critical data related to the activity profile of the sport (i.e. effective playing time, playing-to-resting time ratios). A deeper standing of pickleball's competitive demands could help players and coaches optimise training sessions, enhancing performance, while also benefiting pickleball clubs and organisations in structuring their programs. Therefore, the

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present study aims to conduct a descriptive analysis of the match-play activity profile during the final stages of two professional men's doubles pickleball tournaments.

2.Methods

2.1.Design

In this study, an observational cross-sectional design was employed, characterised as nomothetic and multidimensional due to the number of participants and the variety of parameters analysed. These parameters were classified into different criteria and categories, as outlined in Table 1. The process was non-participatory, as the observer had no direct interaction or engagement with the subjects during the investigation.

Table 1. Instrument of observation.

Criteria	Code	Categories
Hitting player	J1	Player on the right side of winning team
	J2	Player on the left side of winning team
	J3	Player on the right side of losing team
	J4	Player on the left side of losing team
Points duration	BP	Beginning of the point
	EP	Ending of the point
Pause between points	BRT	Beggining of resting time
	ERT	Ending of resting time
Player's hitting location	BAS	Baseline
	TRA	Transition
	NVZ	Non-volley zone
	XBAS	Swapped Baseline
	XTRA	Swapped Transition
	XNVZ	Swapped Non-volley zone
Type of shot	FH	Forehand
	BH	Backhand
	FV	Forehand volley
	BV	Backhand volley
	SV	Serve
	SM	Smash
Ball trajectory	CL	Cross-line
	PL	Parallel
Post hitting ball actions	IN-TRA	Bounce inside transition zone
	IN-NVZ	Bounce inside non-volley zone
	OUT	Bounce outside court
	BHO	Bounce and then hits opponent
	NB	No bounce
	HNBIT	Hits the net and bounces in TRA
	HNBITN	Hits the net and bounces in NVZ
	HNBO	Hits the net and bounces out
	HNNB	Hits the net and no bounce
	HNS	Hits the net and stays at the same courtside
	HOP	Hits opponent player
	INT	Intercepted
Shot outcomes	UNF	Unforced error
	FE	Forced error
	WI	Winner

2.2.Sample and participants

A total of 6839 shots from eight matches were analysed. Six of these matches were part of the quarterfinals (n = 4) and semi-finals (n = 2) of the 2023 Select Medical Orange County Cup, while the other two corresponded to the semi-finals (n = 2) of the 2023 Baird Wealth Management Seattle Open. Matches played as best-of-five sets, which included the tournament finals, were excluded from this analysis. Nineteen different professional male players (age: 27.9 ± 7.6 years; height: 1.83 ± 0.06 m) were observed, of whom 18 were right-handed and one was left-handed for racket manipulation. On average, these players had been professionals for 3.8 ± 2.3 years, and held a ranking 14.3 ± 16.8 among the top players recognised by points from the Professional Pickleball Association (Tour, 2023).

2.3.Procedure

With the approval of institutional ethics (2324006P), three live videos filmed by the PPA Tour organisation were selected for analysis and later rebroadcasted through the PPA Tour YouTube channel. The observational process was conducted using the

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LINCE v.2.1.0. software (Soto-Fernández et al., 2022), along with an ad-hoc observation instrument developed for this study (Table 1), similarly as conducted in other racket-sports such as doubles tennis or padel (Ampuero et al., 2023; Borderias et al., 2021, 2024; Mellado-Arbelo et al., 2019). This instrument included specific criteria such as the player's hitting location (Figure 1), types of shots and their outcomes, ball trajectory, and ball actions following contact. Additionally, time parameters were recorded, including the duration of points, as well as the timing of pauses, with both the start and end times noted.

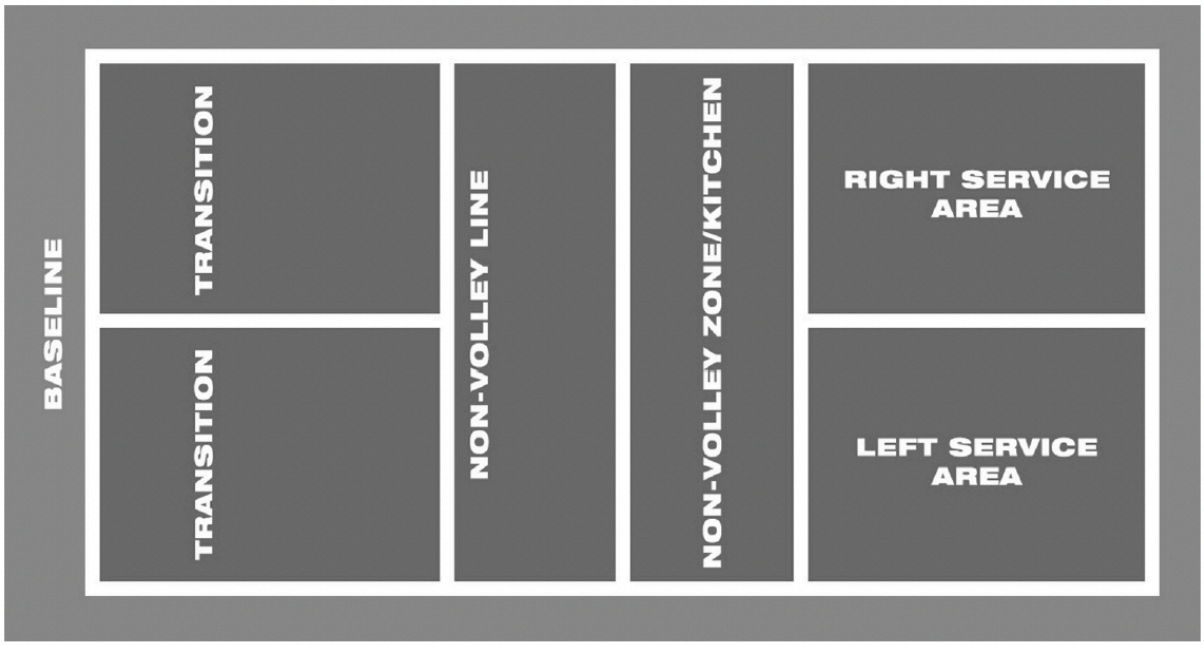

Figure 1. Player's hitting locations.

2.4. Data quality control

The quality of the data was assessed through validity and reliability processes. Construct validity was established based on conceptual consistency, grounded in pickleball regulations and previous scientific publications related to game analysis and activity profiles in other racket-sports (i.e. tennis and paddle tennis) mentioned in the "observational instrument" section (Borderias et al., 2021, 2024). Validity was obtained from the conceptual consistency by four pickleball coaches (graduated from the RFET; Real Federación Española de Tenis – Royal Spanish Tennis Federation), who reached 100% agreement on each category. The validation process involved a virtual questionnaire, allowing experts to agree or disagree with the categorisation of each criterion. The data collected from each match using LINCE PLUS software were exported in ".csv" format and transferred to an Excel file, where all data processing and analysis were conducted.

2.5. Statistical analyses

A descriptive analysis was conducted on the match-play activity profiles from two professional men's double pickleball tournaments. Absolute (n) and relative (%) frequencies were calculated for categorical variables, while measures of central tendency and dispersion were computed for continuous variables. For the comparison between effective playing time and resting time (in minutes), a paired samples t-test was con ducted. The mean difference and 95% confidence intervals were calculated to provide context for the observed differences. A two-sided p-value <0.05 was considered evidence that the differences were not due to chance. For the comparison between rally duration and pause between rallies (in seconds), a non-parametric Wilcoxon signed-rank test was used due to tied pairs and potential non-normality in the data distribution. The mean difference with its 95% confidence interval was reported, and statistical significance was determined using a two-sided p-value <0.05. Reliability was assessed using the Kappa coefficient for the categorical variables (e.g. types of shots, hitting location, post-hitting ball actions, and outcomes) and the intraclass correlation coefficient (ICC) for uous variables (e.g. time parameters and shots per player) (Królikowska et al., 2023). Reliability of the observation was determined through interobserver agreement across 200 game actions. An ICC of 1.0 and Kappa coefficient of 0.93 was obtained (Królikowska et al., 2023) when comparing the observer who authored this study with a tennis instructor knowledgeable in pickleball. Intraobserver agreement revealed an ICC of 1.0 and Kappa coefficient of 0.99 during the analysis of the 200 same game actions (Królikowska et al., 2023). The data obtained from each match using LINCE PLUS software were exported in ".csv" format and transferred to an Excel file, where all the data processing and analysis were conducted. Statistical analyses were performed using SPSS 23.0 software (SPSS Inc., Chicago, IL).

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3.Results

3.1.Time parameters

Table 2 shows the time parameters of a men's doubles pickleball match. The mean duration of a match was 36.4 ± 15.9 min, whereas the mean duration of the points was 10.7 ± 8.7 s. Additionally, resting times between points were nearly 40% longer than the rally duration. Effective playing time represented 38.6% of the total game time of the game and the activity-to-rest ratio was 1:1.6 ± 0.3. The comparison of mean times for effective playing time and resting time, as well as rally duration and pause between rallies, showed significant differences ($p = 0.011$ and $p < 0.001$, respectively). The 95% confidence intervals for the mean differences ranged from 157.0 to 835.0 min for playing and resting time, and from 2.0 to 3.0 s for rally duration and pauses between rallies.

Figure 2 shows the distribution of rally durations and rest times between points. In 78.0% of the cases, points lasted less than 15 s, with points lasting between 6 and 9 s accounting for 28.4% of the time, and those lasting between 3 and 6 s accounting for 27.0%. Points lasting 21 s or more accounted for 11.5% of the time, with the longest point recorded being 61 s. The majority of rest times lasted between 9 and 12 s (44.3%), followed by those lasting 12–15 s (20.3%) and between 6 and 9 s (19.7%). However, 6.1% of the rest times exceeded 30 s. The shortest pause recorded was 6 s, while the longest was 197 s. A total of 633 points (mean per match: 79.1 ± 29.1) were analysed, of which only 286 points (mean per match: 35.8 ± 10.8) contributed to the final scoreboard. In terms of shots, 6839 were analysed, resulting in an average of 854.9 ± 312.4 shots per game.

Table 2. Time parameters of a men's doubles pickleball match.

Time parameters	mean ± SD	Range
Rally duration (s)	10.7 ± 8.7	0–61
Pause between rallies (s)	17.1 ± 26.7	6–197
Effective playing time (min)	14.0 ± 5.0	8.5–21.8
Resting time (min)	22.3 ± 11.2	12.6–41.1
Match duration (min)	36.4 ± 15.9	22.7–62.4
Work-to-rest ratio	1:1.6 ± 0.3	1:0.9–1:1.9

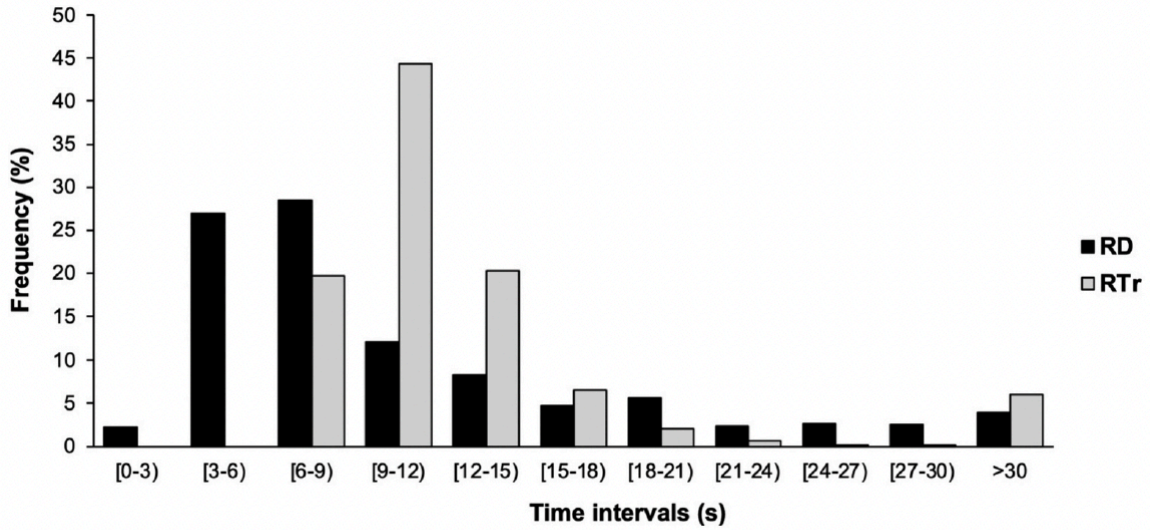

Figure 2. Time interval distribution of rally durations and resting times betweeen points.

3.3. Shots per player

Figure 3 shows the distribution of shots during rallies, showing that the interval between 3 and 10 shots occurred in 60.5% of the cases, with exchanges consisting of 5–6 shots being the most frequent (20.1%). Table 3 shows that left-side players from the

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winning pair executed the highest number of shots per game (27.3%), closely resembling the performance of left-side players from the losing pair (26.6%). Likewise, the right-side players from the winning team showed comparable shot counts to right-side players from the losing team (23.3% vs. 22.7%).

3.4. Type of shots and ball trajectory

The most frequently executed shot was the forehand (40.2%; mean per match: 343.4 ± 146.1), followed by the backhand volley (18.4%; mean per match: 157.3 ± 61.9), the backhand (17.8%; mean per match: 151.9 ± 54.5) and the forehand volley (12.7%; mean per match: 108.4 ± 42.4). The least performed shots, accounting for only 11% of total shots, were the serve (9.3%; mean per match: 79.3 ± 29.1) and the smash (1.7%; mean per match: 14.8 ± 6.6). Regarding ball trajectory, cross-court shots predominated (54%; mean per match: 461.5 ± 169.1) over parallel shots (46%; mean per match: 393.4 ± 152.1) (Table 3).

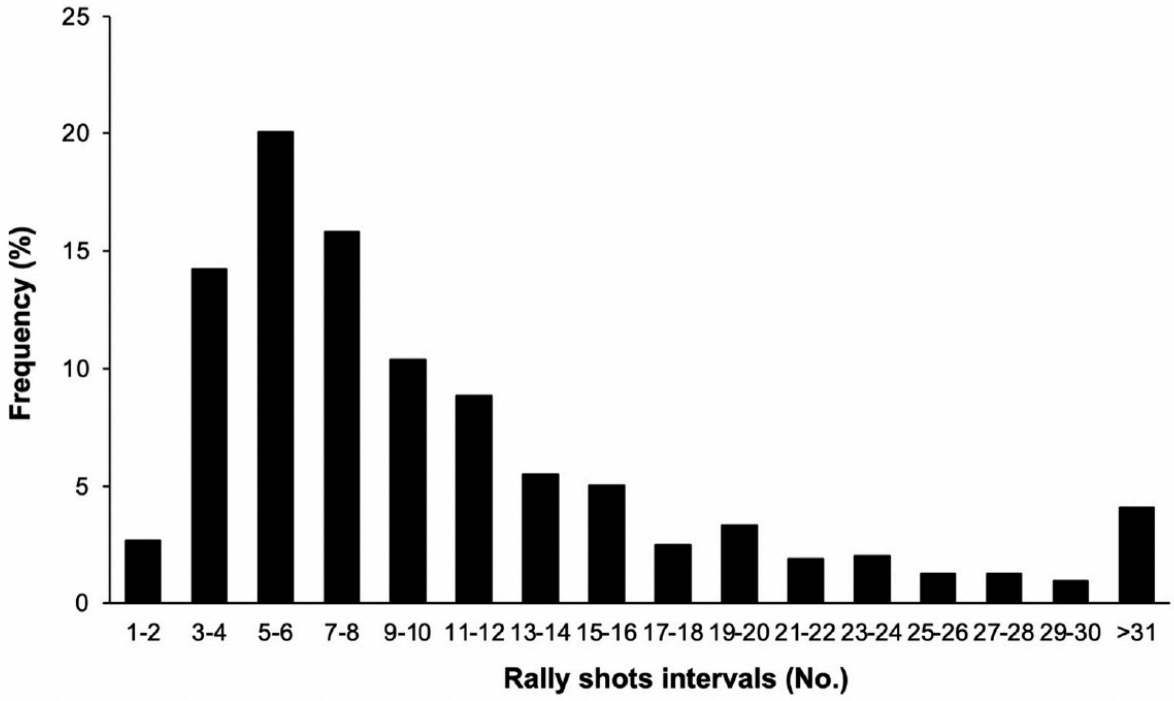

Figure 3. Distribution of shots per rally.

3.5. Player's hitting location

Most of the shots were made from the transition zone (60.7%; mean shots per match: 519.1 ± 215.3), followed by the baseline zone (15.2%; mean shots per match: 129.6 ± 48.3). The least frequent shots occurred in the non-volley zone (3.7%; mean shots per match: 31.4 ± 23.6). Players frequently changed positions in the transition zone (10.6%; mean shots per match: 90.5 ± 21.3) and the baseline zone (9.5%; mean shots per match: 81.5 ± 36.5). In the non-volley zone, positional changes were minimal (0.3%; mean shots per match: 2.75 ± 1.67) (Table 3).

3.6. Post-hitting ball actions

Most shots resulted in the ball bouncing inside the opponent's court (60.1%), with more frequent bounces occurring in the non-volley zone (32%) compared to the transition zone (27%). Instances where the ball did not bounce (i.e. directly hit by the opponent) were less common (32.4%). Additionally, there were occurrences where the ball touched the net and remained in play (3.8%) and where the ball bounced outside the opponent's court (2.8%). Other types of ball actions were infrequent (Table 3).

3.7. Shot outcomes

The majority of shots were intercepted (90.8%; mean shots per match: 775.9 ± 285.6). Forced errors accounted for 3.5% (mean shots per match: 29.5 ± 10.6), which was similar to the rate of unforced errors (3.2%; mean shots per match: 27.8 ± 8.4). Winning shots were the least frequent, comprising only 2.5% (mean shots per match: 21.8 ± 11.3) (Table 3).

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Table 3. Technical-tactical parameter during a men's doubles pickleball match.

Shots per player	n	%
Left side player winning team	1868	27.3
Left side player losing team	1822	26.6
Right side player winning team	1595	23.3
Right side player losing team	1554	22.7
Types of shots		
Forehand	2747	40.2
Forehand volley	1258	18.4
Bakchand	1215	17.8
Backhand volley	867	12.7
Serve	634	9.3
Smash	118	1.7
Player hitting location		
Transition	4153	60.7
Baseline	1037	15.2
Transition switched position	724	10.6
Baseline switched position	652	9.5
Non-volley zone	251	3.7
Non-volley zone switched position	22	0.3
Post-hitting ball actions		
No bounce	2216	32.4
NVZ bounce	2186	32
TRA bounce	1845	27
Hits net and stays at the same courtside	259	3.8
Bounce out	191	2.8
Net and NVZ bounce	61	0.9
Hits opponent	32	0.5
Net and no bounce	24	0.4
Net and TRA bounce	16	0.2
Net and bounce out	8	0.1
Bounce and hits opponent	1	0
Shot outcomes		
Intercepted	6207	90.8
Forced error	236	3.5
Unforced error	222	3.2
Winner	174	2.5

n, absolute value; %, relative value.

4.Discussion

To the best of our knowledge, this is the first study that provides detailed results on the match-activity profile of professional men's doubles pickleball. Main results showed that the mean duration of the points was around 10 s with resting periods lasting approximately 40% longer (17.1 s) with the effective playing time accounted for 38.6% of the total playing time. Points lasting between 6 and 9 s were the most common (28.4%), while rest times between 9 and 12 s accounted for 44.3%. This data allows players and coaches to elaborate specific technical-tactical trainings based on the duration of points and the resting periods between points. In addition, the percentage of effective playing time, the number of shots per rally and the most frequent type of shots allows coaches to approximate the workload of matches, which is essential for performance optimisation.

The majority of rally exchanges consisted of 5–6 shots (20.1%), being the most frequent shot, the forehand (40.2%), and 60.7% of the shots were made from the transition zone. This suggests the importance of practicing certain type of shots in specific areas of the court. Given the limited research on the competitive demands of professional doubles pickleball, the results of this study are compared with findings from other racket-sports such as tennis, padel, and badminton in doubles categories. Pickleball doubles have a shorter average match duration (36.4 ± 15.9 min) compared to badminton (45.9 ± 16.5 min) (Gawin et al., 2015), tennis doubles (79.4 ± 7.2 min) (Martínez-Gallego et al., 2021), and padel (83.8 ± 20.8 min) (García-Benítez et al., 2016). However, pickleball and padel share similarities in average rally duration (10.7 ± 8.7 s and 10.8 ± 7.7 s,respectively) and resting times (17.3 ± 26.7 s and 17.2 ± 7.7 s, respectively) (García-Benítez et al., 2016). In contrast, tennis presented shorter rally durations (2.5 ± 2.91

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s) (Martínez-Gallego et al., 2021). The shorter mean rally duration in tennis could be attributed to the serve, where players perform an overhead shot in which the ball reaches high-level of speed resulting as a difficult shot to return; therefore, these actions could produce more aces per match giving the chance for points lasting less than 1 s. In the present study, results showed that most of the analysed rallies lasted between 3 and 9 s. Most of the resting periods lasted between 9 and 12 s, with the longest pauses (up to 180 s) occurring during timeouts, side changes, or play reviews. Given the significant differences observed between effective playing and resting time, as well as rally duration and pause between rallies ($p = 0.011$ and $p < 0.001$), it is crucial to consider this information in the design of training programs. The work-to-rest ratio in pickleball doubles (1:1.6) was similar to that observed in padel (1:1.54) but lower than in tennis doubles (1:6.6). The effective playing time in pickleball (39%) exceeded that in padel (29%), badminton (20%), and tennis doubles (16%). These results indicate that, in terms of time parameters, pickleball doubles is more similar to padel than to badminton or tennis, except for match duration.

A total of 633 points were analysed (79.13 ± 29.07 per match), with only 286 points (35.75 ± 10.79 per match) were added to the scoreboard, due to the rule that points are only scored when the point is won while in possession of the service. The number of points, shots and duration of the match can vary widely depending on this rule, the number of sets played and the rule requiring a two-point difference to end the game. The number of shots per game in men's doubles pickleball (854.9 ± 312.4) was lower than in padel (1178.9 ± 443.1) due to the shorter match duration (García-Benítez et al., 2016).

Players on the left-side tend to make more shots per game, likely due to the dominance of right-handed players who take advantage of the centre court with forehands, similar to padel (Ampuero et al., 2023). In 60.5% of cases, rallies consisted of 3–10 shots, with rallies between 5 and 6 shots accounted for 20.1%. Moreover, the forehand was the most common shot in pickleball (40.2%). These results are in contrast with other similar racket-sport (i.e. padel), which shows longer number of shots per rally (9.5 shots), and where the backhand volley is more frequent (Mellado-Arbelo et al., 2019; Ungureanu et al., 2024). The smash, while more common in padel (Mellado-Arbelo et al., 2019), is less frequent in pickleball, likely due to the smaller court size, and the ball characteristics (i.e. very light), making lobs less practical.

The prevalence of cross-court play in pickleball is partly explained by the rules requiring cross-court serves. However, the frequency of cross-court and parallel shots is nearly equal (49.3% cross-court, 50.7% parallel). Players mostly hit from the transition zone (60.7%), whereas in padel, more shots are made from the baseline (49.1%) (Mellado-Arbelo et al., 2019). In pickleball, all players tend to move close to the net, while in padel, the players in the offensive phase are usually close to the net, while those in the defensive phase stand near the back glass, even though there are moments in which both pairs are closer to the net. In contrast, in pickleball, all four players usually end up near the net, being the majority of baseline shots serves and returns. Similar to padel, the primary objective in pickleball is to reach the net to score points (Courel, 2014). In this regard, winning teams in padel tend to hit 5% fewer shots from the baseline and 5% more near the net compared to losing teams (Sánchez-Alcaraz et al., 2022). Therefore, the net zone is crucial for executing attacking shots, as 85% of points are won with shots from this area (Sánchez-Alcaraz et al., 2020). Similarly, in doubles pickleball, players aim to get close to the net, positioning themselves in the transition zone without entering the nonvolley zone to maximise their chances of scoring.

The double-bounce rule means that the opponents can be closer to the net before the serving team. However, once the double bounce rule is overcome, the serving players try to get into the transition zone near the non-volley zone. In the non-volley zone, there are not usually many hits, possibly because of the non-volley zone rule, which does not allow direct hits in this zone. In the same way, when the ball bounces inside the non-volley zone and the players would be allowed to enter this zone to hit, the players prefer to stay to hit from the transition zone, unless the ball is very short and close to the net. This could be due to the fact that if they enter inside the non-volley zone to make a hit and do not leave it quickly, the opponents can make a quick hit against the body of the player, not being able to make a direct hit, thus being in a compromised situation of losing the point.

Pickleball doubles players often perform hits in a changed position, more frequently than padel players (Mellado-Arbelo et al., 2019). These are given either by the rules of the serves, where every time a point is added, the server changes sides when performing the serve, or by tactical aspects.

About the predominance of indirect hits over direct hits, it is explained, first, by the rule of double bounce, where the return must be an indirect hit. And it is explained due to when the players are in the transition zone near the non-volley line, try to make short hits that bounce to the non-volley zone of the opponent's court, since a direct hit from the rival team from such close zones can be a great advantage. Thus, pickleball players try to make short shots that bounce in the non-volley zone of the opponent's court with the objective that the rivals miss with an unforced error. Those hits that look for the forced error or the winner are usually the direct hits, since they are fast shots that involve little reaction time for the opponents at the time of being returned. The majority of hits in pickleball are intercepted (90%), and unforced errors are relatively low, indicating that players maintain high consistency and accuracy, similar to padel (87.6% intercepted hits) (Mellado-Arbelo et al., 2019). Pickleball's indirect hits are favoured due to the doublebounce rule, where a rally must begin with an indirect hit. Direct hits, aimed at forcing errors, are used less frequently. Compared to tennis doubles, pickleball has fewer forcederrors (37%), more unforced errors (35%), and fewer winning shots (28%) (Martínez-Gallego et al., 2019).

As a study limitation, these results are focused only on male high-level players, so more studies would be needed to be carried out to know how the parameters may vary depending on different types of levels, ages and genres. In addition, it would have been interesting to include the variable spin of the shot in the analysis, but it has not been included for reliability reasons.

5. Conclusions

The aim of this study was to analyse the activity profile of professional male doubles pickleball. Having a closer approach of pickeball's competitive dynamics by coaches and players is of vital importance for their daily practice, as for this objective information provides better guidelines for training session methodologies which can help to improve and optimise the players

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performance during competition. It was found that the average duration of a professional men's doubles pickleball match is around 36 min, with a workto-rest ratio of 1:1.6 and effective playing time representing 39% of the total match duration. Most of the analysed rallies lasted between 3 and 9 s, with resting times ranging from 9 to 15 s, and rally exchanges typically involve 5–6 shots. The forehand is the most frequent shot. Cross-court play predominates, largely due to the serving rules. Players on the left-side tend to hit more frequently than those on the right, and the majority of the shots are made from the transition zone. Intercepted shots are more common than forced errors, unforced errors, or winning shots, highlighting the importance of long rally exchanges in pickleball.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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