Athletes temporal and tactical mapping of the XXVIII Pan American Junior Championships 2019 – from sub 13 to sub 19

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Abstract
The characteristics of the profile of activities and performance of the badminton game can be used at helpful tools for an adequate elaboration of competitive training. Although the literature provides a large number of studies that describe the profile of activities and game performance in world-class badminton athletes, just a few focus on junior players. This study identified the characteristics of the game profile and performance of junior badminton players. The sample consisted of 124 games from the 5 types of events (singles and doubles) of the 28th Pan American Junior Championships 2019 from the under-13 to under-19 categories starting from the quarterfinals, totaling 9.847 rallies from 277 games. The results showed that the duration of the rally is shorter in men's doubles and mixed doubles than in other events ($p \leq 0.001$). The female single´s event, in general, presented a longer rest time between rallies ($p \leq 0.001$). In all events, players sought to force their opponents to make mistakes ($p \leq 0.001$). This information can be useful for the development of specific training for each type of event, with the reenactment of the different time scenarios characteristic of the match and the activity profile.

Keywords: performance analysis, young players, match analysis, sports training, racket sports.

Introduction
For the spectator, a badminton match can be fascinating. In fractions of seconds, players alternately hit the shuttlecock, moving around their playing area in a variety of steps, jumping, turning, lunging until they get the ideal moment to finish the point or force their opponent to miss, and recovering themselves briefly to start all over again until finishing the game (Manrique & González-Badillo, 2003; Valldecabres et al., 2017). When the characteristics of the game activity and performance profile are known, it is possible to structure teaching-learning-training processes that may result in better sports performance (Aburachid et al., 2018; Gawin et al., 2015). Profile characterization is understood here as technical actions such as the number and types of strokes, for example (Chiminazzo et al., 2018) and performance can be evaluated, among other variables, through winning strokes, errors and type of service (Manrique & González-Badillo, 2003; Valldecabres et al., 2017; Gomez-Ruano et al., 2020). In this sense, previous research in world elite games had identified that in the disputing the point, players exchange an average of 7-14 blows, between 6-10 seconds (s) (Torres-Luque et

al., 2019), and, recover for the next point fight at around 23 s of time (Gawin et al., 2015). Also, it was observed that doubles perform shorter rallies compared to singles, except for female doubles which perform long rallies (Torres-Luque et al., 2019; Gawin et al., 2015). Combined with the characterization of the activity profile and performance in games, there is the temporal structure, often investigated via the duration of the match, game and rally, rest time between rallies and work density (Chiminazzo et al., 2018). These data can be obtained by recording videos and researchers use the notational analysis method (Hughes et al., 2007) to sequentially describe the players' behavior throughout the match and in the different phases of a competition.

The results of notational and temporal analysis can reveal differences between the events, whether in the activity profile, in the physical demands imposed by the game, or in performance, bringing evidence that training must be specific (Alcock & Cable, 2009). Although the game profile and performance in badminton have been extensively studied, the available literature brings a small number of studies related to junior and doubles event games: notational analysis studies brought data from singles games and categories between U-15 to U-19, and only one with doubles games, two of which in a simulated context (Fernandez-Fernandez et al., 2014; Ming et al., 2008) and three others in a real game situation. Cabello and Padial (2002) present the data grouped to the main category and under the punctuation system considered as traditional or conventional. Leong and Krasilshchikov (2016) compared juniors' data with the main category, encompassing only the temporal structure and some technical aspect variables, verifying that the main category's game has higher duration values in relation to the juniors'. Istchuk (2016) verified the temporal structure, technical variables, and physiological responses of players in the five Badminton events and observed that the male individual game is more intense, that is, with shots delivered in a smaller fraction of time compared to the female one, however, differences were not found in the doubles game.

There is an agreement about differences in physical abilities between elite main category players versus junior players at any sport (Yuksel et al., 2015). The identification of the game's activity profile and performance are essential for the ideal prescription of competitive training, allowing training not too focused on the development of physical abilities alone (Zemková et al., 2017), considering the integral development of the players, as well as respecting the transition of competitive skill level from juniors to the main category (Leong & Krasilshchikov, 2016). Therefore, the general objective of the present study was to identify the characteristics of the game profile and performance considering notational and temporal variables of junior players at the Pan American level.

Methods

Design and samples
The study design was observational and descriptive supported by the notational analysis method (Anguera and Mendo, 2013). The sample included a total of 277 games and 9,847 rallies from 124 games of the five badminton events of the 28th Pan American Junior Championships 2019 from the U-13 to U-19 categories starting from the quarterfinals, with 60 games in Boys' Singles (BS); 63 games in Girls' Singles (GS); 51 games in Boys' Doubles (BD); 48 games in Girls' Doubles (GD); and 55 games in Mixed Doubles (XD). All matches were played under the 21-point best-of-three-game scoring system (BWF, 2021).

The independent variables were events, games, knockout stage, categories, while the dependent variables were: match/game duration, rally time, real playing time, rest time between rallies, density, % time played, total points played, shots per rally/game, shot frequency rally/game, point outcome performed of the last shot (winner stroke, unforced error, and forced error), and hitting area of the last shot (fault, net, out, and nine zones of court).

The recordings were obtained from the public access platform YouTubeTM, specifically from the Badminton Pan Am Confederation's official channel (link).

Procedures
Each game was analyzed using a game analysis tool called Ideal Performance®; its interface allows the reproduction of the video of the match under analysis and the triggering of specific commands to record in spreadsheets the data of the studied variables. Data was collected by an observer with two years of practical experience in badminton. Prior to the registration stage (two months), the main observer received technical-tactical training sessions in badminton and about the use of the tool by an expert (25 years of experience in badminton training), while an external observer trained in badminton (seven years of experience) received training to use the tool. Upon reaching consensual agreement on the study variables between the researcher, the expert and the external observer, the recording were started. The intraobserver and interobserver agreement, using the Kappa Cohen (Landis & Koch, 1977) were considered almost perfect (kappa between 0.95 and 1.00 for intra-observer and 0.92 and 0.99 for inter-observer).

Statistical Analysis
The 3-way Manova was used in the General Linear Models at the identification of the temporal and notational structure for the quantitative variables. Data distributions were tested and the tweedie distribution with log link function was adopted. Multiple comparisons were performed applying Bonferroni corrections. For the nominal-categorical variables, multinomial regression models were performed considering events, games, competition phases and categories as predictors in a generic model established for this analysis. The results of the Omnibus - Chi-square test summarized the effect of the regression model and data from this analysis was presented in a visual model of absolute frequency (heatmap), where the darker color indicates an association between the predictors and the outcome. The established significance level was $P<0.05$.

Results

Results of temporal variables
Tables 1, 2, 3 and 4 show the temporal and technical-tactical comparisons between the events, games and phases of the competition. Considering the result of the events in a comprehensive way, there were significant differences in most of the contextual scenarios, which correspond to the games and phases of the competition, for all variables, with the exception of the total variable of points played.

Rally Time
Quarter finals
- 1 st and 2 nd game: GS presented a longer rally duration than the DGs. BD completed the rallies in shorter duration of time compared to BS, GS and GD.
- 3 rd game: BS rallies were longer compared to BD and XD, and GS had higher rally duration values than BD.

Semifinals
- 1 st game: BD and XD performed shorter rallies compared to GS, BS and GD point disputes.
- 2 nd game: BD performed short duration rallies compared to GS, BS and BD.

Finals
- 1 st game: BD and XD performed shorter rallies compared to GS, BS and GD
- 2 nd game: BD had shorter rallies than BS.

- 3 rd game: BD had shorter rallies compared to GS. Between games there were significant contrasts in the quarterfinals for the BS with shorter rally duration in the 1st game compared to the 3rd game (see table 1).

Rest time between rallies
Quarter finals
- 1 st and 2 nd game: for the BD and XD events, the rest time was lower than the other events, however, in the 2nd game the GS rested longer compared to the GD.
- 3 rd game: GS extended the rest time (longer) compared to XD.

Semifinals
- 1 st game: GS presented a longer rest time than the DG

Finals
- 1 st game: GS presented higher resting time values compared to BS.
- 3 rd game: GS rested 16.81 ± 1.18 s compared to BD (11.49 ± 1.14 s) and XD (11.46 ± 1.13 s) (see table 1).

Density
Quarter finals
- 1 st and 2 nd game: 1st and 2nd game: density values were lower for BD and XD compared to other events.
- 3 rd game: The density was lower for BD versus BS.

Semifinals
- 1st and 2nd game: BD and XD showed lower density values in the 1st and 2nd game compared to the other events.

Finals
- 1 st game: For the BD the density value was lower than for the GS, BS and GD, on the other hand the XD density was lower than that of the BS (see table 1).

Table 1 – 3-way MANOVA in the General Linear Model for comparison of temporal variables per rally between events, games and competition phases, using categories (U13, U15, U17 and U19) as covariates.

Variables	Tournament round	Games	GS $\bar{X}$	GS SE	BS $\bar{X}$	BS SE	GD $\bar{X}$	GD SE	BD $\bar{X}$	BD SE	XD $\bar{X}$	XD SE	Significant Contrasts* Events	Significant Contrasts* Games	Significant Contrasts* Tournament round
Rally time (s)	Quarter finals	1st	7.09	0.20	6.71	0.21	6.19	0.24	5.04	0.22	5.28	0.20	BD e XD < GS, BS, GD / GS>GD		
		2nd	7.47	0.20	7.03	0.20	6.41	0.25	5.18	0.22	5.83	0.20	BD e XD < GS, BS, GD / GS>GD		
		3rd	7.67	0.45	8.81	0.83			5.68	0.45	6.25	0.49	BS>BD E XD / GS>BD		
	Semifinals	1st	7.60	0.31	6.48	0.31	6.93	0.32	4.85	0.35	4.25	0.83	BD e XD < GS, BS, GD	F1BS: G1 < G3	GS G2: F3 < F1 and F2
		2nd	7.71	0.31	7.06	0.31	7.09	0.32	4.91	0.34	5.50	0.84	BD < GS, BS, GD		GDG2: F3 < F2
		3rd	7.10	0.44											
	Final	1st	7.06	0.40	6.99	0.41	7.14	0.40	4.44	0.39	5.20	0.39	BD e XD < GS, BS, GD		
		2nd	6.19	0.42	7.19	0.40	5.60	0.41	5.59	0.39	6.23	0.39	BD < GS		
		3rd	8.86	1.28					4.23	1.23	6.70	1.23	BD < GS		
Rest time between rallies (s)	Quarter finals	1st	11.17	0.19	10.27	0.19	10.19	0.23	10.39	0.21	10.55	0.18	BD e XD < GS, BS, GD	F1GS: G1<G2<G3	GS G3: F1 and F3 > F2
		2nd	12.63	0.18	11.89	0.19	11.01	0.23	11.08	0.21	11.90	0.19	BD e XD < GS, BS, GD / GS > GD	F1BS: G1<G2 e G3	GDG1: F1 and F2 < F3
		3rd	13.96	0.42	12.47	0.77			13.03	0.42	11.54	0.45	GS > XD	F1GD: G1<G2	BDG2: F1 and F2 < F3
	Semifinals	1st	11.66	0.28	10.56	0.28	10.09	0.29	10.56	0.32	11.74	0.76	GS > GD	F1BD: G3>G1 e G2	XDG2: F1 < F3
		2nd	12.07	0.29	12.05	0.28	11.52	0.29	10.89	0.31	12.32	0.78		F1XD: G1<G2	
		3rd	11.77	0.40										F2BS, GD: G1<G2	
	Final	1st	11.57	0.37	9.96	0.37	11.40	0.37	11.17	0.36	10.45	0.36	GS > BS	F3GS: G1eG2 < G3	
		2nd	11.67	0.39	12.34	0.37	11.69	0.38	12.41	0.36	13.11	0.36		F3BS, BD, XD: G1<G2	
		3rd	16.81	1.18					11.49	1.14	11.46	1.13	GS > BD e XD		
Density	Quarter finals	1st	0.69	0.02	0.72	0.02	0.65	0.03	0.52	0.02	0.53	0.02	BD e XD < GS, BS, GD		
		2nd	0.65	0.02	0.66	0.02	0.63	0.03	0.52	0.02	0.53	0.02	BD e XD < GS, BS, GD		
		3rd	0.62	0.05	0.78	0.09			0.45	0.05	0.58	0.05	BD < BS		
	Semifinals	1st	0.73	0.03	0.67	0.03	0.73	0.03	0.49	0.04	0.35	0.09	BD e XD < GS, BS, GD	GDF3: G1 > G2	GSG2: F2 > F3
		2nd	0.71	0.03	0.63	0.03	0.67	0.03	0.49	0.04	0.44	0.09	BD e XD < GS, BS, GD		GDG2: F1 e F2 > F3
		3rd	0.67	0.05											
	Final	1st	0.67	0.04	0.75	0.04	0.69	0.04	0.42	0.04	0.53	0.04	BD < GS, BS, GD / XD < BS		
		2nd	0.56	0.04	0.66	0.04	0.51	0.04	0.50	0.04	0.53	0.04			
		3rd	0.67	0.14					0.35	0.13	0.60	0.13			

$\bar{X}$, mean; SE, standard error; F1, quarter finals; F2, semifinals; F3, final; G1, 1st game; G2, 2nd game; G3, 3rd game; GS: Girls' Singles; BS: Boys' Singles; GD: Girls' Doubles; BD: Boys' Doubles; XD: Mixed Doubles; * Multiple comparison test with Bonferroni correction. Marginal mean and standard error, estimated considering the covariate: category = 2,42. GLM: General Linear Model - Multivariate Test: Pillai Trace (F=3.486, P<0.001); Wilk-Lambda (F=3.501, P<0.001).

Real time played
Quarter finals

- 1 st game: During the match, GS kept the shuttlecock in action longer than BD and XD, while BS also kept the shuttlecock in volley longer than BD
- 2 nd game: GS kept the shuttlecock in play for a longer period of time than the doubles events

Semifinals
- 1 st game: GS stayed longer in play than BD
- 2 nd game: GS and BS stayed longer in play than BD

Finals
- 1 st game: GS was higher than BD (see table 2).

Percentage time played

Quarter finals
- 1 st game: GS, BS e GD presented a higher % of real time played than the BD. Individual events had a higher % of real time played than XD.

Semifinals
- 1 st game: GDs achieved a higher % of real time played than the others events. BD performed lower % of real time played than GS and BS.
- 2 nd game: GS and BS had a higher % of real time played compared to BD.

Finals
- 1 st game: BS presented a higher % of real time played in relation to BD and XD. GS was superior to BD (see table 2).

Table 2 – 3-way MANOVA in the General Linear Model for comparison of temporal variables per rally between events, games and competition phases, using categories (U13, U15, U17 and U19) as covariates

Variables	Tournament round	Games	GS $\bar{X}$	SE	BS $\bar{X}$	SE	GD $\bar{X}$	SE	BD $\bar{X}$	SE	XD $\bar{X}$	SE	Significant Contrasts * Events	Games	Tournament round
Real playing time (s)	Quarter finals	1st	247.24	11.39	228.47	11.39	202.76	13.55	180.23	12.61	191.59	11.42	GS > BD and XD; BS > BD		
		2nd	279.31	11.39	249.16	11.39	203.34	13.55	181.56	12.61	207.80	11.42	GS > GD, BD and XD; BS > BD		
		3rd	296.82	28.59	301.12	20.20			251.57	26.48	214.17	28.45			
	Semifinals	1st	274.17	17.96	226.92	17.05	221.68	17.07	168.18	20.07	184.74	38.81	GS > BD	F1BS: G1<G3 F1BD: G1, G2<G3	G2GS: F1>F3
		2nd	262.68	17.96	252.29	17.05	241.53	17.07	177.53	20.07	197.10	38.81	GS and BS > BD		
		3rd	245.20	25.44	155.46	59.35	249.85	32.59			195.70	95.65			
	Final	1st	273.34	22.07	241.03	22.08	238.74	22.10	160.70	22.07	220.21	22.10	GS > BD		
		2nd	211.34	22.07	253.48	22.08	206.24	22.10	205.13	22.07	244.04	22.10			
		3rd	280.10	26.24	164.24	129.39	343.59	129.65	162.64	55.06	252.63	26.29			
Percentage time played (%)	Quarter finals	1st	36.52	0.94	36.60	0.94	34.75	1.12	29.62	1.04	30.82	0.94	GS, BS and GD>BD, GS and BS>XD	F1GS, BS: G1>G2, G3 F1GD-XD: G1>G2 F2GS-GD: G1>G2, G3 F2BD: G1>G2 F3GS: G1>G2, G3 F3BS, GD: G1>G2 F3XD: G1>G3	G1GD: F2>F1, F3
		2nd	31.65	0.94	30.51	0.94	28.58	1.12	25.04	1.04	26.87	0.94	GS and BS > BD; GS > XD		
		3rd	30.28	2.35	30.27	1.66			26.15	2.18	26.88	2.34			
	Semifinals	1st	37.55	1.48	36.56	1.40	45.50	1.41	29.84	1.65	31.84	3.20	GD > GS, BS, BD, XD; BD<GS, BS		
		2nd	32.17	1.48	31.11	1.40	30.68	1.41	24.97	1.65	28.05	3.20	GS and BS > BD		
		3rd	30.94	2.09	22.22	4.89	26.98	2.68			37.04	7.87			
	Final	1st	36.48	1.82	39.40	1.82	34.51	1.82	27.50	1.82	32.08	1.82	BS > BD, XD; GS>BD		
		2nd	27.92	1.82	31.43	1.82	26.26	1.82	24.78	1.82	27.59	1.82			
		3rd	29.48	2.16	33.08	10.65	44.63	10.67	22.68	4.53	25.34	2.16			

$\bar{X}$, mean; SE, standard error; F1, quarter finals; F2, semifinals; F3, final; G1, 1st game; G2, 2nd game; G3, 3rd game; GS: Girls' Singles; BS: Boys' Singles; GD: Girls' Doubles; BD: Boys' Doubles; XD: Mixed Doubles; * Multiple comparison test with Bonferroni correction. Marginal mean and standard error, estimated considering the covariate: category = 2,42. GLM: General Linear Model - Multivariate Test: Pillai Trace (F=1.644, P≤0.001); Wilk-Lambda (F=1.656, P≤0.001).

Shots per rally

Quarter finals
- 1 st game: The number of shots per rally delivered by the GS was lower compared to the GD
- 2 nd game: GS had a lower number of hits per rally than the GD and XD.

Semifinals and finals
- 1st and 2nd game: DGs performed a greater number of strokes per rally than the other events (see table 3).

Shot frequency per rally
Quarter finals
- 1st and 2nd games: BD and XD performed higher shot frequency than GD, BS and GS
- 3 rd game: BD and XD had a higher frequency of shots compared to the BS and GS.

Semifinals and finals
- 1st and 2nd games: GD, BD and XD performed higher shot frequency values than the individual events.
- 3 rd game: In the finals, BD and XD hit more shots in fractions of a second compared to GS (see table 3).

Table 3 –3-way MANOVA in the General Linear Model for comparison of temporal variables per rally between events, games and competition phases, using categories (U13, U15, U17 and U19) as covariates

Variables	Tournament round	Games	GS		BS		GD		BD		XD		Significant Contrasts *		
			$\bar{X}$	SE	$\bar{X}$	SE	$\bar{X}$	SE	$\bar{X}$	SE	$\bar{X}$	SE	Events	Games	Tournament round
Shots per rally	Quarter finals	1st	5.94	0.23	6.61	0.24	7.27	0.28	6.44	0.26	6.81	0.23	GS < GD		
		2nd	6.42	0.23	7.00	0.23	7.53	0.28	6.60	0.26	7.40	0.23	GS < GD and XD		
		3rd	6.65	0.52	8.20	0.96			7.69	0.52	7.78	0.56			
	Semifinals	1st	6.40	0.35	6.34	0.35	8.27	0.36	6.33	0.40	5.79	0.95	GD > GS, BS, BD and XD	F3GD: G1>G2	G1GD: F1<F3 G2GD: F2>F3
		2nd	6.49	0.36	7.23	0.35	8.55	0.36	6.37	0.39	7.57	0.97	GD > GS, BS, BD and XD		
		3rd	5.71	0.50											
	Final	1st	6.03	0.46	6.73	0.48	8.57	0.46	5.86	0.45	6.63	0.45	GD > GS, BS, BD and XD		
		2nd	5.30	0.48	7.18	0.46	6.77	0.47	7.31	0.45	7.93	0.45	GD > GS, BS, BD and XD		
		3rd	8.50	1.48					6.20	1.41	9.40	1.41			
Shot frequency rally (s⁻¹)	Quarter finals	1st	0.81	0.01	0.99	0.01	1.20	0.01	1.29	0.01	1.31	0.01	GS<BS<GD<BD and XD		
		2nd	0.83	0.01	0.99	0.01	1.20	0.01	1.31	0.01	1.31	0.01	GS<BS<GD<BD and XD		G1GD: F1<F2 G2BD: F1<F3 G3XD: F1<F3
		3rd	0.84	0.03	0.93	0.05			1.34	0.03	1.28	0.03	GS and BS < BD and XD		
	Semifinals	1st	0.80	0.02	0.97	0.02	1.26	0.02	1.34	0.02	1.39	0.05	GS<BS<GD, BD and XD	F2BS: G1<G2 F3XD: G2<G3	
		2nd	0.81	0.02	1.03	0.02	1.24	0.02	1.31	0.02	1.33	0.05	GS<BS<GD, BD and XD		
		3rd	0.76	0.03											
	Final	1st	0.82	0.02	0.94	0.02	1.24	0.02	1.35	0.02	1.31	0.02	GS<BS<GD, BD and XD		
		2nd	0.85	0.02	0.98	0.02	1.23	0.02	1.38	0.02	1.28	0.02	GS<BS<GD, BD and XD		
		3rd	0.92	0.07					1.37	0.07	1.45	0.07	GS < BD and XD		

$\bar{X}$, mean; SE, standard error; F1, quarter finals; F2, semifinals; F3, final; G1, 1st game; G2, 2nd game; G3, 3rd game; GS: Girls' Singles; BS: Boys' Singles; GD: Girls' Doubles; BD: Boys' Doubles; XD: Mixed Doubles; * Multiple comparison test with Bonferroni correction. Marginal mean and standard error, estimated considering the covariate: category = 2,42. GLM: General Linear Model - Multivariate Test: Pillai Trace (F=10.608, P≤0.001); Wilk-Lambda (F=10.770, P≤0.001).

Shots and shot frequency per game
Quarter finals
- 1st and 2nd games: BD and XD had a higher frequency of hits per game compared to GD, BS and GS
- BD and XD showed higher values compared to GS.

Semifinals
- 1st and 2nd games: the doubles events performed higher shot frequency values per game compared to the individual events
- 3 rd game: XD, GD and BS had higher values of frequency of shots per game compared to GS

Finals
- 1st and 2nd games: the pairs performed higher average values of frequency of shots per game than the individual events. For shots per game there was a contrast only in the 2nd game where GS had a lower value of shots than XD.
- 3 rd game: BD and XD presented higher frequencies of shot per game compared to the GS. The BD had higher shot frequencies than the BS (see table 4).

Table 4 –3-way MANOVA in the General Linear Model for comparison of temporal variables per rally between events, games and competition phases, using categories (U13, U15, U17 and U19) as covariates

Variables	Tournament round	Games	GS $\bar{X}$	GS SE	BS $\bar{X}$	BS SE	GD $\bar{X}$	GD SE	BD $\bar{X}$	BD SE	XD $\bar{X}$	XD SE	Significant Contrasts * Events	Games	Tournament round
Shots per game	Quarter finals	1st	206.91	13.31	225.33	13.32	237.90	15.84	232.49	14.75	246.41	13.35			
		2nd	238.38	13.31	248.28	13.32	238.59	15.84	234.20	14.75	263.71	13.35			
		3rd	256.97	33.43	292.85	23.62			339.16	30.96	264.42	33.27			
	Semifinals	1st	232.36	21.00	222.76	19.93	263.25	19.95	217.52	23.46	236.20	45.37		F1BS: G1 < G3	
		2nd	220.82	21.00	255.33	19.93	290.31	19.95	247.77	23.46	260.39	45.37		F1BD: G1 e G2 < G3	
		3rd	198.30	29.74	180.29	69.40	292.24	38.11			254.19	111.83			
	Final	1st	236.39	25.81	232.72	25.82	289.42	25.84	206.65	25.81	281.16	25.84			
		2nd	180.46	25.81	254.45	25.82	252.73	25.84	268.78	25.81	311.06	25.84	GS < XD		
		3rd	248.96	30.69	135.17	151.28	422.72	151.59	235.76	64.37	333.15	30.74			
Shot frequency rally per game (s^{-1})	Quarter finals	1st	0.84	0.02	0.98	0.02	1.17	0.02	1.28	0.02	1.28	0.02	GS<BS<GD<BD and XD		
		2nd	0.85	0.02	0.99	0.02	1.18	0.02	1.28	0.02	1.26	0.02	GS<BS<GD<BD and XD		
		3rd	0.87	0.04	0.97	0.03			1.33	0.03	1.25	0.04	GS < BD and XD		
	Semifinal	1st	0.84	0.02	0.98	0.02	1.19	0.02	1.31	0.03	1.29	0.05	GS<BS<GD, BD and XD	F2BD: G1 < G2	G2BD: F2 > F1, F3
		2nd	0.84	0.02	1.01	0.02	1.19	0.02	1.40	0.03	1.32	0.05	GS<BS<GD, BD and XD		
		3rd	0.80	0.03	1.14	0.08	1.19	0.04			1.20	0.12	GS < BS, GD and XD		
	Final	1st	0.86	0.03	0.96	0.03	1.21	0.03	1.29	0.03	1.27	0.03	GS and BS < GD, BD, XD		
		2nd	0.85	0.03	1.00	0.03	1.22	0.03	1.30	0.03	1.27	0.03	GS and BS < GD, BD, XD		
		3rd	0.88	0.03	0.87	0.17	1.19	0.17	1.41	0.07	1.33	0.03	GS < BD, XD; BS < BD		

$\bar{X}$, mean; SE, standard error; F1, quarter finals; F2, semifinals; F3, final; G1, 1st game; G2, 2nd game; G3, 3rd game; GS: Girls' Singles; BS: Boys' Singles; GD: Girls' Doubles; BD: Boys' Doubles; XD: Mixed Doubles; * Multiple comparison test with Bonferroni correction. Marginal mean and standard error, estimated considering the covariate: category = 2,42. GLM: General Linear Model - Multivariate Test: Pillai Trace (F=1.440, P<0.001); Wilk-Lambda (F=1.444, P≤0.001).

Total points played
For the total number of points played, no significant differences were found.

Technical-tactical performance
The heatmap of the characteristic of finalization of the point showed that in all events and games there was a higher frequency of forced error (p≤0.001; X2=63.5, see figure 1). When relating it to the target area, it is observed that the errors occurred most of the time with the shuttle being lost to the net or out (p≤0.001; X2=207, see figure 2).

1st Game

Phase	Cat	GS Winner	GS Forced error	GS Non-forced error	BS Winner	BS Forced error	BS Non-forced error	GD Winner	GD Forced error	GD Non-forced error	BD Winner	BD Forced error	BD Non-forced error	XD Winner	XD Forced error	XD Non-forced error
Quarter finals	U13	58	62	23	48	56	23	59	36	31	49	46	40	52	52	38
	U15	48	70	24	39	72	16	22	26	22	24	25	24	57	62	31
	U17	51	68	14	53	66	26	47	51	28	53	62	30	62	65	24
	U19	45	84	17	49	74	17	22	35	9	40	56	21	59	67	18
Semifinals	U13	20	32	23	27	35	11	28	24	13	24	32	20	27	34	18
	U15	19	37	10	17	44	15	26	30	18	23	26	16	19	36	18
	U17	27	38	8	13	19	3	12	13	5	6	12	14	6	0	0
	U19	17	15	4	22	30	10	24	30	7	12	18	4	0	0	0
Finals	U13	13	15	5	11	19	5	13	17	10	12	20	7	16	16	6
	U15	12	22	4	9	22	4	12	19	8	14	18	12	10	16	12
	U17	9	23	5	7	19	3	10	22	5	11	18	5	10	24	5
	U19	10	23	7	12	23	1	11	14	4	10	11	10	17	18	4

2nd Game

Phase	Cat	GS Winner	GS Forced error	GS Non-forced error	BS Winner	BS Forced error	BS Non-forced error	GD Winner	GD Forced error	GD Non-forced error	BD Winner	BD Forced error	BD Non-forced error	XD Winner	XD Forced error	XD Non-forced error
Quarter finals	U13	59	70	14	48	74	19	58	39	29	50	45	37	58	45	28
	U15	55	66	18	55	68	20	29	21	12	27	22	18	55	60	24
	U17	63	67	19	55	76	17	45	63	19	50	68	28	51	68	25
	U19	58	84	25	51	71	23	22	32	10	39	65	13	55	69	27
Semifinals	U13	27	45	8	14	32	11	25	26	14	23	36	19	30	22	22
	U15	26	38	9	32	45	9	30	19	14	25	36	17	26	36	9
	U17	16	37	6	10	24	1	16	18	4	9	19	5	0	0	0
	U19	13	20	2	27	34	7	24	34	7	14	15	4	0	0	0
Finals	U13	8	17	5	12	22	6	9	14	11	17	13	8	14	13	10
	U15	6	20	8	9	21	6	10	14	7	9	19	11	8	14	16
	U17	12	23	3	12	22	5	14	21	5	11	20	4	18	18	4
	U19	11	14	7	5	20	4	12	21	4	16	23	5	10	25	5

3rd Game

Phase	Cat	GS Winner	GS Forced error	GS Non-forced error	BS Winner	BS Forced error	BS Non-forced error	GD Winner	GD Forced error	GD Non-forced error	BD Winner	BD Forced error	BD Non-forced error	XD Winner	XD Forced error	XD Non-forced error
Quarter finals	U13	0	0	0	0	0	0	0	0	0	12	5	14	27	26	18
	U15	25	47	8	0	0	0	0	0	0	10	14	12	0	0	0
	U17	16	14	7	38	68	15	0	0	0	0	0	0	0	0	0
	U19	0	0	0	16	15	5	0	0	0	14	25	7	12	18	5
Semifinals	U13	23	38	12	0	0	0	0	0	0	0	0	0	36	19	16
	U15	12	16	5	6	23	4	0	0	0	0	0	0	0	0	0
	U17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	U19	12	15	6	0	0	0	11	24	3	0	0	0	0	0	0
Finals	U13	0	0	0	12	18	7	12	18	9	12	19	7	0	0	0
	U15	0	0	0	0	0	0	0	0	0	5	18	10	0	0	0
	U17	16	22	2	0	0	0	0	0	0	0	0	0	18	25	1
	U19	8	20	9	0	0	0	0	0	0	0	0	0	13	18	8

Figure 1 – Absolute frequency of finishing characteristic according to event, category, phase, game. Multinomial Regression, Omnibus test, X2 = 63.5; P<0.01

Figure 2 – Absolute frequency of target court area according to event, category, phase, game. Multinomial Regression, Omnibus test, X2 = 207; P<0.01

Discussion

The objective of this study was to identify the characteristics of the game profile and performance of junior badminton pan-american players in its five events, considering competition phases and games.

As in previous research, it is observed that male and mixed doubles have a more explosive game characteristic than the other events (Torres-Luque et al., 2019; Gawin et al., 2015), noted by the shorter rallies, greater exchange of shots per second and lower working density value.

Badminton, as consolidated in the literature, has an intermittent structure of physical effort and recovery breaks (Manrique & González-Badillo, 2003), with a highly variable duration (Valldecabres et al., 2017).

If the male and mixed doubles won the point in a few strokes, the female pairs exchanged a greater number of shots to finish the point. From this, it can be said that the event differs from other doubles events, according to the basic assumption already described in previous studies (Torres-Luque et al., 2019; Gawin et al., 2015), which label female players of women's doubles from the main category of the world elite with great defense capacity and offensive construction (Gawin et al., 2015). Therefore, in this regard, the result of the current study indicates a similar characteristic of the youth game to that of the main category.

The real time played was greater for the women's individual, which may be due to the longer duration of the point dispute. This result is not in line with a previous study that observed this characteristic in badminton matches at the Olympic Games with men's singles players compared to women's singles (Abian-Vicen et al., 2013). It can be deduced that there was greater physical demand for the female individual event in the current study, and this generated more rest time between rallies.

For the total variable of points played, there were no differences between the modalities, and this finding corroborates the study by Abian-Vicen et al. (2013) in an Olympic context, with individual events, however, disagrees with the study by Chiminazzo et al. (2018), also with

Olympic players, but from the men's individual, who reported the increase in the total points played when comparing the group stages with knockout.

Regarding the characteristic of finishing the point, in all games and stages of the competition, categories and events, the forced error was frequent, followed by the winning hit. Previous studies, in general, observed only the unforced error and winning shot and identified that the unforced error occurs frequently in the female individual game compared to the male individual game (Abian-Vicen et al., 2013; Gomez et al., 2019), while in juniors of individual sports the unforced error occurs with the same magnitude in both events (Ming et al., 2008). The result found here can be explained in terms of the similarity of the skill level between the players in competition.

The highest prevalence of forced error and winning shots were lost to the net or out, and when conquered, it was observed that players preferred the back corners of the court to send the shuttlecock. In a previous study with juniors, despite investigating simulated games, the characteristic of unforced error was verified when comparing individual events. The point was often lost in both events for the network (Ming et al., 2008), different from what was observed in this study, which were due to forced error.

Conclusion

The present study identified the characteristics of the game activity profile and performance of junior players in the five badminton events. The profiles seem to follow the characteristics revealed in the main category's playing behavior. Regardless of the categories, differences were observed in all variables of both temporal and notational structure, except for the number of points played.

The main limitation of the study was the unavailability of some U-17 (n=5) and U-19 (n=4) doubles games in the semifinal phase of the competition. It is suggested that, in future studies, analysis should be carried out about the finalization characteristic considering the winner and loser of the point/match for a better identification of the player´s skill levels. In addition, statistical analysis that find possible associations between the zones of the court with the type of stroke, trajectory of the shuttlecock, position of the player in the finalization and characteristics of the finalization, components which could present more effective performance indicators, as they would show if the player was in the right zone for the ideal shot and in a good technical-tactical position to attack or press the opponent.

As a practical application, the results support the application of training in the ecological and situational approach, which can encourage rich movements that emerge in the game, thus avoiding the application of closed skill exercises only.

The results of this study, via specific scenarios of the match and/or phases of the competition, may imply benefits for the training process of junior groups at the Pan American level, and other skill levels of the same age group. It is suggested the implementation of reduced games and conditioned to the design of the training program, enabling attack and defense training through situations that allow players to explore various solutions in the game context.

Research team notes

1. The objective of analyzing the existing relationship between scored points, the classification obtained by the athletes in the competition and the temporal characteristics was changed to analysis considering the phases and games of the competition.

2. The analysis between games are shown in the tables, but are not described in the results, in order to make the text more succinct.

3. So far, 10 abstracts have been presented at national and international conferences, 3 of which received award as the best paper presentation, 1 paper was published, two course conclusion papers defended, one of them of the course managed by the National Olympic Committee (Brazilian Academy of Coaches) and another from the Faculty of Physical Education of the Federal University of Mato Grosso. The finalization of an academic master's

thesis and the submission of other papers to international journals arising from this work are still in progress.

Title	Type of publication
Badminton games of single male and female u13: A temporal and notational comparison between Games In Portuguese: Jogos de badminton de simples masculina e feminina Sub-13: uma comparação temporal e notacional entre games.	Article. Journal: Collection Research in Physical Education v.20, n.4, 2021 In portuguese: Coleção Pesquisa em Educação Física - v.20, n.4, 2021
Performance analysis of temporal and technical factors in junior men's singles badminton athletes at the Pan American level In Portuguese: Análise de desempenho de fatores temporais e técnicos em atletas de badminton juniores de simples masculina sub-17 ao nível pan-americano	Abstract published in congress proceedings - 12th International Congress of the Regional Council of Physical Education of the 7th Region – 2022. In Portuguese: 12º Congresso Internacional do Conselho Regional de Educação Física da 7ª Região – 2022. This study was an award-winning poster.
Comparison between genders of temporal demand in Elite Junior Badminton U13 In Portuguese: Comparação entre sexos da demanda temporal no Badminton Junior de Elite Sub13	Abstract published in congress proceedings - 11th International Congress of the Regional Council of Physical Education of the 7th Region – 2021. In Portuguese: 11º Congresso Internacional do Conselho Regional de Educação Física da 7ª Região – 2021.
Badminton games of single male and female u13: A temporal and notational comparison between Games In Portuguese: Jogos de badminton de simples masculina e feminina Sub-13: uma comparação temporal e notacional entre games.	Abstract published in congress proceedings - College of Physical Education Final Paper Summary Book – 2021. In Portuguese: Caderno de Resumos Trabalhos de Conclusão de Curso da Faculdade de Educação Física – 2021.
Proposed Characterization of Temporal and Notational Demands in Pan American Junior Badminton Athletes In Portuguese: Proposta de Caracterização das Demandas Temporais e Notacionais em Atletas Juniores de Nível Pan-Americano no Badminton	Abstract published in congress proceedings - XII Postgraduation Exhibition of the Pró-reitoria de Ensino de Pós-graduação – 2021. In Portuguese: XII Mostra da Pós-Graduação da Pró-reitoria de Ensino de Pós-graduação – 2021.
Tactical situations versus finishing characteristics of winning and losing players in Pan American Badminton U13 In Portuguese: Situações táticas versus características da finalização de jogadores vencedores e perdedores no Badminton Panamericano Sub13	Abstract published in congress proceedings - 11th International Congress of the Regional Council of Physical Education of the 7th Region – 2021. In Portuguese: 11º Congresso Internacional do Conselho Regional de Educação Física da 7ª Região – 2021.
Temporal and tactical diagnosis in U13 badminton athletes In Portuguese: Diagnóstico temporal e tático em atletas Sub13 no badminton	Abstract published in congress proceedings -XXIX Seminar of undergraduate research Project/ Federal University of Mato Grosso – 2022. In Portuguese: XXIX Seminário de Iniciação científica/ Universidade Federal de Mato Grosso – 2022.
Comparison of temporal and technical structure between U-13 and U-17 junior badminton athletes at the Pan American level In Portuguese: Comparação da estrutura temporal e técnica entre atletas juniores sub-13 e sub-17 de badminton ao nível pan-americano	Abstract published in congress proceedings - XIII Postgraduation Exhibition of the Pró-reitoria de Ensino de Pós-graduação – 2022. In Portuguese: XIII Mostra da Pós-Graduação da Pró-reitoria de Ensino de Pós-graduação – 2022. This study was an award-winning best paper presentation of the Post-Graduate Programme in Physical Education
Association between tactical situations and finishing characteristics of U17 Pan American badminton players In Portuguese: Associação entre situações táticas e características da finalização de jogadoras sub17 do badminton pan-americano	Abstract published in congress proceedings - Racket sports congress – 2021. In Portuguese: Congresso em esportes de raquete – 2021. This study was awarded honorable mention.
Probing temporal variables in the U17 women's singles badminton panamerican games	Abstract published in congress proceedings - Racket sports congress – 2021.

In portuguese: Sondagem de variáveis temporais nos jogos panamericanos de badminton de simples feminina sub17	In Portuguese: Congresso em esportes de raquete – 2021.
Time interval in games of U-13 junior athletes at Pan American level in badminton In Portuguese: Intervalo de tempo em jogos de atletas juniores sub-13 ao nível pan-americano no badminton	Abstract published in congress proceedings - Academic Week of the physical education faculty – 2022. In Portuguese: Semana Acadêmica da Faculdade de Educação Física – 2022.
Badminton games of single male and female u13: A temporal and notational comparison between Games In Portuguese: Jogos de badminton de simples masculina e feminina Sub-13: uma comparação temporal e notacional entre games.	Course conclusion papers – Undegraduate in kinesiology – Universidade Federal de Mato Grosso – 2021. In Portuguese: Graduação em Educação Física/Federal Univesidade Federal de Mato Grosso – 2021.
Temporal demands and point completion of elite junior athletes in Pan American badminton In Portuguese: Demandas temporais e finalização dos pontos de atletas junior de elite no badminton pan-americano	Course conclusion papers – Expertise Degree in High Performance Sport by National Olympic Committee (Brazilian academy of coaches) – 2021 In Portuguese: Especialização em Esporte de Alto Rendimento pelo Comitê Olímpico do Brasil – 2021.

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