Professional male modern boxing: An analysis of activity profile by category
Boxeo moderno masculino profesional: un análisis del perfil de actividad por categoría

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Abstract. The purpose of this study is to examine modern professional male boxing by analyzing world champions differences between winners and losers by categories. 322 male professional boxers (age 28.95 ± 4.10, height 175.26 ± 9.44 cm, and weight 147.82 ± 31.31 lb) were included in this observational descriptive analysis, through 320 fights separated by weight divisions [Heavy (H) (n = 24), Cruiser (C) (n = 48), Light Heavy (LH) (n = 62), Super Middle Weight (SMW) (n = 17), Middle Weight (MW) (n = 68), Light Middle Weight (LMW) (n = 42), Welter Weight (WW) (n = 49), Light Welter Weight (LWW) (n = 28), Light Welter (LW) (n = 33), Super Feather Weight (SFW) (n = 63), Feather Weight (FW) (n = 66), Super Bantam Weight (SBW) (n = 42), Bantam Weight (BW) (n = 30), Super Fly Weight (SFLW) (n = 39), Flyweight (F) (n = 29)]. Differences were found between winners and losers (U = 57804 - 90908.5; p <.001; d = 0.129 - 0.776) for all the variables analyzed. Four significant correlations were highlighted: %PL (Percentage of Punches Landed) (rho = .630); AVG PLxR (Punches Landed Per Round) (rho = .594); AVG PPLxR (Power Punches Landed Per Round) (rho = .517); %PPL (Percentage of Power Punches Landed) (rho = .672) and differences were also observed between weight categories (H = 32.29 - 93.11; p <.001 - .004), except for %PL, AVG JLxR, %JL (Percentage of Jabs Landed) and %PPL. This data suggests that in order to win these events, fighters must deliver precise punches, especially power punches, and that there are differences between the categories with this type of punch (AVG PPLxR).
Keywords: Performance, trajectory analysis, punch indicators, power punches, ecological study

Resumen. El propósito de este estudio es examinar el boxeo masculino profesional moderno analizando las diferencias entre campeones mundiales entre ganadores y perdedores por categorías. En este análisis descriptivo observacional se incluyeron 322 boxeadores profesionales masculinos (edad $28,95 \pm 4,10$, altura $175,26 \pm 9,44$ cm y peso $147,82 \pm 31,31$ lb), a través de 320 peleas separadas por divisiones de peso [Heavy (H) (n = 24), Cruiser (C) (n = 48), Semipesado (LH) (n = 62), Superpeso medio (SMW) (n = 17), Peso medio (MW) (n = 68), Peso medio ligero (LMW) (n = 42), Peso Welter (WW) (n = 49), Peso Welter ligero (LWW) (n = 28), Peso Welter ligero (LW) (n = 33), Peso súper pluma (SFW) (n = 63) , Peso pluma (FW) (n = 66), Peso súper gallo (SBW) (n = 42), Peso gallo (BW) (n = 30), Peso súper mosca (SFLW) (n = 39), Peso mosca (F) (n = 29)]. Se encontraron diferencias entre ganadores y perdedores (U = 57804 - 90908,5; p < 0,001; d = 0,129 - 0,776) para todas las variables analizadas. Se destacaron cuatro correlaciones significativas: %PL (Porcentaje de golpes dados) (rho = .630); AVG PLxR (golpes dados por asalto) (rho = .594); AVG PPLxR (golpes de poder lanzados por asalto) (rho = .517); %PPL (Porcentaje de Golpes de Poder Acertados) (rho = .672) y también se observaron diferencias entre categorías de peso (H = 32.29 - 93.11; p <.001 - .004), excepto %PL, AVG JLxR, % JL (porcentaje de Jabs Land-ed) y %PPL. Estos datos sugieren que para ganar estos eventos los peleadores deben dar golpes precisos, especialmente golpes de potencia, y que existen diferencias entre las categorías con este tipo de golpe (AVG PPLxR).
Palabras clave: Rendimiento, análisis de trayectoria, indicadores de golpe, potencia de golpe, estudio ecológico.

Introduction

Boxing is an intermittent-activity sport (Franchini et al., 2019), with high intensity intervals characteristic of combat sports (Ruddock et al., 2021; Silva et al., 2011), in which two opponents from the same category (El-Ashker et al., 2018; Morton et al., 2010; Murugappan et al., 2021) exchange offensive and defensive actions to punch the adversary (Guidetti et al., 2002; Krabben et al., 2019). Depending on the competition, combats typically range from three, three-minute rounds per fight in Olympic boxing (International Boxing Association, 2021), to twelve, three-minute rounds in professional boxing, where more than one organization controls the rules in the competition (Pic, 2018). Amateur and professional boxing differ due to reasons of motivation, regulations and exposure to certain types of injury (McCrory et al., 2012), which means the technical demands could depend on the event (Thomson & Lamb, 2016).

In recent years, several studies have been carried out to analyze the different boxing activity profiles. Some of this research has provided differences between winners and losers (Davis et al., 2013; Dunn et al., 2017; El Ashker, 2011; Fin-lay, 2022; Puchol & Caparrós, 2020), including discriminations between weight categories (Davis et al., 2018; Thomson & Lamb, 2016) and competition level (Thomson & Lamb, 2016), with the purpose of identifying technical/tactical skills, including offensive (punch types: jab, hook, uppercut, etc.) as well as defensive (through guard, trunk, footwork, etc.), and performance parameters. These analyses provide an opportunity to understand the characteristics of the sport discipline in question (Hughes & Bartlett, 2002; O'Donoghue, 2009).

The studies used to analyze boxers are becoming more efficient to find fight patterns in the most recent events and to be able to investigate the opponents as much as possible, such as their punching characteristics, lateral dominance, punching activity profile, etc. (Schinke & Ramsay, 2009). The use of new technologies is a very precise way to facilitate improved performance (Kojman et al., 2022).

Several studies on the activity profiles that identify the types of actions that make up the rounds of this sport have reported that boxers throw an average of 63 to 82 punches per round and between 14-29% land accurately in the scoring area (Davis et al., 2015, 2018; Dunn et al., 2017; Puchol & Caparrós, 2020), with the jab being the most-used and

most-effective boxing punch with 37% accuracy (Kruszewski et al., 2016). Winners tend to have a higher average number of punches landing in the scoring zone due to their higher activity profile (El Ashker, 2011; Puchol & Caparrós, 2020). Regarding defensive actions, boxers perform an average of 30 actions during the round, including defense actions with their arms, trunk, and defense with footwork (Dunn et al., 2017). Boxers spend more time during the round on footwork than even other actions such as punches thrown (Devesa & Pons, 2020), so it could be a determining factor for defensive as well as offensive actions (Davis et al., 2016).

Studies undertaken to identify boxing parameters and professional boxing profiles (Finlay, 2022; Pic, 2018; Pic & Jonsson, 2021) are scarce and only one of them aims to obtain records of the punching activity. An analysis was conducted to compare fights between winners and losers in the heavyweight category, stating that boxers throw an average of 320.1 punches per fight, 37.6 punches per round, and land 34.6% of punches thrown. 172.4 Jabs are thrown per fight and 27.29% land, and of the 147.8 punches thrown with power, 42.4% land. Winners have a higher average number of punches thrown and greater accuracy during these events (Finlay, 2022).

Efficient evaluation and identification of specific aspects in combat sports is crucial to support athletes as well as coaches (Barley et al., 2019; Thomson et al., 2013) and offer the possibility of analyzing events and boxers in order to design future training plans (Puchol & Caparrós, 2020). The purpose of this work is to undertake a descriptive observational study of professional boxers from different weight categories who hold one or more world titles, where their last fights were analyzed to identify profiles and performance parameters and to identify any differences between the different modern professional boxing categories.

Material and methods

Participants

The actions of 322 male professional boxers (mean ± standard deviation [SD]), age 28.95 ± 4.10, height 175.26 ± 9.44 cm and weight 147.82 ± 31.31 lb, who held at least one of the internationally recognized titles (World Boxing Association [WBA], World Boxing Organization [WBO], World Boxing Council [WBC] and International Boxing Federation [IBF]) were analyzed during 320 fights of the following weight categories: H (n = 24), C (n = 48), LH (n = 62), SMW (n = 17), MW (n = 68), LMW (n = 42), WW (n = 49), LWW (n = 28), LW (n = 33), SFW (n = 63), FW (n = 66), SBW (n = 42), BW (n = 30), SFW (n = 39), F (n = 29). The Light Flyweight (LFW) and Minimumweight (M) categories were not included due to their scarcity in the sample.

Design and procedure

The official websites (*International Boxing Federation*, 2022; *World Boxing Association*, 2022; *World Boxing Council*, 2022; *World Boxing Organization*, 2022) were accessed to find out who the world champions were as of February 28, 2022, and from that date onward. The latest ten fights of each world champion were analyzed as the established maximum, which can be in different categories depending on their professional career. For some of the selected boxers, the maximum limit of 10 fights could not be reported, either because some of the fights did not have certain anthropometric data and/or punching activity records, or simply because of the age of the boxers, since the average age in professional boxing is usually 23.85 years (Tasiopoulos & Nikolaidis, 2022) and more experience is needed for their promotion (McCrory et al., 2012).

The boxers' characteristic records and anthropometric data were obtained from www.boxrec.com and those of the punching actions from beta.compuboxdata.com, both free access websites. Several studies have previously accessed these websites (Finlay, 2022; Pic, 2018; Pic & Jonsson, 2021).

The punching action records extracted from beta.compuboxdata.com were analyzed as variables (Table 1) on the boxing activity profile during the fight and during the round, to determine the quantity, punch types and their precision.

Table 1.
Description analysed variables

VARIABLES	DESCRIPTION OF THE VARIABLES ANALYSED
End fight (EF)	Indicates the round in which the fight ends.
BOXING ACTIVITY PROFILE DURING FIGHT	
Total Punches Thrown (TPT)	Number of punches thrown during the fight. Indicates the sum of Jabs and power punches thrown during the fight
Total Punches Landed (TPL)	Number of punches landing in the valid scoring zone. Indicates the sum of Jabs and power punches landed during the fight
Percentage Punches Landed (%PL)	Indicates the percentage of punches landing in the valid scoring zone of the total number of punches thrown during the bout
Jabs Thrown (JT)	Number of Jabs thrown during the bout
Jabs Landed (JL)	Number of Jabs landed during the fight
Power Punches Thrown (PPT)	Number of power punches thrown during the fight
Power Punches Landed (PPL)	Number of power punches landed in the validated scoring zone during the bout
Percentage Power Punches Landed (%PPL)	Percentage of power punches landing in the valid scoring zone out of the total number of power punches thrown during the bout
Percentage Jabs Landed (%JL)	Indicates the percentage of jabs landing in the valid scoring zone out of the total number of jabs thrown during the bout
BOXING ACTIVITY PROFILE DURING ROUND	
Average Punches Thrown per Round (AVG PTxR)	It is the average number of punches thrown during the round
Average punches landed per round (AVG PLxR)	Average number of jabs landing in the valid scoring zone during the round
Jabs Thrown per Round (AVG JTxR)	Is the average number of jabs thrown during the combat
Jabs Landed per Round (AVE JLxR)	Average number of jabs landed in the valid scoring zone
Average Power Punches Thrown per Round (AVG PPTxR)	Average number of power punches thrown during the round
Average Power Punches Landed per Round (AVG PPLxR)	Average number of power punches landed in the valid scoring zone per round

Statistical analysis

Central tendency of Boxing activity profile during fight and during round (Table 1) were descriptively analyzed for the entire sample (mean and standard desviation – SD -).

Next, and taking the sample's non-normality into account shown in the Shapiro-Wilk test, a statistical analysis was carried, any differences between the variables and the different categories analyzed using the Kruskal-Wallis Test were assessed. Subsequently, any differences in the variables according to the result (win or lose) were assessed using the Mann Whitney test. Finally, possible relationships between the actions and winning the fight were determined using Spearman's rho test (rho). This index ranges between -1 and +1, defining the magnitude of the relationships, according to Hopkins (2002) criteria as casual: 0-.09; low: .10-.29; moderate: .30-.49; high: .50-.69; very high: .70-.89; almost perfect .90-.99; 1 perfect. The significance level for all tests is p <.05. The analysis was performed using JASP 0.16.1.0 statistical software (The Jasp Team, Amsterdam, Holland).

Results

Boxing activity profile during combat

The descriptive analysis (Table 2) shows that the boxers finished the fight in the round 8.46 ± 3.65, varying between maximum values of 9.82 ± 2.78 in the LW category and minimum values of 5.33 ± 3.70 in BW. The activity profile during fight was 443.93 ± 264.60 Total Punches Thrown (TPT), with ranges fluctuating between 652.1 ± 304.97 and 240.67 ± 233.45, between the SFLW and BW

categories respectively. Of these TPT, the fighters obtained an average of 117.31 ± 73.88 Total Punches Landed (TPL), with maximum values in the SFLW category (166.69 ± 91.46) and minimum in BW (66.80 ± 74.23), which in values of %PL per fight corresponds to 26.34 ± 7.48, with maximums (28.54 ± 7.67) for the MW category and minimums (24.52 ± 6.81) in the H category. Boxers averaged 195.12 ± 133.10 Jabs Thrown (JT) during the fight, with highs of 259.28 ± 122.27 (SFLW) and lows of 116.97 ± 119.45 (BW). Of these JT, 31.35 ± 26.22 correspond to Jabs Landed (JL), with maximum (40.23 ± 25.18) and minimum (21.87 ± 28.16) values that vary between the SFLW and BW categories respectively and that, in Percentage of Jabs Thrown (%JT), corresponds to 15.96 ± 8.61 during the fight, with maximums of 17.96 ± 8.26 in the MW category and minimums of 13.72 ± 7.58 in LWW. During the fight, there were 248.79 ± 167.78 Power Punches Thrown (PPT), with the SFLW category having the highest value (392.82 ± 123.7) and BW the lowest value (123.7 ± 122.03), a total of 85.91 ± 58.54 PPL were in the scoring zone, varying between maximums and minimums between the SFLW (125.67 ± 77.93) and BW (44.93 ± 48.43) categories, and which translated into the Percentage of Power Punches Landed (%PPL) corresponding to 34.59 ± 9.08, with maximum values of 38.19 ± 6.82 in the SMW category and minimum values of 32.01 ± 7.05 in the SFLW category.

Table 2.
Descriptive analysed variables of central tendency and different categories, differentiated by win or lose.

VARIA-BLES		AC All	AC Win	AC Lose	H All	H Win	H Lose	C All	C Win	C Lose	LH All	LH Win	LH Lose	SMW All	SMW Win	SMW Lose	MW All	MW Win	MW Lose	LMW All	LMW Win	LMW Lose	WW All	WW Win	WW Lose
VARIABLES	n	640	320	320	24	12	12	48	24	24	62	31	31	17	8	9	68	34	34	42	22	20	49	24	25
End Round	x	8.46	8.46	8.46	8.92	8.92	8.92	9.58	9.58	9.58	8.10	8.10	8.10	6.72	7.00	6.44	8.21	8.15	8.27	8.24	8.23	8.25	8.90	8.88	8.92
	SD	3.65	3.65	3.65	3.37	3.37	3.37	3.20	3.20	3.20	4.02	4.02	4.02	4.24	4.21	4.28	3.91	3.97	3.84	3.81	3.74	3.88	3.19	3.22	3.16
TPT	x	443.93	483.02	404.84	358.33	444.42	272.25	476.65	573.67	379.63	408.16	469.39	346.94	275.08	291.38	258.78	410.53	470.30	350.88	400.51	449.33	351.80	450.33	486.33	414.08
	SD	264.60	273.61	255.59	196.17	199.19	193.15	213.22	245.75	180.69	254.17	265.42	242.93	164.75	177.32	152.18	241.24	271.11	211.37	288.71	331.72	245.70	242.94	246.27	239.62
TPL	x	117.31	148.22	86.39	90.04	120.33	59.75	122.98	158.33	87.63	105.13	145.10	65.16	80.30	109.38	51.22	116.24	152.91	79.56	104.84	133.68	76.00	126.61	160.63	92.60
	SD	73.88	84.43	63.33	48.99	51.80	46.10	65.17	71.68	58.66	63.66	78.73	48.43	52.72	72.11	33.42	70.98	82.25	59.58	76.49	97.55	55.24	68.27	77.26	59.22
%PL	x	26.34	31.85	20.84	24.52	27.78	21.26	25.15	28.40	21.90	26.77	31.99	21.55	28.50	37.41	19.58	28.54	34.66	22.42	25.71	30.57	20.85	28.16	33.65	22.68
	SD	7.48	8.06	6.90	6.81	7.02	6.59	7.29	6.56	8.02	7.18	5.27	9.10	6.72	7.65	5.79	7.67	7.99	7.35	6.09	6.98	5.21	5.24	4.54	5.94
AVG PTxR	x	50.81	55.95	45.65	40.14	51.97	28.30	49.64	59.68	39.66	49.49	58.59	40.33	44.18	44.14	44.24	50.20	58.35	42.21	44.66	51.60	38.86	49.61	54.56	44.78
	SD	18.54	18.69	18.39	13.96	15.03	12.90	15.65	17.96	13.36	15.23	15.42	15.04	12.82	10.68	14.96	18.03	20.55	15.51	19.80	23.55	16.05	16.42	16.16	16.68
AVG PLxR	x	13.62	17.69	9.55	10.08	14.18	5.98	12.76	16.95	8.62	13.42	18.57	8.25	12.41	16.51	8.29	14.86	20.27	9.50	11.86	15.41	8.20	14.06	18.16	9.96
	SD	6.02	7.12	4.92	4.00	4.81	3.19	5.31	6.33	4.29	4.76	5.12	4.40	3.94	5.36	2.53	6.99	9.08	4.90	5.80	7.71	3.89	4.96	5.30	4.63
JT	x	195.12	216.55	173.68	183.96	240.58	127.33	225.08	297.13	153.04	209.08	237.10	181.07	132.45	130.13	134.78	179.77	209.77	149.77	167.85	181.91	153.80	206.41	236.58	176.24
	SD	133.10	139.77	126.68	126.85	135.18	118.52	117.72	154.08	79.37	164.85	174.37	155.33	90.71	89.18	92.26	125.64	146.11	105.26	114.64	109.11	120.17	140.52	142.55	138.49
AVG JLxR	x	3.61	4.81	2.40	3.03	4.39	1.67	3.99	5.80	2.18	4.12	5.91	2.33	3.45	3.88	3.02	3.96	5.66	2.27	3.09	3.92	2.26	3.99	5.44	2.54
	SD	2.38	2.99	1.77	1.76	2.12	1.41	2.47	3.25	1.70	2.49	3.34	1.64	1.69	2.29	1.10	2.60	3.38	1.82	1.78	1.89	1.67	2.45	3.12	1.79
AVG JTxR	x	22.29	24.80	19.77	20.35	28.02	12.68	23.78	30.99	16.58	24.22	27.74	20.69	21.23	19.58	22.88	21.07	24.25	17.90	19.20	21.63	16.78	22.69	26.82	18.57
	SD	10.70	10.56	10.85	10.63	12.13	9.12	9.68	12.74	6.62	10.85	10.85	10.85	9.58	6.92	12.25	9.61	10.76	8.46	8.96	8.23	9.69	11.15	11.15	11.19
JL	x	31.35	41.37	21.32	27.83	38.50	17.17	37.81	53.42	22.21	34.92	51.52	18.32	24.98	30.63	19.33	32.31	45.38	19.24	26.15	32.00	20.30	36.38	48.75	24.00
	SD	26.22	32.79	19.62	20.73	23.69	17.79	25.55	30.22	20.99	32.11	47.39	16.95	24.68	34.04	15.38	27.68	33.33	21.99	17.98	18.08	17.78	29.98	38.98	20.89
% JL	x	15.96	19.43	12.48	14.98	17.25	12.71	15.96	18.15	13.75	16.92	21.00	12.87	16.75	19.16	14.31	17.96	22.78	13.14	15.24	18.12	12.27	17.51	20.30	14.72
	SD	8.61	9.82	7.41	7.28	7.75	6.81	7.86	7.02	8.70	8.94	7.64	10.23	6.55	7.98	5.13	8.26	8.97	7.55	8.03	8.06	8.00	6.79	7.19	6.39

(Continuation of table — first eight categories AC, H, C, LH, SMW, MW, LMW, WW, each split into All / Win / Lose; column headers appear on the previous page.)

Variable	Stat																								
AVG PPLxR	x	10.00	12.86	7.14	6.80	9.33	4.28	8.79	11.15	6.44	9.28	12.66	5.91	8.99	12.69	5.29	10.93	14.62	7.24	8.73	11.51	5.95	10.07	12.72	7.43
	SD	5.16	6.14	4.18	3.06	3.77	2.34	4.01	4.55	3.47	4.51	5.12	3.91	3.98	5.32	2.64	5.99	8.03	3.94	5.09	7.45	2.73	3.95	4.34	3.56
PPL	x	85.91	106.84	64.90	62.21	81.83	42.56	85.17	104.92	65.42	70.16	93.58	46.74	55.32	78.79	31.83	83.96	107.53	60.32	78.61	101.68	55.70	90.24	111.88	68.63
	SD	58.54	65.58	51.50	33.65	34.04	33.26	51.47	56.68	46.25	43.49	48.23	38.76	30.96	41.21	20.72	50.63	56.03	45.19	64.98	88.79	41.19	50.89	56.99	44.73
AVG PTxR	x	28.52	31.14	25.90	19.42	23.48	15.36	25.85	28.70	23.00	25.20	30.89	19.65	22.95	24.55	21.34	29.28	34.04	24.38	25.43	28.99	22.09	26.91	27.68	26.15
	SD	13.33	14.14	12.52	6.24	5.96	6.52	9.37	8.67	10.08	11.05	12.50	9.59	9.77	7.69	11.84	13.75	17.02	10.48	14.47	19.55	9.39	8.79	8.80	8.78
PPT	x	248.79	266.38	231.19	173.46	202.92	144.92	251.54	276.54	226.58	199.08	232.29	165.87	142.00	161.00	124.00	230.41	260.12	201.12	232.00	267.92	198.00	243.92	250.00	237.84
	SD	167.78	172.37	163.20	92.82	87.30	98.35	125.87	122.75	128.99	128.47	131.35	125.58	86.30	98.50	74.03	139.77	151.93	127.61	196.72	247.19	146.24	130.05	131.22	128.88
%PPP	x	34.59	42.09	27.10	34.65	41.59	27.72	33.24	38.51	27.98	35.65	41.95	29.35	38.19	51.18	25.20	36.51	43.38	29.65	34.59	42.01	27.17	37.12	46.26	27.97
	SD	9.08	9.50	8.65	10.04	11.12	8.96	9.09	9.35	8.84	8.28	7.25	9.30	6.82	8.97	4.68	9.10	9.01	9.20	10.67	12.16	9.18	8.15	9.37	6.94

CATEGORIES (LWW to FLW)

		LWW			LW			SFW			FW			SBW			BW			SFLW			FLW		
		All	Win	Lose	All	Win	Lose	All	Win	Lose	All	Win	Lose	All	Win	Lose	All	Win	Lose	All	Win	Lose	All	Win	Lose
VARIABLES	n	28	14	14	33	17	16	63	31	32	66	33	33	42	21	21	30	15	15	39	20	19	29	14	15
Finaliza Asalto	x	8.29	8.29	8.29	9.82	9.77	9.88	7.76	7.68	7.84	9.53	9.61	9.46	7.91	7.91	7.91	5.33	5.33	5.33	9.79	9.80	9.79	8.14	8.07	8.20
	SD	3.93	3.93	3.93	2.78	2.75	2.80	3.82	3.82	3.83	2.94	2.94	2.94	4.00	4.00	4.00	3.70	3.70	3.70	3.08	3.04	3.12	3.56	3.61	3.51
TPT	x	375.07	372.64	377.50	447.47	437.12	457.81	406.69	409.84	403.69	579.63	625.42	533.18	475.07	519.71	430.43	240.80	259.43	221.53	652.91	673.00	631.14	484.67	484.14	485.67
	SD	241.05	204.06	278.03	158.06	159.14	156.98	238.55	229.41	247.69	285.70	297.31	274.08	291.02	305.86	276.17	233.45	231.93	234.97	304.97	287.23	322.72	269.53	271.93	267.13
TPL	x	98.93	117.71	80.14	114.29	138.71	89.88	103.59	119.48	87.69	148.30	184.36	112.24	136.05	171.05	101.86	66.89	88.65	44.93	166.69	196.75	136.63	121.59	154.79	88.40
	SD	69.83	65.85	73.80	44.03	47.74	40.43	64.29	67.19	61.47	78.70	94.37	63.07	90.17	98.83	81.53	74.23	104.19	44.27	91.48	88.65	94.87	70.89	91.06	50.63
%PL	x	24.45	30.89	18.02	26.18	32.39	19.97	25.22	30.16	20.28	25.34	30.23	20.46	27.93	33.42	22.44	27.37	36.05	18.68	25.05	30.08	20.03	25.66	33.32	18.00
	SD	8.08	6.96	9.21	5.46	5.08	5.84	7.12	6.99	7.25	6.30	7.49	5.10	6.23	6.02	6.44	14.51	20.57	8.45	5.57	5.54	5.59	6.62	9.08	4.16
AVG PTxR	x	42.11	42.53	41.69	45.88	45.22	46.46	50.58	53.27	47.89	59.34	63.55	55.14	58.69	64.50	52.80	39.36	42.80	35.90	64.21	67.62	60.99	57.74	58.13	57.35
	SD	15.71	12.15	19.17	10.94	10.07	11.80	15.17	14.08	16.27	21.64	21.67	21.75	18.47	17.75	19.27	18.57	18.66	18.44	20.21	19.70	20.81	16.11	14.21	18.04
AVG PLxR	x	10.56	13.31	7.81	11.82	14.59	9.06	13.17	16.17	10.16	15.42	19.32	11.53	16.64	21.61	11.66	10.77	14.36	7.17	16.47	20.07	12.77	14.67	19.02	10.31
	SD	5.37	4.94	5.81	3.43	4.00	2.86	5.46	6.03	4.88	7.23	9.04	5.43	6.15	6.93	5.37	6.82	9.41	4.22	6.48	6.00	6.96	4.78	6.05	3.51
JT	x	167.82	171.29	164.36	203.28	197.18	209.38	176.22	181.10	171.34	248.15	282.70	213.61	169.81	196.38	143.24	116.47	114.47	119.47	259.28	244.20	274.37	187.63	189.86	185.95
	SD	110.64	91.89	129.40	88.54	73.13	103.97	112.51	112.14	112.88	154.00	166.66	141.35	112.61	129.26	95.95	119.45	106.06	132.85	122.27	103.92	140.62	142.01	139.06	144.95
AVG JLxR	x	2.68	3.26	2.10	3.74	4.66	2.83	3.06	3.68	2.44	3.79	5.02	2.56	3.31	4.71	1.91	3.21	3.77	2.65	4.27	5.29	3.24	3.16	4.18	2.14
	SD	2.03	2.22	1.84	2.43	3.03	1.83	1.76	1.71	1.81	2.74	3.21	2.26	2.12	2.87	1.38	2.92	4.09	1.74	2.37	2.92	1.81	2.27	2.76	1.79
AVG JTxR	x	19.57	20.45	18.69	21.41	20.81	22.01	21.49	23.07	19.93	25.32	28.32	22.23	21.09	23.81	18.36	18.62	18.29	19.08	26.72	28.42	27.22	22.33	21.78	22.89
	SD	8.03	6.15	9.90	8.71	6.13	11.30	8.46	6.76	10.17	13.05	12.06	13.44	9.50	8.26	10.73	10.36	7.17	10.75	11.13	12.44	9.82	12.29	9.78	14.79
JL	x	23.93	27.07	20.79	33.80	41.82	25.81	24.59	27.60	21.42	37.08	49.89	24.67	26.53	37.40	15.57	21.86	28.26	15.56	40.23	47.39	33.16	27.49	35.71	19.28
	SD	21.52	19.80	23.25	20.52	23.50	17.51	18.82	18.99	18.65	29.84	36.67	23.02	20.39	27.59	13.19	28.16	41.87	14.44	25.18	27.08	23.36	26.53	32.50	20.48
% JL	x	13.72	15.44	12.01	17.20	21.33	13.03	13.83	16.25	11.42	14.31	17.71	10.91	15.67	19.27	12.06	17.76	21.98	13.59	16.25	20.52	11.98	15.13	21.11	9.14
	SD	7.58	7.76	7.40	8.33	9.19	7.48	6.71	6.95	6.47	7.63	8.75	6.52	8.19	8.72	7.67	17.31	26.08	8.55	7.32	9.18	5.46	7.73	10.44	5.02
AVG PPLxR	x	7.86	10.00	5.72	8.10	9.95	6.24	10.16	12.50	7.73	11.64	14.24	8.99	13.34	16.92	9.75	7.55	10.59	4.51	12.08	14.77	9.40	11.52	14.85	8.19
	SD	3.91	3.48	4.35	2.48	2.54	2.42	5.06	5.73	4.40	5.94	7.24	4.64	6.17	6.92	5.43	4.78	6.66	2.91	5.69	5.77	5.61	3.78	4.64	2.92
PPL	x	74.93	90.50	59.36	80.47	96.88	64.06	79.04	91.86	66.28	111.23	134.88	87.58	109.95	133.62	86.29	44.93	60.47	29.40	125.67	149.45	101.90	94.17	119.07	69.13
	SD	53.17	52.43	53.91	35.93	37.98	33.88	55.06	56.95	53.16	63.18	71.98	54.47	80.87	86.00	75.64	48.43	65.97	30.94	77.93	80.87	74.96	53.37	68.17	38.56
AVE PTxR	x	22.54	22.08	23.00	24.48	24.43	24.53	29.09	30.20	27.93	33.96	35.21	32.76	37.67	40.74	34.42	20.65	24.58	16.85	37.59	42.29	33.75	35.43	36.34	34.47
	SD	9.90	8.15	11.65	6.87	5.82	7.91	12.60	12.27	12.93	13.76	14.38	13.13	16.13	16.37	16.01	11.13	12.57	9.70	16.67	18.15	15.20	11.19	10.48	11.90
PPT	x	207.25	201.36	213.14	244.50	239.94	249.06	230.47	228.74	232.19	333.12	342.18	320.06	305.24	323.29	287.19	123.70	145.33	102.07	392.82	429.00	356.63	297.28	294.29	300.27
	SD	141.75	121.55	161.96	106.74	95.91	117.57	156.05	136.45	175.65	178.90	181.98	175.82	216.55	218.58	214.51	122.03	140.06	104.00	233.61	250.82	216.41	163.44	157.30	169.59
%PPP	x	34.36	45.94	22.79	33.29	40.90	25.69	33.87	41.17	26.62	33.31	40.16	26.46	34.97	41.73	28.11	35.17	45.83	24.31	32.01	37.17	26.86	32.68	41.33	24.03
	SD	9.33	7.08	11.58	6.31	6.02	6.60	8.90	7.61	10.18	7.45	7.86	7.03	6.50	6.52	6.48	15.90	18.96	12.83	7.05	6.95	7.15	8.05	9.67	6.42

Notes: All: is the sum of the Win (win the match) and lose (lose the match) samples. Mean (x) and standard desviation (SD) of 320 events analysed (n), differentiated by win and lose of; All categories (AC), Heavy (H), Cruiser (C), Light Heavy (LH), Super Middle Weight (SMW), Middle Weight (MW), Light Middle Weight (LMW), Welter Weight (WW), Light Welter Weight (LWW), Light Weight (LW), Super Feather Weight (SFW), Feather Weight (FW), Super Bantam Weight (SBW), Bantam Weight (BW), Super Fly Weight (SFLW), Fly Weight (FW).

Boxing activity profile during the round

The boxers had an Average Punches Thrown per Round (AVG PTxR) of 50.81 ± 18.54 with maximum and minimum values that varied between the SFLW (64.29 ± 20.27) and BW (39.36 ± 18.57) categories, respectively (Table 2). A total of 13.62 ± 6.02 corresponds to Average Punches Landed per Round (AVG PLxR), with the maximum value belonging to the SFLW category (16.42 ± 6.48) and minimum for H (10.08 ± 4.00). An Average Jabs Thrown per round (AVG JTxR) of 22.29 ± 10.70 was obtained with respect to the fighters' central tendency, with ranges that vary between 26.78 ± 11.13 (SFLW) and 18.68 10.36 (BW). A total of 3.61 ± 2.38 belongs to Average Jabs Landed per Round (AVG JLxR), with a maximum of 4.27 ± 2.37 in SFLW and a minimum of 2.68 ± 2.03 in LWW. The fighters obtained values of 28.52 ± 13.33 of Average Power Punches Thrown per round (AVG PPTxR), data that fluctuates between the SBW category (37.6 ± 16.7) and H (19.42 ± 6.24) and obtained 10.00 ± 5.16 of Average Power Punches Landed per Round (AVG PPLxR), varying between the maximum values of the SBW category (13.34 ± 6.17) and minimum H (6.80 ± 3.06).

The Kruskal-Wallis Test reported significant differences between the variables analyzed and the different categories (H = 32.29 - 93.11; p <.01 - .004), except for %PL, AVG JLxR, %JL and %PPL.

Significant differences were observed between "winner and loser" (Table 3) for the variables TPT, TPL, %PL, AVG PTxR, AVG PLxR, JT, AVG JLxR, AVG JTxR, JL, %JL, PPT, PPL, AVG PPTxR, AVG PPLxR, %PPL. (U = 57804 − 90908.5; p <.01; d = 0.12 − 0.77)

Finally, significant relationships were observed between the winner and the different variables analyzed, of which high relationships with %PL (Punches Landed) stood out (rho = .63; p <.01); AVG PLxR (rho = .59; p <.01); AVG PPLxR (rho = .51; p <.01); %PPL (rho = .67; p <.01) and moderate for TPL (rho = .38; p <.01); AVG JLxR (rho = .45; p <.01); JL (rho = .35; p <.01); %JL (rho = .39; p <.01); PPL (rho = .34; p <.01).

Discussion

This is the first descriptive observational study to analyze activity profiles within modern professional boxing in different categories to analyze possible indicators of victory as well as differences in activity between different weight classes. The most important findings of this study are that the types of power punches are a determining factor to be victorious in these events, since they have greater validity in the event of judging decisions, unlike amateur boxing, where the jab is considered a more frequent and precise punch (Kruszewski et al., 2016). These discrepancies could be attributed to conditioning factors of the event in question (McCrory et al., 2012). It is also observed that the winning fighters develop a greater activity profile in the actions carried out and that they also have greater precision in their punches.

The boxers threw an average of 443.93 TPT and conceded a total of 26.34% PL during the fight, with PPT being the most-used punches (248.79) and more accurate to land in the valid scoring zone (34.95% PPL) compared to the jabs (195.12 JT and 15.96% JL). These values are somewhat heterogeneous (Finlay, 2022), with 320.1 TPT, 34.6% PL, who agrees with other studies on amateur boxing (Kruszewski et al., 2016) in which it is stated that the punches most used by boxers are the jabs, with a total of 53.8% of the punches thrown, but which is in agreement with our work that power punches are more accurate compared with jabs with averages of 42.4% PPL and 27.9% JL respectively. These differences might be caused by the fact that the cited study was carried out only with the heavyweight category, since these works were not homogeneous with respect to the categories analyzed (Thomson, 2015). In addition, Table 2 indicates that the fights usually end in the 8.46 round, so this could be another reason why the results differ, since fights in professional boxing can range from 1 to 12 rounds, depending on how they end (Bianco et al., 2013).

Descriptively, the fighters throw an average of 50.81 AVG PTxR, of which a total of 13.62 AVG PLxR land in the scoring zone, with AVG PPTxR being the most-used punches (28.52) and those that land the most in the valid zone (10.00 AVG PPLxR) compared to jabs (22.29 AVG JTxR and 3.61 AVG JLxR). These are somewhat unequal results compared to the only study of these characteristics with professional boxers and in which no differences stood out between Jabs and Power Punches during the rounds, with 37.6 AVG PTxR and 13.3 AVG PLxR (Finlay, 2022), and with studies in amateur boxing with figures ranging between 63 and 82 punches thrown and 10 and 23.6 PLxR (Davis et al., 2015, 2018; Dunn et al., 2017; Puchol & Caparrós, 2020). These differences could be attributed to the diversity of categories analyzed (Puchol & Caparrós, 2020) and activity strategies with varied performance objectives common in amateur boxing (Dunn et al., 2017; Halperin et al., 2019).

Differences between categories

Regarding the possible discrepancies between categories, significant differences are observed in many of the variables studied apart from: %PL, %JL, %PPL and AVG JLxR. This suggests that in all categories, the accuracy percentage in the types of punches is similar to the punches that are thrown during the fight and the average number of Jabs landed during the round is also similar, since they are punches used to set the rhythm of fight, not so forceful and of a preparatory nature for other punches (Pic & Jonsson, 2021). On the contrary, the same does not occur with AVG PPLxR, since the impact force that is produced is not identical for the different weight categories (Pierce et al., 2006).

Although the boxers in the LW category didn't turn out to be the ones with the highest activity records regarding the variables analyzed, they were the ones who completed

the most rounds during the fight (9.82). When comparing their numbers with BW, the category that fought fewer rounds (5.33), their low records can be justified with respect to the average magnitudes in many of these variables during the fight (TPT, TPL, AVG PTxR, JT, JL, PPL, PPT), although also in round (AVG PTxR and AVG JTxR). The SFLW category is also the one with the most activity in some of the variables, apart from: %PL, %JL, %PPL, AVG PPTxR and AVG PPLxR, and the second in number of rounds completed (9.79).

Differences between weight categories are common in combat sports, in other disciplines such as Judo (Batista et al., 2022), Taekwondo (Bridge et al., 2011) Muay Thai (Podhurskyi & Pavlenko, 2021) or Mixed Martial Arts (Kirk, 2018) technical and strategic differences have been demonstrated. In this sense, it could be intuited that one of the criteria upon which it is coherent to base the training prescription could be weight category (Thomson & Lamb, 2016), although not before considering situational roles (Hristovski et al., 2006), precompetitive pressures (García Pazmiño et al., 2018) and other relevant factors such as general physical conditioning and, especially, lower body work (Lenetsky et al., 2020), which requires more than half of the round through so-called footwork (Puchol & Caparrós, 2020). This shows that boxing is a multi-factorial sport, like many other sports disciplines (Hughes & Bartlett, 2002).

Differences between winners and losers

The significant differences between winners and losers (Table 3) enables the assessment that in most of the boxing actions carried out by the winners, their average is higher in relation to the losers. Winners have a higher activity profile of punching actions during the fight and during the round. These results coincide with most of the previously analyzed studies, in which the total number of punches thrown during the fight and during the round was higher in winners than in losers (Finlay, 2022). Winners also tend to have a higher average number of punches landed in the scoring zone due to their higher activity profile, as indicated in amateur boxing studies (El Ashker, 2011; Puchol & Caparrós, 2020) and other striking sports with similar results (Ouergui et al., 2013). To win in boxing competitions, the ability to maintain a high number of punches during the fight is required (El Ashker, 2011).

Finally, possible relationships between certain variables that could define the profiles of world champions and victory are observed. Four variables stand out from the others: %PL (rho = .63), AVG PLxR (rho = .59), AVG PPLxR (rho = .51) and %PPL (rho = .67), and would reinforce the idea that the higher the proportions, the greater the boxer's performance and the more likely he is to win a fight. It is observed that the winners have a better punching accuracy average during fight (31.84% PL) than the losers (20.84% PL), obtain greater precision in relation to Power Punches, 106.84% PPL and 64.97 PPL% respectively, and achieve also better activity results during the round. At the same time, the winners take more punches during the

round (13.31 AVG PLxR) than the losers (7.81 AVG PLxR) and also obtain better results when it comes to Power Punches Landed, with 10.00 AVG PPLxR and 5.72 AVG PPLxR respectively, confirming the importance of precision during these events (El Ashker, 2011; Puchol & Caparrós, 2020) and that possibly these results are due to a more precise physical preparation (Santos-Junior & Franchini, 2021).

Table 3.
U Mann Whitney Test for analysed variables. Difference between winners and losers.

	W	p	Rank-Biserial Correlation	95% CI for Rank-Biserial Correlation	
				Lower	Upper
TPT	59729.5	< .01	.16	.07	.25
TPL	74220	< .01	.45	.37	.51
%PL	88426	< .01	.72	.68	.76
AVG PTxR	67599	< .01	.32	.23	.39
AVG PLxR	86345	< .01	.68	.63	.73
JT	60839.5	< .01	.18	.1	.27
AVG JL.ROUND	77871.5	< .01	.52	.45	.58
AVG JTxR	66215	< .01	.29	.2	.37
JL	72043	< .01	.4	.33	.47
% JL	74375.5	< .01	.45	.37	.52
AVG PPLxR	81782.5	< .01	.59	.53	.65
PPL	71856	< .01	.4	.32	.47
AVG PTxR	63007.5	< .01	.23	.14	.31
PPT	57804	<..01	.12	.04	.21
%PPP	90908.5	< .01	.77	.73	.8

Notes: CI = 95% Confidence Interval

Despite the consistency of the results obtained in this study, it has some limitations. The punching numbers scarcely distinguished between offensive actions without considering the defensive actions, as in previous amateur boxing studies (Puchol & Caparrós, 2020). They only differentiated between the types of jab and power punches, and did not include others such as hooks and/or uppercuts (Finlay, 2022), for example. Nor was it possible to obtain results of temporary parameters during the round (Slimani et al., 2017), such as footwork time, among others (Puchol & Caparrós, 2020). Although the results show world champion profiles, this is not a guarantee of success since in combat sports, fighters are continually adapting to the opponent's behavior and demands (Krabben et al., 2019). Finally, a larger sample would be needed in other categories to reinforce the study. It should be noted that there are profiles in which less data was considered, since boxers in certain categories may be too young for professional boxing (Tasiopoulos & Nikolaidis, 2022), so they offer a limited registry base.

Conclusions

Successful fighters in modern boxing have a high activity profile and good punching accuracy, with %PL, AVG PLxR, AVG PPLxR and %PPL standing out for their relationship to victory. The fighters of the different weight classes have a homogeneous average precision of punches thrown, with the exception of power punches in the round, which could suggest that the impact force produced may be a determining factor in the different weights. These results would provide some indicators that would help to adopt performance strategies for these categories in question.

Practical applications

The definition of boxing profiles would indicate the rhythms of punching activity with respect to offensive actions during the fight as well as during each round. Through observational ecological analysis, specific aspects of boxing events and boxers can be distinguished and identified with the aim of supporting coaches as well as fighters in terms of improving sports performance.

Compliance with ethical standards

This article did not receive any sources of financial support. This article does not contain any studies with human participants or animals performed by any of the authors.

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