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Diferencias en el rendimiento de los toreros durante una corrida de toros. ¿Tiene el comportamiento del toro influencia directa en las variables que determinan la actuación de los toreros profesionales? Differences in the performance of bullfighters during a bullfight. Does bull behavior have direct influence on the variables determining professional bullfighter's performance?

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Resumen. El objetivo del estudio fue analizar sí las variables fisiológicas y de tiempo de movimiento de los toreros son diferentes en cada uno de los toros lidiados durante una corrida de toros profesional. Para ello, se utilizaron pulsómetros para registrar los parámetros de frecuencia cardiaca y GPS para el registro de velocidades y distancia recorrida de tres toreros durante la lidia de seis toros (n = 6). Los resultados hallados muestran que variables de rendimiento como la frecuencia cardiaca máxima (P <0.001; CV = 53.55%), TRIMPS (P = 0.006; CV = 53.55%), distancia total recorrida (P = 0.001; CV = 26.45), Velocidad media (P = 0.001; CV = 26.45) son diferentes en cada toro debido a la variabilidad en el comportamiento del toro durante la lidia, la cual aumenta conforme aumenta la intensidad. Al mismo tiempo, la frecuencia cardiaca media alcanzada por los toreros durante la lidia, pese a ser diferente en cada uno de los toros (p <0.001), presenta un coeficiente de variación del 4.24%, lo que significa que los parámetros de frecuencia cardiaca media son homogéneos, pudiéndose establecer indicios de que la frecuencia cardiaca media de los toreros se encuentra dentro del intervalo de confianza (143.61, 169.06). Nuestros hallazgos podrían ayudar a los preparadores físicos y a los investigadores a conocer mejor el contexto del toreo desde el punto de vista del rendimiento deportivo.
Palabras claves: Toros, rendimiento, frecuencia cardiaca, variabilidad, toreros.

Abstract. The aim of the study was to analyze whether the physiological variables and movement time of bullfighters are different with each bull fought during a professional bullfight. For this purpose, heart rate monitors were used to record heart rate parameters and GPS to record the speed and distance traveled of three bullfighters during the fight with six bulls (n = 6). The results found show that performance variables such as maximum heart rate (P <0.001; CV = 53.55%), TRIMPS (P = 0.006; CV = 53.55%), total distance traveled (P = 0.001; CV = 26.45), average speed (P = 0.001; CV = 26.45) different with each bull due to the variability in the behavior of the bull during the fight, which increases as the intensity increases. At the same time, the average heart rate achieved by the bullfighters during the fight, despite being different with each of the bulls (p <0.001), presents a coefficient of variation of 4.24%, which means that the average heart rate parameters are homogeneous. It is possible to establish indications that the average heart rate of the bullfighters is within the confidence interval (143.61, 169.06). Our findings could help physical trainers and researchers better understand the context of bullfighting from the point of view of sports performance.
Key words: Bull, performance, heart rate, variability, bullfighter.

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Introduction

In recent years, the monitoring of physiological and mechanical demands in sport has gained great interest in scientific literature (Harper et al., 2019; Spyrou et al., 2020). Researchers, coaches and physical trainers monitor heart rate and variables related to movement, so that they can obtain information about the physiological and mechanical demands of the athlete in training and competition environments (Akarçeşme et al., 2022; Canário-Lemos et al., 2023). In this way, relevant information is obtained to be able to know the context and program the training in a more individualized way, considering movement time variables (Minghelli et al., 2019), heart rate (HR) values achieved and the time at different intensities of exercise (Teixeira et al., 2021).

The scientific literature related to the monitoring of physiological and mechanical variables in bullfighting is very scarce. Bullfighting is an activity that requires an optimal level of physical condition (Reyes, 2004; Zafrillas et al., 2015;Teba del Pino et al., 2024). The physical condition of the bullfighters seems to contribute to reducing the emotional stress, as well as increasing their safety when carrying out the activity (Reyes, 2004). Furthermore, low levels of physical fitness could lead bullfighters to poor performance during the bullfight, increasing the risk of physical injuries, and even death (Reyes, 2004; Negro Peral et al., 2006).

Bullfighting or the activity of bullfighting involves the intelligent use of all the unforeseen and spontaneous reactions of the bull (Del Moral, 2009), through a good understanding of its reactions through technical-artistic actions carried out by the bullfighter. These unforeseen actions of the bull could be established as a principle of determining uncertainty in the performance of the bullfighters. In the case of bullfighting, this uncertainty and variability is mostly caused by the fighting bull (Del Moral, 2009), because the different specimens have irregular behavior, making it very difficult to predict, even if their livestock is known. (Del Moral, 2009). The variability of bullfighting activity derived from uncertainty, as happens in many sports (Rampinini et al., 2007; Alvarez Medina et al., 2019; Branco et al., 2023), requires optimal physical preparation by part bullfighter (Reyes, 2004).

At the same time, as the behavior of each bull is different, so too are the ways each bullfighter responds to these stimuli, which is influenced by variables such as experience, knowledge, gender, customs, type of training, etc. Thus, the individualized physical preparation of the bullfighter is

of special importance (Reyes, 2004; Teba del Pino et al., 2024). Therefore, the purpose of the study was to determine if the performances of the bullfighters differ with each of the bulls fought during a bullfight.

Material and method

Participants

The study participants were three professional bullfighters (age: 29.3 ± 5.5 years old; height: 181.7 cm ± 3.51; body mass: 73.7 kg ± 3.21). Participants were notified about the study design, as well as its objectives and possible risks. Before starting the study, all participants gave their consent. The study was approved by the University Research Ethics Committee and conformed to the recommendations set forth in the Declaration of Helsinki.

Physiological Profile: Heart Rate

The physiological profile of the bullfights was measured based on HR, recording it every 5 seconds using a telemetric device (Polar Team Sport System, Polar Electro Oy, Finland). The intensity of physical activity was measured from maximum heart rate (HRmax), obtained through the Tanaka equation (208-(0.73*age)). The percentage of HRmax (%HRmax) and average HR (HRmean) was recorded for the six bulls. HR was classified according to the total time that each bullfighter was in a certain intensity zone during each bull's fight. The zones were: >70% HRmax, >80%HRmax and >90%HRmax. Another variable added to the physiological profile of the bullfighters during the fight was the TRIMPS (Training Impulse) through the Edwards method. Edwards's method, based on HR, integrates the total volume of the training session with the total intensity of the exercise session relative to five intensity phases. The exercise score obtained while fighting each bull and the whole bullfight was calculated by multiplying the accumulated duration in each HR zone by a multiple associated to each zone (50% to 60% HRmax = 1; 60% to 70% HRmax = 2; 70 to 80% HRmax = 3; 80% to 90% HRmax = 4; 90% to 100% HRmax = 5) and the result was obtained by adding all the data. Using this method, the internal load (ITL) was measured, that is, the physiological stress of the bullfighter caused by the demands of the fight.

Time Motion Analysis

Movement patterns were measured using a GPS, with a sampling rate of 15 Hz (GPSports, GPSports Systems). The recorded data was downloaded to the PC and analyzed using GPSports Team AMS (GPSports Systems, 2006). Three zones were established to group the distance traveled according to the travel speed: Zone 1 = 0-6 km/h-1, Zone 2 = 6.1-14 km/h-1, Zone 3 = >14 km/h-1, total distance traveled (TD), maximum speed (Smax) and average speed (Smean) during the six bulls fought during the bullfight. Three zones were established for the accelerations carried out during the six bulls: Zone 1 = 0.5-1 m/s-2, Zone 2 = >1-2 m/s-2 and Zone 3 = >2 m/s-2.

Result

The statistical analysis shows significant differences between the six bulls in the following variables: HRmax ($p < 0.001$; CV = 53.55%), %HRmax ($p < 0.001$; CV = 7.76%), HRmean ($p < 0.001$; CV = 4.24%), >70% ($p = 0.005$; CV = 50.20%), >80% ($p = 0.004$; CV = 48.78%), >90% ($p = 0.017$; CV = 69.14%) and TRIMPS ($p = 0.006$; CV = 53.55%) for a 95% confidence interval. (See table 1)

Table 1.
Comparative of the HR variables of the bullfighters during the bullfight.

		Mean ± SD	CI	CV (%)	P-value
HRmax (bpm)		184.83 ± 10.55	(173.76, 195.91)	53.55	< 0.001*
%HRmax		97.4 ± 4.11	(93.09, 101.71)	7.76	< 0.001*
HRmean (bpm)		156.33 ± 12.13	(143.61, 169.06)	4.24	< 0.001*
>70%	mm:ss	20:22 ± 10:13	(10:38, 31:10)	50.20	0.005*
	%	83.51 ± 8.6	(74.91, 92.11)		
>80%	mm:ss	16:34 ± 8:04	(8:09, 25:05)	48.78	0.004*
	%	68.46 ± 12.56	(55.9, 70.02)		
>90%	mm:ss	6:42 ± 4:37	(2:24, 11:56)	69.14	0.017*
	%	31.98 ± 23.21	(8.77, 55.19)		
TRIMPS		91.83 ± 49.18	(40.22, 143.44)	53.55	0.006*

P*< 0.05; SD = Standard Deviation; CI = Confidence Interval; CV = Coefficient of Variation; HRmax = Maximum heart rate; %HRmax = percentage of HRmax; HRmean = average heart rate; 70% = time that the bullfighter was above 70% HRmax; 80% = time that the bullfighter was above 80% HRmax; 90% = time that the bullfighter was above 90% HRmax; TRIMPS = Training Impulse.

The statistical analysis of the results obtained in the analysis of the bullfighters' movement time shows significant differences in the distance traveled variables: TD ($p = 0.001$; CV = 12.20%), Zone 1 ($p < 0.001$), Zone 2 ($p = 0.017$; CV = 70.03%). In the speed variables: Smax ($p < 0.001$; CV = 23.39%) and Smean ($p < 0.001$; CV = 19.36%). In acceleration variables, the following results were obtained: Zone 1 ($p = 0.001$; CV = 52.73%), Zone 2 ($p = 0.006$; CV = 37.50%) and Zone 3 ($p = 0.028$; CV = 79.80%), for a 95% confidence interval.

Table 2.
Comparative of the HR variables of the bullfighters during the bullfight.

		Mean ± SD	IC (95%)	CV (%)	P-value
Displacement distance (m)					
DT (m)		628.01 ± 229.84	(386.82, 869.22)	12.20	0.001*
Zona 1 (0-6 km/h^{-1})	m	491.63 ± 130.06	(355.15, 628.12)	26.45	<0.001*
	%	80.57 ± 8.10	(72.06, 89.07)		
Zona 2 (6.1-14 km/h^{-1})	m	125.03 ± 87.55	(33.14, 216.92)	70.03	0.017*
	%	18.18 ± 6.45	(11.41, 24.95)		
Zona 3 (>14 km/h^{-1})	m	13 ± 18.23	(0, 32.13)	140.21	0.141
	%	1.8 ± 1.74	(0, 3.63)		
Speed (km/h^{-1})					
Smax		15.65 ± 3.61	(11.85, 19.44)	23.39	<0.001*
Smean		1.91 ± 0.15	(1.53, 2.30)	19.36	<0.001*
Acceleration (m/s^{-1})					
Zone 1 (0.5-1 m/s-2)		29.67 ± 15.64	(13.25, 46.08)	52.73	0.001*
Zone 2 (1-2 m/s-2)		13.67 ± 5.12	(8.29, 19.05)	37.50	0.006*
Zone 3 (>2 m/s-2)		4.67 ± 3.72	(0.76, 8.57)	79.80	0.028*

P*< 0.05; SD = SD = Standard Deviation; CI = Confidence Interval; CV = Coefficient of Variation; TD = total distance traveled; Smax = maximum speed; Smean = average speed; Zone 1 = Accelerations carried out between 0.5-1 m/s-2; Zone 2 = Accelerations carried out between 1-2 m/s-2; Zone 3 = accelerations greater than 2 m/s-2.

Discussion

The purpose of the study was to determine if the

performance of the bullfighters is different in each of the bulls fought during a bullfight. After the statistical analysis, the null hypothesis is accepted, because the physiological variables and the variables related to movement time were different in each of the bulls. With this finding, we could say that the bull has a high influence on the physiological demands and the characteristics of the bullfighter's movement time during the fight, increasing the degree of uncertainty because the bullfighter will not be able to foresee the physical demand necessary to be able to successfully fight the bull. Regarding uncertainty, Reyes (2004) defined bullfighting as a physical activity that, given its non-systematic, intermittent and irregular nature, bullfighters had to carry out unforeseen but protocol actions. Negro Peral et al., (2006) stated that bullfighters are subjected to a psychological-cognitive effort where they must carry out a physical-artistic activity in collaboration with an animal with unpredictable reactions, where at the same time, the bullfighter risks his life. The findings of the present study could explain that the unforeseen actions that condition the individual performance of the bullfighter on each bull or in other words, the uncertainty generated by the activity of bullfighting itself may be due to the interaction between the bullfighter and the bull. Therefore, the bull could have a direct influence on the bullfighter's performance during the fight, as well as on the physiological demands and movement time.

One of the most important observable physiological variables that is closest to the physiological tension experienced by the bullfighter during the activity is HR (Reyes, 2006). In the present study, the mean HR of the bullfighters during the fight was 156 ± 12.13 hpm. The statistical analysis showed that the HRmean achieved was different in each of the bulls fought ($P < 0.001$), at the same time a reduced variability was observed obtained through the coefficient of variation (CV: 4.24%). With these results we could say that the behavior of the bull has a high influence on the HRmean of the bullfighters during the fight. At the same time, the HRmean did not suffer variations and the HRmean achieved by the bullfighters while fighting a bull in the bullring could be established in the confidence interval (CI) established in the present study.

Zafrillas et al., (2015) recorded data on HRmean achieved by a bullfighter during 24 different bullfights, establishing an HRmean of 164 hpm. These data are within the CI reached in the present work (145.89, 170.78). Teba del Pino et al., (2024) show in their study that the average HR reached by the bullfighter during a bullfight was 159 ppm, an intensity that is also within the IC achieved in the present study. However, the results of HRmean (175 ppm) achieved by the bullfighters in the study carried out by Reyes (2004) do not resemble the results obtained in the present study. The work of Reyes (2004) was carried out with a total of 12 bullfighters of different levels of experience (novilleros without picadors, novilleros with picadors and bullfighters, which could influence the average value obtained for the HRmean variable, since the Cardiac activity could be greater in young bullfighters (novilleros with picadors and novilleros without picadors) than in professional bullfighters with more experience.

At the same time, the HRmax achieved by the bullfighters was 185 ± 10.55 hpm. After statistical analysis, it was discovered that HRmax was different in each of the bulls ($P < 0.001$). Furthermore, the statistical analysis showed a CV of 53.55%, which shows that there is a high variability in the HRmax achieved by the bullfighters and this is subject to the behavior of the bull. However, the %HRmax achieved shows significant differences in each bull ($P < 0.001$) but presents low variability (CV: 7.76%). Which could mean that the individual HRmax achieved by each bullfighter is different in each bull, at the same time that %HRmax recorded in the present study could represent the %HRmax that bullfighters achieve during the fight of a bull. The results achieved in the study carried out by Teba del Pino et al., (2024) show that the bullfighter reached 96.4% of HRmax, data similar to those obtained in the present study. However, the results obtained do not agree with those of Zafrillas et al., (2015), who show that the bullfighter reaches 89.6% of HRmax during a bullfight, data lower than those obtained in the present study (97.4% HRmax). This difference could be due to the design of the study, where Zafrillas et al., (2015) analyzed the HR responses in the same bullfighter, while the present study was based on the cardiac response of three different bullfighters.

The time that the bullfighters accumulated at submaximal intensities of HR, intensities at >70% ($P = 0.005$; CV: 50.20%), >80% ($P < 0.004$; CV: 48.78%) and >90% ($P < 0.017$; CV: 69.14%), show significant differences and great heterogeneity in the values of the HR variables studied. This fact could be due to the fact that HR at submaximal intensities is influenced by factors such as physical condition, level of fatigue, accumulated fatigue, environmental conditions and nutritional factors (Naranjo et al., 2014), variables not controlled in the present study, and which could explain both the high variability and the dispersion of the data with respect to the mean. Therefore, the time that bullfighters carry out the activity of bullfighting at submaximal intensities of HRmax is different for each bull.

Regarding movement time, the results of the study show that in variables such as the distance traveled in Zone 2 ($P = 0.017$) the accelerations in Zone 1 ($P = 0.001$), Zone 2 ($P = 0.006$) and Zone 3 ($P = 0.028$), TD ($P = 0.001$), Smax ($P < 0.001$) and Smean ($P < 0.001$), show significant differences between bulls. This means that movement time variables are different for each bull and that the bullfighter has to adapt to the bull's demands. However, we can observe that some variables such as TD (CV: 12.20%), Smax (CV: 23.39%) and Smean (CV: 19.36%) show homogeneity in the data set. While variables such as the distance traveled in Zone 2 (CV: 70.03%), the accelerations in Zone 1 (CV: 52.73%), Zone 2 (CV: 37.50%) and Zone 3 (CV: 79.80%) show heterogeneity in the data set. This means that the TD, Smax and Smean achieved by the bullfighters analyzed could be closer to reality. On the other

hand, the high variability in the acceleration zones could explain that the accelerations that the bullfighter performs during the fight are subject to the behavior of the bull and the same accelerations are not always performed with each bull. Due to the lack of data regarding the variability in the characteristics of the movement time of professional bullfighters in the scientific literature, the discussion of this section is carried out with studies referring to different sports. The results shown by Casterllano & Blanco-Villaseñor (2015) and Rampinini et al., (2007) show that as the soccer players' movement speed increases, the variability is greater, showing a greater coefficient of variation. These results are similar to those obtained in the present study, where the coefficient of variation was lower in the meters traveled at a lower speed (Zone 1 = 26.45%) and increased as the speed increased (Zone 2 = 70.03%). Therefore, it could be said that movements made at a speed greater than 6.1 km/h are subject to the variable behavior of the bull.

Because the behavior of each bull is different, irregular and modifiable depending on the performance of the bullfighter (del Moral, 2011), the ITL of the bullfighters after the fight of each bull could be different. The results of the study show significant differences in the TRIMPS accumulated by each bullfighter after fighting a bull (P = 0.006). Furthermore, the statistical data obtained from the TRIMPS in the present study show a CV = 53.55%, representing the heterogeneity and dispersion of the data with respect to the TRIMPS mean of the six bullfighters analyzed. This fact could establish that the training load is different in each bullfighter and in each bull fought. In the context of bullfighting, there are no studies in the scientific literature to compare the results obtained in the present study. Therefore, we compare our results with those obtained in other contexts. Oliva Lozano et al., (2022) show significant differences in the performance and training load of professional soccer players depending on the level and characteristics of the opponent.

Conclusions

This study showed that the performance of professional bullfighters could be determined by the unpredictable behavior of the bull. Behaviors that directly influence the activity of the HR, as well as the movement time of the bullfighters during the fight. The HRmean and %HRmax parameters achieved by the bullfighters are different in each bull, but due to the low variability of the data when observing the CV of 4.24% and 7.76% respectively. With which, we could establish that the mean HR of the bullfighters during the fight with a bull range between 145.89 bpm and 170.78 bpm with a CV of 4.24% and the HRmax represented by the %HRmax ranges between 93.09% and 101.71%. of HRmax. The results of this study will allow greater knowledge of the context of bullfighting on foot from the point of view of physical performance, as well as carrying out more specific physical preparation for the activity of bullfighting.

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