



Effect of Lidia bulls training on the falling syndrome and the physical activity developed during the show

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Abstract

Aim of study: The aim of this work was to study the effect of different length of physical activity carried out by the bull prior to the show during the final performance of the animal, analyzing the behavior and physical activity displayed in the ring.

Area of study: There is no clear scientific evidence of physical capacity improvements during the lidia show or “corrida”, in Lidia cattle, as a result of previous training.

Material and methods: A total of 233 bulls from eight farms were studied and classified, on each farm, into three groups according to the length of the training period: group 1 (no training), group 2 (training for 3 months prior to the show) and group 3 (training for 6-9 months prior to the show). Locomotion times or percentage of time the animals moved were quantified, and number of falls, their severity and distribution during the show were registered.

Main results: Trained animals performed last phase of the “corrida” show with a significantly longer length compared to untrained animals. Furthermore, they remained longer in motion during the initial phase of the “corrida”. However, trained animals experienced more falls of type 1 and 2 during the last phase (“muleta”).

Research highlights: A training period of up to 3 months before the show is positive, providing animals a greater physical performance, improving the quality of the lidia show. However, longer training periods over 3 months prior to the show, can negatively affect the performance of these bulls during the “corrida”.

Additional key words: on farm workout; exercise performance; bullfighting; fall types.

Authors' contributions: Designed the experiments and supervised the work: VRG, MEA. Performed the experiments: JML, MEA. Analysed the data: MEA, JML, FE. Wrote the paper: JML.

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Introduction

The Lidia bull is the essential protagonist in festivities that occur in many of the municipalities of Spain, Portugal, southern France, and several countries in Latin America, constituting an important cultural and socio-economic reality, as a popular spectacle. The use of this cattle is based on the development of a certain behavior called “bravura” (Domínguez-Viveros *et al.*, 2018), which entails physical effort of the animal varying in intensity depending on the different parts of the show.

The bull performance during the lidia show or “corrida” can be described as a continuous exercise with different phases of varying intensity. Throughout the show the bull goes through exercise of different intensity. During the

first stage of the “corrida” the physical exercise is of high intensity and anaerobic nature (for about 5 min). During the second phase of the show, the bull performs a physical exercise of a medium intensity and for a short length. The last part of the lidia show demands an exercise of aerobic nature and low intensity for about 10 min (Agüera *et al.*, 1998; García-Scheider, 2008). The Lidia bull is not adapted to this kind of physical activity due to its physiological characteristics (Picard *et al.*, 2006; Escalera-Valente *et al.*, 2013) and often experiences falls in the ring (Lomillos *et al.*, 2018). These symptoms of lack of strength has been collectively called “falling syndrome” (Alonso *et al.*, 1995a,b,c,d) and it has concerned different authors for more than a century (Orensanz, 1950; Jordano & Gómez-Cárdenas, 1954a,b).

In recent years, many farmers have tried to alleviate this problem by conducting a physical training plan in the year prior to the show, through which the bulls are subjected to moderate-intensity runs along trails set up on the farm, driven by horse riders (Lomillos *et al.*, 2013).

In horses, it is well known that training increases the capacity of an individual to perform physical exercise (García *et al.*, 1999; Gómez *et al.*, 2004). There is not enough scientific evidence of physical capacity improvements as a result of training in Lidia cattle (Picard *et al.*, 2006; Requena, 2012). It is therefore unknown whether the aforementioned training is beneficial for the animal taking into account the characteristics of the effort involved in bull's performance during the "corrida" (Escalera-Valente *et al.*, 2013). The type and length of physical exercise which would be optimal, it is also unknown.

Considering the general hypothesis that training on the farm would be beneficial for the performance of the bulls in the ring, the aim of this work was to study the effect of different length of physical activity carried out by the bull prior to the show during the final performance of the animal, analyzing the behavior and physical activity displayed in the ring, classified into four periods of the lidia show.

Material and methods

A total of 233 Lidia bulls, four to five years old, were monitored (Table 1). The animals belonged to two different genetic lines used as representative model of the Lidia breed (Cañón *et al.*, 2008): Domecq (112 from 4 farms) and *Atanasio-Lisardo* (121 animals from 4 farms), located in the same area of Salamanca (Castilla y León, Spain) (Rodríguez-Montesinos, 2002). Farms were recruited based on a similar sanitary and food management. Weight and age data were recorded for each bull at the end of the training period. Animals from all the farms were classified into three groups according to the length of physical training carried out: group 1 (no training), group 2

(training for 3 months prior to the show) and group 3 (training for 6-9 months prior to the show).

The training protocol consisted in an exercise every two days of 30 min trotting along 5 km distance, with an increasing intensity and accompanied by two associated periods, warming up (at the beginning) and cooling down (at the end), of approximately 500 meters. The bulls were driven with the help of a horse rider along a specific track for this purpose that was connected to the fences where the bulls were raised.

The behavior of the animals and falls during the lidia show were recorded on video for their further evaluation. The software and methodology described by Sánchez *et al.* (1990 a,b) were used. Six different types of falls were considered depending on the severity of the symptoms undergone by the animal according to the classification of Alonso *et al.* (1995b): (1) contact of the dorsal side of the hoof or joint area with the ground, (2) flexion of the carpal-metacarpal or tarsal-metatarsal joint, contacting or not with the ground, (3) transitory contact with the ground for less than 10 sec, either of the sternum, head, or buttock, (4) lateral or sterno-abdominal *decubitus* lasting less than 20 sec, (5) *decubitus* of the animal (type 4 fall) extends beyond the 20 sec, but without reaching the 120 sec, (6) *decubitus* lasts more than 120 sec.

Number and type of the falls of each animal were registered individually to calculate the frequency and percentage of each type of fall. The "still" and "in motion" times of each animal were measured with a stopwatch to calculate the percentage of time in movement (locomotion time) in each part of the "corrida" and the total percentage in movement.

The lidia show was divided in four parts to study the behavior with greater precision (phase 1: bull entrance to the ring; phase 2: measure of the bull bravery with the horse; phase 3: placement of "banderillas" on the animal; and phase 4: last part with the performance of the bullfighter facing the bull). All data were separately analyzed by phase of the "corrida". The incidence of the falling syndrome (percentage of studied animals which experienced, at least, one fall during the whole lidia show) was calculated.

A statistical analysis of the descriptive variables was carried out for the three groups considered. Normality distribution of each variable was verified using the Kolmogorov-Smirnov test. Analyses of variance (ANOVA) with Tukey test for post-hoc comparison were used for the variables length (min) of the different parts and total show, length (sec) of the time the bulls are in motion during the lidia show and during each part of the show, frequency of total falls and falling types during the lidia show and in each phase. Chi-square tests (χ^2) were used for the locomotion time percentage analyses. All analyses were performed with the IBM® SPSS® statistic version 19.0 package (SPSS Inc., Chicago, USA).

Table 1. Distribution of animals studied and genetic lines among the groups considered.

Group	N	Training length (months)	Genetic line (n)
1	55	0	Domecq (29) Atanasio-Lisardo (26)
2	58	3	Domecq (28) Atanasio-Lisardo (30)
3	120	6-9	Domecq (55) Atanasio-Lisardo (65)
Total	233	-	Domecq (112) Atanasio-Lisardo (121)

Results

Descriptive data

Table 2 presents the average values (\pm SD) of weight and age of the three groups considered in this study. Regarding the weight and age values, there were no significant differences between experimental groups, $F_{(2, 231)} = 0.014$ $p=0.98$ and $F_{(2,231)} = 1.926$ $p=0.14$, respectively.

Length of the different phases of lidia show

Table 3 shows the average length (min) of the complete lidia show and of each phase of the lidia show. The whole length average was 17 min. The time of the phase 1 stand out as the shortest, with only 2 min and 15 sec of average length (13.43% of the total time), while the fourth phase with 8 min and 40 sec represented 51.82% of the total of the show.

We observed significant differences among groups (Table 3) with the trained animals (groups 2 and 3) those lasting longer times during the total "corrida" with no differences between groups in the initial part.

Locomotion and rest times

Table 4 shows the average length (sec) of the time the bulls were in motion during the lidia show and during each part of the show. We observed significant differences

among the groups of trained and untrained animals in the first and fourth phases ($p<0.001$).

The untrained animals developed exercise during the first phase for approximately 10 sec less than the trained animals and their activity during the final phase was considerably lower (about 40 sec), with no significant differences in training length (Table 4). At the same time, we observed the highest percentage of movement at the beginning or the first phase (about 70%), and a progressively decrease with time, up to the fourth phase (about 25%).

Falling syndrome

Frequency of falls

Table 5 shows the falls per type and experimental group with type 1 and 2 being the most common ones (32.59 and 37.90% of the falls, respectively). Significant differences were observed in the frequency of these types of fall among groups, with the group of untrained animals showing the lowest number of falls. For types 1 and 2, the group of bulls trained for at least 6 months (group 3) presented significantly higher number of falls than the groups 1 and 2. On the other hand, type 5 and 6 falls (the most severe) were observed in none of the bulls studied.

Distribution of falls throughout the lidia show

Table 6 shows the average frequency \pm SD of the falls undergone in each part of the lidia show and experimental

Table 2. Average \pm SD of weight and age of Lidia bulls studied at the end of the study by the three experimental groups

	Group 1	Group 2	Group 3	Total
Weight (kg)	540.2 \pm 42.13	541.4 \pm 41.94	541.0 \pm 32.23	540.9 \pm 37.13
Age (months)	52.2 \pm 8.1	51.1 \pm 5.3	50.3 \pm 4.7	50.9 \pm 5.8
n	55	58	120	233

Table 3. Average \pm SD length (min) of the different parts of the show for each experimental groups: 1 (no training), 2 (training for 3 months prior to the show) and 3 (training for 6-9 months prior to the show).

Group	n	Length of 1 st phase	Length of 2 nd phase	Length of 3 rd phase	Length of 4 th phase	Total length
1	55	2.33 \pm 0.72	2.93 \pm 0.94a	2.69 \pm 1.05a	7.78 \pm 2.30a	15.72 \pm 1.25a
2	58	2.35 \pm 0.74	3.24 \pm 0.97b	2.69 \pm 1.10a	9.27 \pm 2.18b	17.55 \pm 1.25b
3	120	2.16 \pm 0.91	2.71 \pm 1.53a	3.12 \pm 1.25b	9.62 \pm 2.03b	17.63 \pm 1.43b
Total	233	2.25 \pm 0.83	2.99 \pm 1.30	2.92 \pm 1.18	8.67 \pm 2.34	16.72 \pm 1.41
<i>p</i>			*	*	***	*

ANOVA and Tukey test for post-hoc comparison among the experimental groups. * $p<0.05$, *** $p<0.001$. Different letters in the same column indicate significant differences ($p<0.05$).

Table 4. Length of movement average \pm SD (sec) and percentage of the periods in movement in the different parts of the show, taking into account the three experimental groups.

Group	1	2	3	Total	<i>p</i>
n	55	58	120	233	
Movement 1 st phase	79.48 \pm 21.28a	98.44 \pm 17.40b	97.50 \pm 18.50b	91.73 \pm 20.83	***
% Movement 1 st phase	57.02 \pm 19.70a	69.52 \pm 18.16b	71.12 \pm 20.88b	68.09 \pm 13.12	***
Movement 2 nd phase	98.32 \pm 50.20	88.24 \pm 36.02	74.63 \pm 34.51	87.23 \pm 41.53	
% Movement 2 nd phase	55.92 \pm 21.32	45.35 \pm 17.28	45.88 \pm 20.75	50.14 \pm 21.47	
Movement 3 rd phase	63.32 \pm 33.74	57.60 \pm 15.65	61.29 \pm 18.26	60.73 \pm 23.78	
% Movement 3 rd phase	39.28 \pm 22.33	35.72 \pm 18.30	32.54 \pm 19.58	34.72 \pm 22.93	
Movement 4 th phase	110.80 \pm 37.73a	150.28 \pm 39.66b	151.00 \pm 39.88b	137.18 \pm 42.97	***
% Movement 4 th phase	24.17 \pm 14.29a	27.02 \pm 15.82b	26.16 \pm 16.02b	26.39 \pm 17.25	***
Total movement	351.92 \pm 99.39	394.56 \pm 60.58	384.42 \pm 55.83	376.86 \pm 76.00	
% Total movement	37.30 \pm 20.55	37.48 \pm 21.02	36.35 \pm 18.69	37.56 \pm 23.17	

χ^2 test (% movement) and ANOVA with Tukey test for post-hoc comparison (length of movement) in the experimental groups. *** $p < 0.001$. Different letters in the same line indicate significant differences ($p < 0.05$).

Table 5. Average frequency \pm SD per fall type^[1] and by the three experimental groups and percentage of Lidia bulls which underwent each type of fall, during the whole lidia show.

Group	n	Fall 1	Fall 2	Fall 3	Fall 4	Total fall
1	55	0.8 \pm 1.2 ^a	0.9 \pm 1.0 ^a	0.6 \pm 0.8	0.2 \pm 0.4	2.5 \pm 2.1
2	58	0.9 \pm 1.3 ^a	0.9 \pm 0.9 ^a	0.6 \pm 1.0	0.1 \pm 0.3	3.2 \pm 2.5
3	120	1.6 \pm 1.6 ^b	1.5 \pm 1.5 ^b	0.9 \pm 1.3	0.2 \pm 0.4	3.5 \pm 2.9
Total	233	1.0 \pm 1.4	1.2 \pm 1.3	0.8 \pm 1.1	0.2 \pm 0.4	3.2 \pm 2.6
%	233	32.59	37.90	23.92	5.45	100
<i>p</i>		**	**			

ANOVA and Tukey test for post-hoc comparison between the three experimental groups. ** $p < 0.01$. Different letters in the same column indicate significant differences ($p < 0.05$). [1] Alonso *et al.* (1995b): (1) contact of the dorsal side of the hoof or joint area with the ground, (2) flexion of the carpal-metacarpal or tarsal-metatarsal joint, contacting or not with the ground, (3) transitory contact with the ground for less than 10 sec, either of the sternum, head, or buttock, (4) lateral sterno-abdominal *decubitus* lasting less than 20 sec, (5) *decubitus* of the animal (fall of type 4) extends beyond the 20 sec, but without reaching the 120 sec, (6) *decubitus* lasts more than 120 sec.

Table 6. Average frequency \pm SD of the falls undergone in each part of the show taking into account the three experimental groups and percentage of animals that underwent some fall in each phase of the show.

Group	n	Falls 1 st phase	Falls 2 nd phase	Falls 3 rd phase	Falls 4 th phase	Total fall
1	55	0.3 \pm 0.6	0.7 \pm 1.0	0.3 \pm 0.5	1.2 \pm 1.4a	2.5 \pm 2.1
2	58	0.3 \pm 0.6	0.7 \pm 0.9	0.4 \pm 0.8	1.9 \pm 2.1b	3.2 \pm 2.5
3	120	0.3 \pm 0.6	0.7 \pm 1.1	0.2 \pm 0.6	2.1 \pm 2.3b	3.5 \pm 2.9
Total	233	0.3 \pm 0.6	0.7 \pm 1.0	0.3 \pm 0.6	1.8 \pm 2.1	3.2 \pm 2.7
%	233	8.67	22.80	10.07	58.60	100
<i>p</i>					*	

ANOVA and Tukey test for post-hoc comparison among the experimental groups. * $p < 0.05$. Different letters in the same column indicate significant differences ($p < 0.05$).

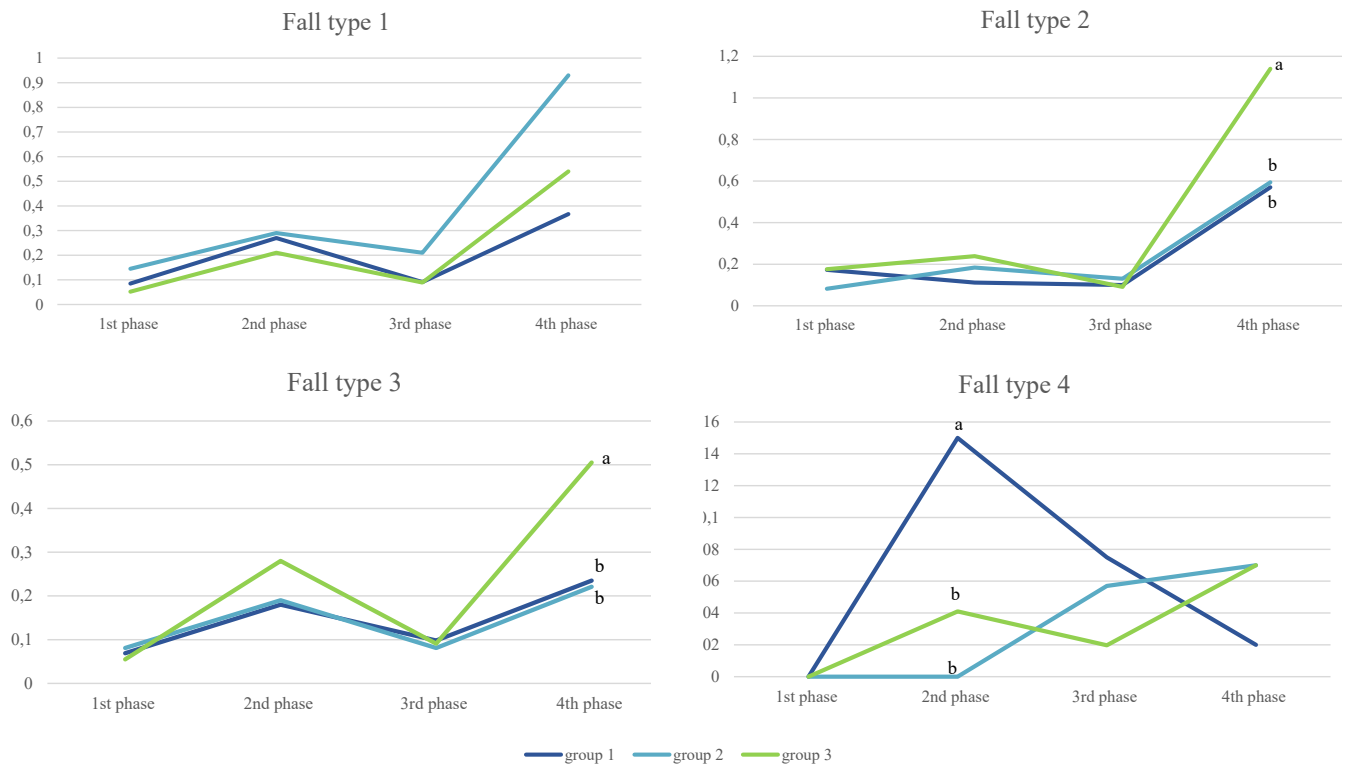


Figure 1. Evolution of the presentation frequency of type of falls 1, 2, 3 and 4 throughout the show. Different letters indicate significant differences in the second and fourth phase among the experimental groups ($p < 0.05$).

groups. Only in the fourth phase were there statistically significant differences between the frequency of falls from the group of untrained animals and the groups of the trained animals. A higher incidence of total falls was observed in the fourth phase of lidia show (58.6% of the total) followed by the second phase (22.8% of the total).

Evolution of the falling syndrome throughout the lidia show

Figure 1 describes the evolution of each type of fall throughout the four phases of the “corrida” by experimental groups. We observed that in the fourth phase, the most numerous falls were those of type 1 and 2. Significant differences were observed in the falls type 2 and 3, in the fourth phase, with the greater value in group 3 (trained > 6 months), in comparison with the rest of the animals.

Discussion

Training on the farm of Lidia bulls had both positive and negative effects which should be considered, reflected as a trend towards a better aptitude for the physical effort that the lidia show or “corrida” entails.

The age and weight of the animals studied did not show any significant differences between the experimen-

tal groups, therefore, these factors can be considered controlled in the study. The animals belonged to the Domecq and Atanasio-Lisardo genetic lines and were used as a model of the Lidia breed due to the fact that these lines represent the majority of all bulls fought in lidia shows in Spain (Lomillos & Alonso, 2017a).

The average length of the lidia show was 16.72 min (Table 2), which agrees with values published before (Sanes *et al.*, 1994; Paniagua, 1997). The fourth phase of the “corrida” registered the longest length, 51.82% of the lidia show time, which reinforces the idea of the predominance of the last phase called “muleta” pointed out in prior studies (Alonso *et al.*, 1995b; Lomillos *et al.*, 2018).

Training on the farms did not lead to longer length of the initial phase, however, significant differences were observed among the experimental groups considering the fourth phase (Table 2; 2 min longer for trained animals). This could be a sign of a worse physical condition in group 1. The fourth phase alternated movements and rest periods that could allow the trained bulls to recover during these rest periods. The circulatory, respiratory and muscular systems of trained bulls accustomed to exercise could cope better with these moments of intermittent exercise compared to untrained bulls. All of this could allow experimental groups 2 and 3 to endure prolonged physical exertion. Agüera *et al.* (2005) published that longer duration of bull training would improve certain parameters associated with exercise physiology. However,

our results did not agree with these authors because there were no significant differences depending on the length of the training period (Table 2).

In phase 1, the animals studied used 68.09% of the total time moving, a value higher than 41% previously published for animals not exercised (Paniagua, 1997). This result indicates a greater mobility and physical capacity of the current bull, compared to the one that was bred 20 years ago. The groups of trained animals (groups 2 and 3) presented percentages of locomotion time in phase 4 significantly higher than those registered in the group of untrained individuals (group 1 = 57.02%, group 2 = 69.52%, group 3 = 71.12%), a fact which reaffirms our hypothesis (Table 3).

The first signs of physical weakness in the Lidia bull is the presentation of falls types 1 and 2 (Alonso *et al.*, 1995b). These slight types may go unnoticed by viewers but they were the most frequently recorded in our study. On the contrary, the most severe symptoms, falls type 3, 4, 5 and 6, which represent an obvious problem for the physical performance of the bull during the lidia show, were less frequent. Only 29.37% of the studied animals presented these types of falls, a result much lower than the 66.57% reported in the 1990s (Alonso *et al.*, 1995c). The nutrition, health and physical training of Lidia cattle have improved in recent years (Lomillos *et al.*, 2018) and all these management strategies are to be reflected in present results.

Taking into account the total number of falls of each group of animals, a higher rate in individuals trained for longer period of time (group 3) was observed, evidencing types 1 and 2 most frequently. A longer locomotion time performed during the “corrida” by Lidia bulls would make them more likely to show signs of overstrain and therefore to undergo falls (Escalera-Valente *et al.*, 2012). This could be the possible cause of this higher rate of falls in the case of the group 3, whose animals developed a longer locomotion times and higher length of fourth phase. During the fourth phase trained bulls make a greater physical effort due to their greater resistance owing to better physical preparation. These animals are physically more active and perform behavioural patterns of greater metabolic intensity reflected in longer locomotion and lidia show times. Our data agree with those published by other authors, who recorded a greater number of falls in bulls that develop longer “corrida” times (Orensanz, 1950; Alonso *et al.*, 1995a).

On the other hand, there is a possibility that training programs carried out on farms cause degenerative joint injuries in animals (Lomillos & Alonso, 2017b). The degenerative joint problems could contribute to a higher rate of falls or an aggravation of the symptoms (Alonso *et al.*, 1995d) in bulls with longer training protocols, as can be seen in group 3 of our work.

Previous studies show a similar trend regarding the presentation of the different types of falls in the diffe-

rent phases of lidia show that increase during the course of the lidia show (Alonso *et al.*, 1995b,c; Bartolomé, 2009; Escalera-Valente, 2011). In our work, taking into account the training of the animals, we also observed how the presentations of falls belonging to the mildest types (degrees 1, 2 and 3) described a progressive and chronological increase in the different phases for all animals. It is the fourth phase where the highest presence of falls occurs (58.60%), agreeing with studies consulted on the incidence of falling syndrome with the fourth phase including more than 50% of the falls (Lomillos *et al.*, 2018). On the other hand, lower numbers of total falls were recorded in the third phase, may be due to the fact that the bull exerts less physical effort, quickly charging in straight line against the bullfighter with short distance sprints followed by recovering breaks between them. The physical effort made by the bulls during the initial phases of the “corrida” takes its toll on in the last phase, thus causing an increase in the frequency of falls (Fig. 1).

However, the presentation of more severe falls (type 4) was recorded differently in untrained animals. In the second phase, the untrained animals (group 1) underwent a significant increase in the number of type 4 falls gradually decreasing in the third and fourth phases. Untrained bulls could find it difficult to perform the phase 2 exercise. This fact could be explained considering that second phase is the moment where the animal uses more anaerobic force charging and pushing the horse. The anaerobic threshold and metabolism of the untrained individuals were possibly lower than that of the trained ones (Paniagua, 1997; Escalera-Valente *et al.*, 2013).

The significant differences in the frequency of type 2 and 3 falls observed between the individuals trained for more than 6 months and the rest of the animals throughout the fourth phase (Fig. 1) remind us that these animals underwent a greater number of falls. As previously mentioned, there may be an effect of the possible articular injuries due to longer training protocols and this should be considered in further studies.

In summary, a training period of at least 3 months before the “corrida” is recommended for the genetic lines Domecq and Atanasio-Lisardo, taking into account the positive effect on the bulls’ physical performance that makes them endure a prolonged lidia show and in the last phase length. They also spend a greater percentage of time in motion during the initial phase of the show, increasing the interest for the spectator and the performance of the bullfighter and improving the quality of the lidia show. However, longer training periods of over 3 months prior to the show, can negatively affect the performance of these animals during the “corrida”. It would be advisable to define the optimal duration, frequency and intensity, as well as to evaluate the effect of training on the physiology of bulls.

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