Original Article

The momentum relationship between rider and horse body parts and their contribution ratios from the total momentum from the take off stage to the double fence jump

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Abstract:

This research has two goals. The first goal is to identify the values of momentum and the total parts of the body of the rider and the horse from take off to the double fence jump stages. The second goal is to identify the sharing ratio of the body parts momentum and the total momentum of the rider and the horse from take off to the double fence jump stages. A camera (Sony) with a speed of 25 images/s and a triple holder were set at a distance of 9 m from the fence. The camera lens was positioned perpendicular to the point of take off stage. The height of the camera was 1.55 m, whereas the height of the fence was 1.125 m. The procedures in the main experiment included the video recording of the three attempts of each rider. The best condition was then chosen based on the least time recorded for fence jumping without hitting or dropping the fence bar. Results showed that the momentum of the horse trunk is part of the total body momentum for the horse and rider because of his huge mass. The momentum of any other part of the rider (arms, legs, and trunk) is not part of the total body momentum of the horse and rider.

Key words: rider and horses, momentum, take off, double fence

Introduction

Fence jumping is a horsemanship activity, which demands a rider to maintain balance and natural control to enable the horse to jump across 14 or more different fences. The rider must concentrate on his horse and complete the jump sequence in four stages, namely, approach, take off, jump suspension, and landing (Clayton et al. 1989). The horse needs to carry its large body and the body of the rider during a jump. The difficulty in this technical stage lies in the ability of the rider and the horse to synchronize their movements during takeoff. The rider and the horse should gain the correct speed during takeoff to obtain the angle suitable for different types of fences and the suitable height at the jump suspension stage. The horse should be at its best strength and speed on land before the take off process, which matches the principle of action and reaction (Muslt, 1991).

The number of movements necessary to perform the take off in double fence events could be analyzed by determining the horizontal and vertical movements of the horse. The vertical movement represents the horse and the rider passing over the fence, whereas the horizontal movement represents the least possible time required to pass over a fence. These movements require increased movement mass by increasing the speed and mass of each body part. The quantity of movement is the result of body mass and velocity (Frederick and Gerd, 1995), whereas velocity is calculated along the path moving each part of the body and the entire mass of the horse and rider. The take-off time, which is stable in each part of the body, is quantified through the number of sharing images in the performance. The effect on the momentum is also different because the ratios of the body mass are different. The importance of this research lies in its attempt to recognize the momentum of each part of the rider and the horse from the total body momentum of each. The take-off stage for the rider and horse over a double fence is the most important and difficult stage because the main orientation to complete the jump should be properly and identically developed within the acceptable standards of the activity. The momentum has special importance because it is one of the main effective factors that influence take-off performance. Compared with mass, velocity has a direct effect on performance, which implies that the moving path has a direct effect on velocity, as shown in many competitions. The researcher observed that the large mass of the horse and its rider affect performance during takeoff in double fence jumping.

This research determines the effect of the moving path of the rider and horse body parts on their momentum and to calculate the sharing ratio effect of these parts from the total momentum of the body.

Methods

The research sample comprises five male riders who participated in the Arab Championships held in Jordan in 2013. The participants were selected purposively, and the sample included five foreign horses. Table 1 shows the height, mass and training age variables of the riders and horses.

Table 1. Height, mass, and training age variables of riders and horses

Sample	Variable		
	Height (cm)	Mass (kg)	Training age (year)
Rider	(165-172)	(65-77)	(4-6)
Horse	(155-162)	(465-515)	(3-5)

The experiment was conducted on a Wednesday at the court the equestrian club and on a Wednesday (23/7/2013) at Jadiriya Baghdad. The camera was installed and distance was established. Each rider was given three attempts to determine the most important needs and the number of specialist teamwork. The experiment conducted a brief summary on a Thursday (24/7/2013) regarding the main experiment. Another three attempts were given to each rider to select the best turnaround time and the best error free performance. A camera (Sony) with a speed of 50 images/s and a triple holder were set at a distance of 9 m and a height of 1.55 m. The distance between the vertical double fence bars are 1 m with a height of 1.25 m and positioned in the approach run at 15 m before the checkpoint. Fig. 1 illustrates the imaging procedures of the experiment.

Fig.1. Position of the camera after the double fence and the individual

Measurements

The real movement path was extracted for each of the body parts and the total body part using a software program (Dartfish Pro Suit 5.5). The camera (Sony) speed was 50 picture/s. The total time was calculated using Dardfish software. Average speed was calculated using the equation, law $x = \text{distance travelled}/\text{time}$ (Al-Samarrie, 1982). The mass of the body parts of the horse is computed using the ratios of parts (head and neck, 10%, trunk, 57%, limb, 14%, and hind limb, 19%) (Springings and Leach, 1986). The mass parts of the rider were calculated using the ratios of the parts (head, 7%, trunk, 43%, arms, 12%, and limbs, 38%) (Omar, 1995). Momentum was extracted using the law of momentum: momentum = mass x speed (Susan, 1999).

Results and discussions

Table 2 shows the correlation values of parts, total momentum, and summation of rider momentum in the double fence jump. Table 3 shows the correlation values among parts, total momentum, and summation of horse momentum in double fence.

Table 2. Correlation values among parts, total momentum, and summation of rider momentum in double fence jump

Variable	Momentum (total)	Momentum (rider)	Head	Arm	Trunk	Legs
Momentum (total)		0.468	0.543	0.472	0.464	0.452
Momentum (rider)	0.468		0.988(**)	0.991(**)	0.999(**)	0.999(**)
Head	0.543	0.988(**)		0.988(**)	0.984(**)	0.982(**)
Fore limb	0.472	0.991(**)	0.988(**)		0.983(**)	0.989(**)
Trunk	0.464	0.999(**)	0.984(**)	0.983(**)		0.999(**)
Hind limb	0.452	0.999(**)	0.982(**)	0.989(**)	0.999(**)	

**at level of error parameter (0.01)

Table3. Correlation values among parts, total momentum, and summation of horse momentum in double fence

Variable	Momentum (total)	Momentum (horse)	Head	Fore limb	Trunk	Hind limb
Momentum (total)		0.951 (*)	0.915 (*)	0.900 (*)	0.967(**)	0.916 (*)
Momentum (horse)	0.951 (*)		0.965 (**)	0.982(**)	0.995(**)	0.972(**)
Head	0.915 (*)	0.965(**)		0.976(**)	0.952(**)	0.904 (*)
Fore limb	0.900(*)	0.982(**)	0.976(**)		0.975(**)	0.920 (*)
Trunk	0.967(**)	0.995(**)	0.952 (*)	0.975(**)		0.954 (*)
Hind limb	0.916 (*)	0.972(**)	0.904 (*)	0.920 (*)	0.954 (*)	

**at level of error parameter (0.01)

* at level of error parameter (0.05)

Tables 2 and 3 refer to the relations between the bio-kinematic variables, the parts of the body, and the total body. The correlation values have good fit between the momentum of part of the body and the total momentum of the horse and the rider. Best performance is accomplished by compatibility, which confirms the finding of (Omar and Khalil, 2007) that movement compatibility exists among the body parts for the horse and the rider to obtain movement (kinetic) technique. Synchronized movement in a single direction for all body parts in fence jumping could gain a large momentum for the rider and horse. Nahi also confirmed that, "It's possible to move the linear and angular momentum from one body to another or from one part to all" (Nahi, 1984). (El-Din, 1998) also confirmed that, "All body part interacts with each other to produce movement" (El-Din, 1998). Table 4 shows the mean and standard deviations of movement path, mass, velocity, and momentum of the body parts of the rider. Figure 2 shows the values of variables, such as movement path, speed, time, mass, and momentum for the body parts of the rider. Figure 3 shows the values of variables, such as movement path, track motor speed, time, mass, and momentum of the body parts of the horse.

Table4. Mean and standard deviations for movement path, mass, velocity, and momentum of the body parts of the rider

Kinematic variable	Statistical variable	Rider				Horses			
		Legs	Trunk	Arms	Head	Hind limb	Trunk	Fore limb	Head
Movement path(m)	mean	1.56	1.58	1.71	1.68	1.13	1.48	2.05	1.84
	Std	1.19	1.54	2.20	2.47	1.14	1.29	2.75	3.65
Velocity (m/s)	mean	6.5	6.58	7.12	7	4.70	6.16	8.54	7.66
	Std	2.87	1.03	1.22	0.98	0.44	1.76	0.82	3.65
Mass (kg)	mean	26.33	29.79	8.31	4.86	92.91	278.73	68.46	48.90
	Std	2.46	2.78	0.77	0.45	3.77	11.31	2.77	1.98
Momentum (kgm/s)	mean	171.14	196.11	59.20	34.02	436.67	1716.97	584.64	374.9
	Std	13.89	15.58	5.25	2.87	29.53	48.35	20.75	10.30

Fig.2. Values of variables, such as movement path, speed, time, mass, and momentum for the body parts of the rider

Fig.3. Values of variables, such as movement path, track motor speed, time, mass, and momentum of the body parts of the horse

Table 4 and figures 2 and 3 show that the highest values of movement path for body parts was 0.10 and 0.92 for each rider and horse, respectively. The time was fixed for all parts. Thus, the speed did not increase significantly because of the movement path lengths. The difference between the highest and the lowest values for the parts of the body was 0.62 m/s and 3.84 m/s). These values did not affect the momentum. The difference is clear between the highest and lowest values (24.93 and 229.03 kg) for the rider and the horse. The impact of mass and a clear increase in momentum by the law (momentum = velocity x mass) was observed (Frederick and Gerd, 1995). Table 5 shows the mean, standard deviation, dimension of the total momentum, and the summation of rider and horse momentum in double fence jumping. Table 6 shows the sharing values of the more important variable between the part momentum and total momentum of rider and horse, parameter value, and (T) value in double fence jumping.

Table 5. Mean, standard deviation, dimension of the total momentum, and the summation of rider and horse momentum in double fence jumping

Variable	dimension	Momentum (rider)	Momentum (horse)	Total rider-horse
Mean	Kg m/s	460.47	3113.18	3573.65
Std		41.92	120.29	134.07

Table 6. Sharing values of the more important variable between the part momentum and total momentum of rider and horse and parameter value and (T) value in double fence jumping

Variable	Correlation	Sharing rates	F- value	Degree freedom		The level of significances
Horse trunk	0.967	0.912	42.561	1	3	0.007
Horse trunk and rider head	0.999	0.998	806.431	2	2	0.01

Table 6 shows the two main variables included in the total momentum. The first variable is the horse trunk, which is associated with the total momentum with a rate of 0.967 and a sharing rate of 0.912. As explained by the horse trunk, the total momentum of 0.92 is a significant rate because the value of counted (F) is less than 0.05. The sharing rate increased to 0.99 when the value for the head of riders was added to the equation. The sharing rate is significant because the value of counted (f) is less than 0.05. The sharing values of other variables did not appear, but they are correlated with other variables, as shown in Tables 2 and 3. Table 7 shows the sharing values of the more important variables between the parts momentum and total momentum of rider and horse and parameter value and (T) values in double fence jumping.

Table7. Sharing values of the more important variables between the parts momentum and total momentum of rider and horse and parameter value and (T) values in double fence jumping

Variable	Beta	T- value	The level of significances
Standard	213.899	87.654	0.007
Horse trunk	2.141	988.67	0.001
Rider horse	20.052	106.994	0.006

Table 7 shows that the two variables are important in predicting total momentum. Increasing the

momentum for the horse trunk (2.141 kg m/s) increases the total momentum by one unit (1 kg m/s), which indicates the importance of the other variables in completing the prediction equation. The change in the total momentum required in the sharing of the rider head is 20.052 kg m/s, which was obtained using the equation, total momentum = constant + horse trunk momentum X2. 141 X rider head momentum X 20.052.

This sharing ratio is attributed to the large trunk mass, which is affected clearly and distinctly by the increase in momentum mass. The value of trunk momentum was 1116.575 kg m/s, which is 1.5 times greater than the nearest part of horse body (the hind limbs). The hind limbs had a momentum value of 750.316 kg m/s, which affected the momentum value. El-Din reported that, "when the property of body is increasing in resistance of movement which is representing in its mass or its velocity is increasing, the movement will increase" (El-Din, 1993).

The merging of the rider head to the horse trunk is attributed to the increase in total sharing. This part of the head of the rider rules the movement, which leads to rider direction and guidance in the movement path. Movement transformation among the body parts will help transform the momentum from the body parts of rider to his head. The prominent effect in sharing ratio was observed after the head of the rider moved close to the horse trunk in total momentum for each rider and horse, which implies that the rider chose the correct path to the goal. (Ali, 1998) confirmed this finding and "stated that any mistake in movement transformation from trunk to other body parts and vice versa or any mistake in head movement guidance will lead to need move extra energy to correct the path and here the correct movement transformation showed that it is one of good economic determinations in emerge of sport skills performance" (Ali, 1998).

The sharing for the rider arms and fore limb in movement path were the greatest effect, but this has no effect on the sharing ratio. The greatest effect was observed on the head of the rider, but the result was ranked second in the movement path beyond the rider arms, which implies that the mass with the greater effect in movement path requires high velocity during takeoff using long movement path.

Conclusion

The momentum of the horse trunk is included in the total momentum of the body for the horse and the rider because of the huge mass of the horse. The momentum of any other part of the rider (arms, legs, and trunk) is not included in the total momentum of bodies of the horse and rider. The momentum of the head of the rider is included in the total momentum if the sharing was necessary to increase momentum. The momentum of the other parts (head, forelimbs, and back limbs) is not included in the total momentum because of the huge mass effect of the horse.

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