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Original Article

Ranking of endurance horses in training based on some selected biochemical and physical parameters

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ABSTRACT

Objective: This study aims to appraise the ranking of endurance horses in training based on some selected biochemical and physical parameters. The increase in skill and gusto in equine endurance sport demands an upsurge in standardized exercise tests and competition to be enforced on endurance sport horses.
Materials and methods: Nine seemingly fit Arabians endurance horses between the ages of 5 and 17 years and with a body weight of 350 and 450 kg were included in the research in Malaysia. We designed a point scale in training based on biochemical and physical parameters of endurance horses for lactate, plasma protein, creatine kinase, heart rate, and rectal temperature.
Results: The results indicated an accumulated lower point of 1 for the biochemical and physical parameters for an individual horse to have an excellent ranking in training and placing in endurance race contrasted with horses that had higher points of 4 to 6. The lower the points, the lower will be the values of the parameters and the higher the points the higher will be the values of the parameters. It is observed that placing in race tally with the ranking in training.
Conclusion: In conclusion, it is observed that placing in race tally with the ranking in training. Therefore, it is suggested that the current ranking system in training could be valid to be used to predict endurance horses' performance in an actual race.

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INTRODUCTION

The growing skill and enthusiasm in equine endurance sport necessitate an increase in training workout and competition to be enforced on endurance sport horses, both globally and at local levels. Conversely, the working out of endurance sport horses is hitherto largely accomplished on the examination of gut sounds. Undeniably, the skills required in the training of endurance horses up till now is in its embryonic stage likened to the modus operandi that is characteristically used in sportspersons. Assessment of fitness level in sportspersons is accomplished using standardized exercise tests (SETs) that are modified for particular sports whereby such parameters as maximum oxygen uptake (VO2max), heart rate (HR), respiratory parameters, blood lactic acid, and maximum power output are checked and in some circumstances, muscle biopsies are also evaluated (Cottin et al., 2010; Fraipont et al., 2012; Ok-Deuk and Yong-Soo, 2017). These assessments can be performed under laboratory conditions. Largely, endurance horse instructors' use GPS furnished with HR monitors to incessantly evaluate HR and velocity during physical training. The modern contrivances even describe the degree of elevations of the landscape on which the training is executed.

SETs are used for endurance horses; nevertheless, information on SETs is ubiquitous. A significant question is which type of SETs applies unsurpassed for endurance horses. Apart from performance ability, there exist the skill factors. Endurance horses require some set of abilities to be able to perform optimally in competitions. Nonetheless, evaluating some physiological parameters such as maximal power output is impossible in endurance horses using some contrivances for evaluating power outputs. Furthermore, gauging VO_2maximum is rather puzzling (Van Erck et al., 2007). In all of these research studies, sportspersons' VO_2max analyzers were applied, which have been modified for usage in endurance equines. Frequently, there is a paucity of scientific confirmation regarding their validation, repeatability, and suitability for use in endurance horses (Franklin and Allen, 2014; Allen et al., 2016; de Mare et al., 2017).

Aerobic and anaerobic exercise tests are the principal means of evaluating endurance horses in the laboratory and in the field. Attaining a rational validity, repeatability, and adequate sensitivity is easier for SETs in the sports ground than on a treadmill for the reason that sports ground method simulates the actual condition, in which the endurance equine requires to participate (Franklin and Allen, 2014; Allen et al., 2016).

The isometrics ability of endurance horses is assumed from the maximum physical strength it can withstand throughout a certain time intermission. Isometrics tests can be utilized to contrast endurance horses, and similarly to check isometrics progression of an endurance horse over a time period. The isometrics ability of an endurance horse is presently appraised by evaluating blood lactic acid levels, velocity throughout SETs, and HR. The frequently used factor is the speed at which the blood lactate concentration reaches 4 mmol/L that is the VLa4 (Davie and Evans, 2000; Adamu et al., 2012; Ok-Deuk and Yong-Soo, 2017) and the speed at which the HR reaches 200 beats per minute is the anaerobic threshold that is the V200. V200 and VLa4 are hypothetically virtually equivalent in fit, properly trained endurance horses, even though V200 is less trainable and HR varies more effortlessly compared to lactate for the reason of psychological prominence or physical anguish. In an inferiorly performing endurance horse, in which case V200 is suggestively inferior compared to VLa4, a subclinical musculoskeletal damage might be assumed. A decline in VLa4, in contrast, is frequently accompanying the respiratory disease. When planning an isometrics testing etiquette, numerous significant physiognomies ought to be observed such as distances and velocity needs to be regulated and ought to be as relentless as conceivable, including path and climatic circumstances, each stage of an incremental isometrics test ought to be protracted to attain a balanced state of the physiological parameters and as a result of lactate flowing out of the muscles to blood, the lactate concentration in blood fluctuates according to the time of sampling which is about 3–5 minutes (Hodgson et al., 2014; Franklin and Allen, 2014; Allen et al., 2016).

For that reason, it is paramount to collect samples at fixed times, steps, and the degree of increment should be standardized. It is indispensable to take into account the age, fitness level, training history, and breed of the horses (Leleu and Cotrel, 2005; Courouce et al., 2002; de Mare et al., 2017; Ok-Deuk and Yong-Soo, 2017). Therefore, the present study aims to appraise the ranking of endurance horses in training based on some selected biochemical and physical parameters. In the current study, it is observed that placing in race tally with the ranking in training. In conclusion, it is suggested that the current ranking system in training could be valid to be used to predict endurance horses' performance in the actual race.

MATERIALS AND METHODS

Nine seemingly hale and hearty Arabians endurance horses between the ages of 5 and 17 years and with a body weight of 350 and 450 kg were included in the research. The body weights were appraised by means of a weighing band. The height of the equines varies between 14 hands 2 inches and 16 hands 1 inch. There was no sex proclivity for equine inclusion in the study, and only seemingly fit horses lacking subclinical contagions were engrossed in the research.

All equines were appraised, and clinical parameters such as body temperature, intestinal motility, capillary refill time, mucous membrane color, and skin recoil were collected prior to the SETs. On arrival from the SETs, blood samples were collected at 0 min and 30 min of recovery time. They were included for the SETs of 30 km training distance. The idea of the study is to rank horses in training based on the best of five parameters-lactate, total plasma protein, creatine kinase (CK), HR, and rectal temperature (RT). Horses undergo 4 weeks of training with one SET at the end of the conditioning program. On arrival from the SETs, blood samples were collected from all the nine endurance horses without cooling. The nine equines included in the study were galloped by riders with body weights between 52 and 70 kg.

All equines were galloped by knowledgeable and talented riders listed under Fédération Équestre Internationale, riders' guideline (AERC, 2006). The SETs of 30 km distance were carried out under ecological settings of the tropical weather (environmental humidity and ambient temperature throughout the 30 km distance were as follows: 29.06°C±1.1°C and 71.73%±4.05%). The humidity and ambient temperature were evaluated by means of handy H1936440N thermohygrometer, Hanna instruments Romania and were documented at an intermission of 30 min throughout the training. The paths used for the SETs were under rubber plantations, palm, dirt paths, and beaches in Selangor of Malaysian peninsular. The topographical landscape was largely uniform and comparatively lacking stony rubbles, however, two watering places were similarly offered at specific sites alongside the path at an intermission of 5 km distance. Blood samples were gotten from all the equines through the jugular vein by the application of 21G needles into a 3 or 5 mL heparinized vacutainer tubing for the analysis of biochemical parameters. The blood was obtained two times from endurance horses on arrival and 30 min of recovery.

The blood sample was analyzed instantaneously in the research laboratory positioned within the buildings of the SETs. The SETs started at 8 AM on the same day the blood sample was obtained. Samplings were carried out affectionately and reliably to safeguard that the procedure could not affect the biochemical variables and the temperament of the individual horses. The plasma biochemical parameters were evaluated using standard diagnostic kits (Roche) with a chemistry analyzer (Hitachi 920).

We designed a point scale in training based on biochemical and physical parameters of endurance horses as presented in **Table 1**, the point scale in training for a lactate concentration between 1.00 and 1.99 mmol/was rated with a point of 1, 2.00–2.99 mmol/L was rated with a point of 2, 3.00–3.99 mmol/L was rated with 3 and continues with the other parameters as shown in **Table 1**.

Statistical analysis: The data were collated and analyzed using descriptive statistics. The data were analyzed using MedCalc Statistical Software version 18.6 (MedCalc Software bvba, Ostend, Belgium; http://www.medcalc.org; 2018). Analyses were considered significant at a P value of <0.05.

RESULTS

Table 2 presented the standardized test of biochemical parameters at 0 and 30 min of post-training. At (0 min, that is the blood lactate concentration of each horse on arrival from the training and also 30 min upon recovery, these two values of each horse were collated and an estimate is taken based on the average of these two values. The mean values translate into the training points of lactate concentration for each horse which ranges between 1 and 6 points for the nine horses. Similarly, the average total plasma protein (TPP) concentration translates into the training points and ranged between 1 and 3 points for the nine horses. Furthermore, the mean CK concentration that translates into the training points ranged between 1 and 6.

Table 3 presented the standardized test of physical parameters at 0 and 30 min of post-training. At 0 min, that is the HR of each horse on arrival from the training and also 30 min upon recovery, these two values of each horse were collated and an estimate is taken based on the average of these two values. The mean values translate into the training points of HR for each horse which ranges between 1 and 6 points for the nine horses. Likewise, the average RT translates into the training

Table 1: Point scale in training based on biochemical and physical parameters of endurance horses

Lactate (mmol/L)	TPP (gm/L)	CK (µmol/L)	Heart rate (beats min-1)	RT (°C)
1.00–1.99	70.0–74.9	100–149	65–69	38.5–38.9
2.00–2.99	75.0–79.9	150–199	70–74	39.0–39.4
3.00–3.99	80.0–84.9	200–249	75–79	39.5–39.9
4.00–4.99	85.0–89.9	250–299	80–84	40.0–40.4
5.00–5.99		300–349	85–89	40.5–40.9
6.00–6.99		350–399	90–94	41.0–41.4

Table 2: Standardized test of biochemical parameters at 0 and 30 minutes of post training

Horses	LACTATE (mmol/L)				TPP (gm/L)				CK (µmol/L)			
	Post-0-min	Post-30-min	Mean	Point	Post-0-min	Post-30-min	Mean	Point	Post-0-min	Post-30-min	Mean	Point
No	(A)	(B)	(A+B)/2		(A)	(B)	(A+B)/2		(A)	(B)	(A+B)/2	
1	6.8	5.43	6.12	6	80	81.6	80.80	3	202	206	204	3
2	1.75	1.19	1.47	1	79	76.6	77.80	2	126	144	135	1
3	3.84	2.72	3.28	3	74.3	72.8	73.55	1	270	286	278	4
4	4.19	3.3	3.75	3	78.7	77.6	78.15	2	300	312	306	5
5	4.37	2.88	3.63	3	78.4	78.4	78.40	2	295	297	296	4
6	6.26	4.21	5.24	5	85.4	80.5	82.95	3	277	262	270	4
7	1.65	1.65	1.65	1	77.9	76.8	77.35	2	266	248	257	4
8	4.53	3.61	4.07	4	87	88.4	87.70	4	377	367	372	6
9	1.49	1.36	1.43	1	74.3	72.1	73.20	1	253	260	257	4

Table 3: Standardized test of physical parameters at 0 and 30 minutes of training

Horses	HR (beats min^{-1})				RT (°C)			
	Post-0-min	Post-30-min	Mean	Point	Post-0-min	Post-30-min	Mean	Point
No	(A)	(B)	(A+B)/2		(A)	(B)	(A+B)/2	
1	92	74	83	4	41.8	39.6	40.7	5
2	86	62	74	2	40.6	39.8	40.2	4
3	92	74	83	4	41.3	40.1	40.7	5
4	96	86	91	6	41.4	39.9	40.7	5
5	80	74	77	3	41.3	40.1	40.7	5
6	92	80	86	5	41.4	41	41.2	6
7	84	64	74	2	40.3	39.2	39.8	3
8	84	76	80	4	41.2	38.4	39.8	3
9	74	58	66	1	39.3	38	38.7	1

Table 4: Ranking and placing in training and race based on biochemical and physical parameters of endurance horses

Horses	Lactate (mmol/L)	TPP (gm/L)	CK (µmol/L)	HR (beats min^{-1})	RT (°C)	Total point	Ranking in training		Placing in race
1	6	3	3	4	5	21	5		6
2	1	2	1	2	4	10	2		2
3	3	1	4	4	5	17	4		lame
4	3	2	5	6	5	21	5	VS	5
5	3	2	4	3	5	17	4		4
6	5	3	4	5	6	23	6		8
7	1	2	4	2	3	12	3		3
8	4	4	6	4	3	21	5		7
9	1	1	4	1	1	8	1		1

points and ranged between 1 and 6 points for the nine horses.

Table 4 presented the ranking and placing in training and race based on biochemical and physical parameters of endurance horses. On the list of the nine horses that participated in the training regimen, the first horse had a point of 6 for lactate, 3 points for TPP, 3 points for CK, 4 points for HR, and 5 points for RT with a total point of 21. The ninth horse on the listing had a point of 1 for lactate, 1 point for TPP, 4 points for CK, 1 point for HR, and 1 point for RT with a total point of 8. The total point translates into their ranking in training. Therefore, the first horse was the fifth in ranking in training and sixth in placing during the actual race while the ninth horse had the least total point of 8 and ranked first in training and first in place during the actual race. Similarly, all the remaining horses between the second and eighth on the list had a corresponding ranking in training and placing in the actual race based on their total points as divulged in Table 4. The placing in the race was their ranking in the actual race based on their total points in the actual race that was collated post-race. The third horse on the list was lame during the race.

DISCUSSION

The developing proficiency and gusto in equine endurance sport require an upsurge in training workout and competition to be imposed on endurance sport horses, both internationally and at local levels. In the current study, we used the field training aspect of conditioning horses for an endurance race, our approach simulates the real circumstances, in which the endurance horse obliges to participate. This finding is in accord with the insinuations of Courroucé-Malblanc and van Erck-Westergren (2013), Franklin and Allen (2014) and de Mare et al. (2017).

The concept of the current study is to rank horses in training based on best of five parameters, namely, lactate, TPP, CK, HR, and RT. The horses went through 4 weeks of training with one SET and at the end of the conditioning program, we hypothesize that the horses would emerge as a good performance endurance horses. In the current study, placing during endurance race is largely dependent on much more accumulated lower points by a singular horse during training and an endurance race. In the current study, the nine horses participated in a training of 30 km distance, the horses that sustain a low point of 1 for lactate had lactate concentration that ranged between 1.43 and 1.65 mmol/L whereas those horses with higher point (between 3 and 6) had higher concentrations of lactate. This finding is in harmony with the study conducted by Lawan et al. (2012a) which indicated that higher concentration of lactate in endurance horses during a 30 km race distance was associated with the development of metabolic disorders and these horses were subsequently eliminated from the race contrasted with those that completed the race successfully. This procedure is similar to the study conducted by Lawan et al. (2012a). However, they evaluated speed, HR, lactate, and uric acid on the performance of Arabian horses during a 120-km endurance race. Usually, horses that were eliminated from endurance races due to poor performance had post-training, lactate concentrations of 6 mmol/l and above (Davie and Evans, 2000; Lawan et al., 2012a). These findings were in agreement with the finding of the current study where the horses with a lactate point of 6 had higher concentration of lactate post training and this could be due to tremendous building up of lactate in the muscle tissues leading to poor performance as divulged by the ranking during training and placing in an actual race. In the present study, we also observe our sampling time and subsequent analysis of all the biochemical parameters, especially as regard lactate to avoid erroneous lactate values during the SET test.

In the current study, the sought point of 1 for TPP ranged between 73.20 and 73.55 gm/L for two horses. The horse with a TPP value of 73.55 gm/L became lame during the actual race, whereas the horse with a TPP value of 73.20 had an excellent placing in the actual race compared with those horses that manifested higher points. In horses, numerous studies have revealed an upsurge in TPP as a result of innumerable racing, workouts, training programs, and competitions (Santos et al., 2001; Schott et al., 2006; Fazio et al., 2011; Janicki et al., 2013). This finding is correspondingly in accord with the finding of the present study that showed horses with higher TPP point were prone to poor placing in actual endurance races. For instance, it has been indicated in earlier studies (Zobba et al., 2011; Walker and Collins, 2017), that horses throughout exercise forces large quantity of erythrocytes in the circulation by means of splenic contraction, and abruptly increasing the circulating blood volume, and this is followed by an upsurge in TPP. The upsurge of TPP throughout isometrics might be due to a decrease in extracellular fluids and hemoconcentration (Muñoz et al., 2010; Piccione et al., 2015). This finding is similarly indicated in the current study in which the horses with higher points had correspondingly higher values of TPP indicating decreased extracellular fluid volume and hemoconcentration. For the period of the maximal exercise, there is a relocation of fluids and electrolytes from the vascular partition to the tissue extracellular fluid spaces, with a subsequent upsurge in TPP (Fazio et al., 2011). This phenomenon is obviously shown in the current study, particularly by the horses having higher points with the poor race placement.

Even though the nine horses in the current study were exposed to the same SET test during the training period, the horse with a point of 1 had the lower value of CK compared with the one that had a point of 6. The differences in the value of CK between these horses could be as a result of their inherent abilities to endure the stress and rigors of training. However, some studies insinuated that the values for plasma CK observed after exercise depend on the duration and type of exercise (Wanderley et al., 2015). The higher the concentration of CK in exercising muscle tissues the more likely it would be linked to muscle deterioration, the horse with a point of 6 in CK had much higher concentrations of CK contrasted with 1 point horse in the present study. This finding is in consonance with the findings of Lawan et al. (2012b) that reported CK obtainable in high concentrations in excitable muscle tissues is similarly associated to muscular damage during endurance races (Lawan et al., 2012b).

In the present study, a horse that maintains an HR range of 65–69 had a point of 1 which virtually corresponds to an HR requirement of endurance horses usually 64 beats/min as stated by Madsen et al. (2014). Evaluation of the suitability or isometrics resilience of an equine is through appraisal and via a physical check of HRs (Bashir and Rasedee, 2009; Lawan et al., 2012c). In the present study, it is obvious that horses with a higher point between 3 and 6 had elevated HRs and poor placement during the actual race. The energetic operational muscle of equines is governed by heart magnitude and ability to transport enormous volumes of blood to the tissue and the splenic reserve supply (Lawan et al., 2010; Kenneth et al., 2013).

In the current study, the ability of enormous deliverance of large volume of blood is clearly exhibited by horse number 9 in the list of horses by indicating augmented maintenance of very low points at training and during the actual race with excellent placement. The unsurpassed recognized anomaly in equines at peril of coming up with metabolic disorder and fatigue is importunately raised HRs after the tournament, this is obvious in the current as long as horses with higher points had elevated HRs and prone to inferior placement and are at higher risk of developing metabolic problems (Schott et al., 2006; Harold, 2010; Lawan et al., 2012c). Throughout endurance rides, the amount of blood the heart pumps through the circulatory system in a minute upsurges in response to the metabolic requirement of active skeletal muscle and similarly owing to a requirement of improved skin blood flow for thermoregulatory freshening (Lawan et al., 2012c). This condition is seemingly seen in the horses with higher points for RT. Horse number 3 in the list of horses had higher point for RT and subsequently developed lameness and had poor placement in the race.

Moreso, during a long-drawn-out endurance ride, a reduction in blood flow might compromise the function of a reduced amount of perfused organs. Precisely, the obstructive function of the mucosal coating of the intestinal tract might be compromised. An unbroken mucosal barricade averts the take-up of numerous toxins that are found in the intestinal lumen, but a sustained reduction in intestinal blood flow throughout endurance isometrics can contribute to mutually reduce intestinal motility, intensified take-up of contaminants, and HR variability which is an efficacious indicator of horse ability, excessive training, and metabolic disorders (Harold, 2010). Increased HR is the main marker for reduction of performance in the active equine endurance race and the outcome is an inferior placement in endurance races.

High HRs seems to upset tissue oxygenation and cardiopulmonary performance in the endurance horses, exposing the endurance horses to greater peril for the development of thumps and hyperthermia which might contribute to modifications in fluid and electrolyte status leading to a greater percentage of the horses eventually being eliminated from endurance races. The HR is likewise contingent on the oxygen carriage capability of blood, which is contingent on hemoglobin levels and erythrocyte amount (Janicki et al., 2013). Throughout the diminution of body fluid reserves as a result of protracted sweating, the tussle for cardiac output might develop between the skin and robust muscle, leading to intensified core temperature and a reduction in performance (Harold, 2010). Accordingly, from the outcomes of the present research, it gave an impression of decline in cardiac output to skin and energetic muscles which could be the outcome of the reduction in the performance of endurance horses (Lawan et al., 2012c). Consequently, causing the persistence of the elevated HRs and body temperature in the endurance horses is eliminated due to metabolic reasons.

CONCLUSION

In conclusion, it is observed that placing in race tally with ranking in training. It is similarly suggested that the current ranking system in training could be valid to be used to predict endurance horses' performance in the actual race.

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CONFLICT OF INTEREST

The authors have no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

AUTHORS' CONTRIBUTION

All the authors contributed equally.

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