UNIVERSITI PUTRA MALAYSIA

METABOLIC DISORDER INDEX AS PREDICTOR OF PERFORMANCE IN ENDURANCE HORSES

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By

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Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Master of Veterinary Science

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DEDICATIONS

This thesis is dedicated to my beloved parents, Mohd Rajdi Idris and Nik Hasmah Daud. Thank you for unconditionally love and support.

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Veterinary Science

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Chairman : Noraniza Mohd Adzahan, PhD
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Endurance is a type of equestrian sport that is recognized by the Fédération Equestre Internationale (FEI). It is a long-distance race ranging from 40 to 120 km and is divided into several loops whereby each loop covers from 20 to 35 km. The performance of endurance horses is usually evaluated on their ability to complete the race in the shortest period. The rate of elimination of horses in the races are still high, ranging from 10% to 60%. Endurance horses are usually eliminated from the race due to lameness, metabolic disorders, and other causes which include failure to reach at the veterinary inspection within the stipulated period, optional withdraws, and concerns over the well-being of the horse. A prediction of horses' performance before the race can help reduce the rate of elimination as well as care for their well-being by preventing the participation of poor performance horses in the competition. Therefore, the purpose of the present study is to determine the current completion and elimination rate of endurance races in Malaysia. A total of 194 endurance horses who participated in 12 endurance races organized in several states in Malaysia from May 2015 until December 2016 are involved. Out of the 194 horses, 188 are from Terengganu while 6 are from Kelantan. From the total of 194 horses, 126 are able to complete the race while 68 of them are eliminated from the race by official veterinarians. In the current study, 35.05% of the horses are eliminated and 64.95% of them are able to complete the race successfully. Among the eliminated horses, 54.41%, 29.41% and 16.18% of them are due to lameness, metabolic disorders and other causes respectively. Most of the eliminated horses competed in the 80 km race while those who successfully completed the race competed in the 40 km race. The average speed for good, moderate, and poor performance horses is 15.72 ± 2.9, 12.19 ± 2.1, and 13.91 ± 2.6 km h-1 respectively. In the 40, 80, and 120 km races, the average speed is 12.65 ± 1.8, 15.99 ± 3.5, and 12.86 ± 0.2 km h-1

respectively showing that the horses performed fastest in the 80 km races. This data could be of assistance to the veterinarians in monitoring the trend of endurance races in Malaysia and improve the current management practices to reduce the rate of elimination in subsequent races. However, the elimination of the horses is unpredictable because there is no specific method to predict their performance before the race. In 2017, Adamu et al. came out with the Metabolic Disorder Index (MDI) which claims can be used in predicting a horse's performance before the race. The MDI is defined as a product of packed cell volume (PCV), creatine kinase (CK), and interleukin-6 (IL-6) divided by the product of chloride (Cl-) and glutathione reductase (GR) multiplied by 100. A prediction is made based on the MDI value. Horses who have MDI value of >5.5 is predicted to be of good performance while those who have MDI value of <5.5 is predicted to be of poor performance. However, this index has not been tested on the field under controlled conditions. Other purpose of this study is to evaluate the MDI's parameters of good and poor performance endurance horses before the race and to validate the MDI as a predictor for horses' performance in endurance races. Out of the 194 horses that are involved in the study, only 54 of them are selected for blood sampling to test the validity of MDI. Blood samples are taken a day prior to the event to determine the packed cell volume (PCV), chloride (Cl-), and Interleukin-6 (IL-6) concentrations as well as creatine kinase (CK) and glutathione reductase (GR) activities. These parameters are used to determine the MDI in endurance horses at rest one day before the competition. Poor performance horses have significantly ($p<0.05$) higher serum CK concentrations at 216.0 ± 65 U L-1 compared to good performance horses at 150.7 ± 29 U L-1. The serum Cl^- concentration in poor performance horses is lower at 99.8 ± 5.6 mmol L-1 compared to good performance horses at 103.7 ± 3.3 mmol L-1. The study shows that MDI has a high ability to identify poor performance horses with approximately 90% sensitivity. However, in terms of accuracy, it is more accurate in predicting good performance horses with a negative predictive value of 90.91%.

Keywords: horses, endurance, metabolic, performance.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains Veterinar

INDEKS GANGGUAN METABOLIK (MDI) SEBAGAI PERAMAL PRESTASI PADA KUDA LASAK

Oleh

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Sukan kuda lasak merupakan salah satu sukan berkuda yang diiktiraf oleh *Federation Equestre Internationale* (FEI). Ianya merupakan perlumbaan jarak jauh dalam lingkungan 40 hingga 120km dan jarak tersebut terbahagi kepada beberapa bahagian yang meliputi jarak antara 20 ke 35km. Prestasi kuda lasak biasanya dinilai berdasarkan keupayaan untuk menamatkan perlumbaan dalam masa tersingkat. Kadar penyingkiran kuda lasak dalam perlumbaan adalah tinggi iaitu pada kadar 10 hingga 60%. Kuda lasak biasanya disingkir daripada perlumbaan kerana ketempangan, penyakit metabolisme atau sebab lain, termasuk kegagalan untuk sampai di tempat pemeriksaan veterinar dalam tempoh yang ditetapkan, pengunduran pilihan dan kebimbangan atas kebajikan kuda. Ramalan prestasi kuda sebelum perlumbaan boleh membantu untuk mengurangkan kadar penyingkiran dan menjaga kebajikan kuda dengan cara menghalang kuda berprestasi lemah daripada menyertai pertandingan. Oleh itu, tujuan kajian ini adalah untuk menentukan kadar pelengkapan dan penyingkiran kuda lasak di Malaysia. Seratus sembilan puluh empat ekor kuda lasak yang telah menyertai 12 perlumbaan kuda lasak yang dianjurkan di beberapa buah negeri di Malaysia bermula dari Mei 2015 sehingga Disember 2016 telah terlibat dalam kajian ini. Seratus lapan puluh lapan ekor kuda lasak daripada 194 ekor tersebut adalah dari Terengganu manakala 6 ekor adalah dari Kelantan. Berdasarkan daripada jumlah tersebut juga, 126 ekor berjaya menamatkan perlumbaan manakala 68 ekor telah disingkir daripada perlumbaan oleh veterinar yang bertugas. Kajian ini menunjukkan 35.05% kuda telah tersingkir manakala 64.95% telah berjaya menamatkan perlumbaan. Kuda yang tersingkir disebabkan oleh masalah ketempangan, gangguan metabolisme dan sebab-sebab lain masing-masing adalah 54.41%, 29.41% dan 16.18%. Kebanyakan daripada kuda yang tersingkir adalah terdiri daripada kuda yang bertanding

dalam jarak 80km sementara kuda yang berjaya menamatkan perlumbaan adalah bertanding dalam jarak 40km. Purata kelajuan untuk prestasi baik, sederhana dan lemah masing-masing adalah 15.72 ± 2.9, 12.19 ± 2.1 dan 13.91 ± 2.6 km h^{-1}. Untuk perlumbaan 40, 80 dan 120km, purata kelajuan masing-masing adalah 12.65 ± 1.8, 15.99 ± 3.5 dan 12.86 ± 0.2 km h^{-1}. Data ini menunjukkan bahawa kuda yang terlibat di dalam perlumbaan 80km mempunyai kelajuan yang terpantas. Data ini mampu membantu para veterinar dalam memerhati corak perlumbaan kuda lasak sekaligus meningkatkan amalan pengurusan semasa dalam mengurangkan kadar penyingkiran dalam setiap perlumbaan. Walau bagaimanapun, penyingkiran dalam kalangan kuda lasak adalah tidak mampu dijangka kerana tiadanya kaedah tertentu bagi meramal prestasi kuda sebelum perlumbaan. Pada tahun 2017, Adamu et al. memperkenalkan indeks gangguan metabolisme (MDI) yang dikatakan dapat digunakan untuk meramal prestasi kuda sebelum perlumbaan. MDI ditakrifkan sebagai hasil isipadu sel padat (PCV), aktiviti kreatin kinase (CK) dan interleukin-6 (IL-6) dibahagi dengan kepekatan klorida (Cl^-) dan glutation reductase (GR) yang kemudiannya dikalikan dengan 100. Ramalan tentang prestasi kuda akan dibuat berdasarkan nilai MDI. Kuda yang mempunyai nilai MDI >5.5 diramal sebagai kuda yang berprestasi lemah manakala kuda yang mempunyai nilai MDI <5.5 diramal sebagai kuda yang berprestasi baik. Namun, indeks ini masih belum diuji di bawah keadaan yang terkawal. Jadi, tujuan kajian ini dijalankan adalah untuk menilai parameter-parameter MDI bagi kuda berprestasi baik dan lemah sebelum perlumbaan dan mengkaji kebolehpercayaan indeks gangguan metabolisme (MDI) dalam meramalkan prestasi kuda dalam perlumbaan lasak. Daripada 194 ekor kuda yang terlibat dalam kajian terdahulu, hanya 54 daripada mereka dipilih untuk pensampelan darah untuk menguji kesahihan MDI. Sampel darah diambil sehari sebelum acara perlumbaan untuk menentukan isipadu sel padat (PCV), kepekatan klorida (Cl^-) dan interleukin-6 (IL-6), dan aktiviti kreatin kinase (CK) dan glutation reductase (GR). Semua parameter ini diguna untuk penentuan MDI dalam kuda lasak sehari sebelum pertandingan. Kuda berprestasi lemah secara tererti ($p<0.05$) menunjukkan kepekatan CK lebih tinggi pada 216.0 ± 65 U L^{-1} berbanding kuda berprestasi baik pada 150.7 ± 29 U L^{-1}. Kepekatan Cl^-serum dalam kuda berprestasi lemah pada 99.8 ± 5.6 mmol L^{-1} lebih rendah daripada kuda berprestasi baik pada 103.7 ± 3.3 mmol L^{-1}. Kajian ini menunjukkan MDI mempunyai keupayaan yang lebih tinggi untuk mengenalpasti kuda yang lemah dengan sensitiviti kira-kira 90%. Walau bagaimanapun, dari segi ketepatan, MDI lebih tepat dalam meramal kuda prestasi yang baik dengan nilai ramalan negatif pada 90.91%.

Katakunci: kuda, lasak, metabolisme, prestasi.

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This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the Master of Veterinary Science. The members of the Supervisory Committee were as follows:

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LIST OF ABBREVIATIONS

%	Percentage
°C	Degree Celsius
ALP	Alkaline phosphatase
AST	Aspartate aminotransferase
Ca	Calcium
CEI	Concours de Raid d'Endurance International
CEIO	Concours de Raid d'Endurance International Official
CK	Creatine kinase
Cl^-,	Chloride
CRT	Capillary refill time
CRI	Cardiac recovery index
EDTA	Ethylenediaminotetraacetic acid
FEI	*Féderation Équestre Internationale*
G	Gauge
GGT	Gamma-glutamyl transferase
GLU	Glucose
GR	Glutathione reductase
Hb	Hemoglobin
IL-6	Interkeukin-6
K	Potassium
Kg	Kilogram
km	Kilometer
km h^{-1}	kilometer per hour
L	Liter
L/L	Liter per liter
Lac	Lactate

M	Meter
MCH	Mean corpuscular hemoglobin
MCHC	Mean corpuscular hemoglobin concentration
MDI	Metabolic disorder index
MCV	Mean corpuscular volume
Mg	Magnesium
Na	Sodium
NPV	Negative predictive value
ORAC	Oxygen radical absorbance capacity
PCV	Packed cell volume
PPV	Positive predictive value
RBC	Red blood cell
ROC	Reactive oxygen species
rpm	Revolution per minute
SDFT	Superficial deep flexor tendon
TAS	Total antioxidant status
TIEP	Terengganu International Endurance Park
TP	Total protein
TPP	Total plasma protein
U/L	Unit per liter
UAE	United Arab Emirates
WEC	World Endurance Championship

CHAPTER 1

INTRODUCTION

1.1 Equestrian Sports

All equestrian sports should get the recognition of the *Fédération Equestre Internationale* (FEI) to be legitimate. The FEI, an organization that has authority in all international equestrian events was established in 1921 in Lausanne, Switzerland. Among the roles of this organization are to regulate rules and regulation and sanction all the equestrian events including the Olympics and Paralympic Games. The main goals of FEI are to promote fair play, foster equality among competing men and women riders, complicity with horses, and respect for horses and the environment. Currently, the FEI recognizes nine equestrian events which are dressage, para-equestrian dressage, jumping, eventing, driving, para-equestrian driving, vaulting, endurance, and reining.

1.2 Endurance Sports

According to the FEI, endurance is the fastest growing discipline and the second most popular discipline among equine sports. The number of endurance events have increased from only 16 in 1994 to 911 in 2016. This shows that endurance is gaining popularity among horse lovers. FEI endurance events are long-distance races conducted over 80 to 160 km which are divided into several phases of 20 to 40 km (Nagy, Dyson, & Murray, 2012).

International endurance rides are divided into two categories, which are *Concours de Raid d'Endurance International* (CEI) and *Concours de Raid d'Endurance International Official* (CEIO). Both must abide to the FEI General Regulation and FEI Endurance Rules. In CEI events, the riders compete individually. The events are conducted according to the level of expertise or 'Stars'. There are four Star levels, which are 4, 3, 2, and 1 Star. In CEIO events, the riders may compete as individual participants or as a member of a team. For each participating nation, an official team must comprise of three teams.

Endurance races are divided into several phases, each comprising a distance between 20 to 40 km. All horses are subjected to a pre-ride examination by veterinary officials. At the end of each phase, the horses must go through a compulsory halt for veterinary inspections and rest for 20 to 50 minutes before they can continue into the next loop. Horses are eliminated from the race if their metabolic or musculoskeletal conditions indicate they are not fit to continue. Horses can also be eliminated if their well-being are compromised

because of conditions such as sore at the back, girth, or mouth or suffering from extensive wounds. The horses can be eliminated either before or during the final examination after completion of the ride.

According to the FEI Rules for Endurance Events, a horse should be eliminated due to lameness at any inspection during the race. The horse shall be removed from competition and deemed failed to qualify for the next phase of the race if "the irregularity of gait is consistently observable when the horse is trotted on a loose lead held in the hand with arm straight out and back, or without flexion or deep palpation observed to be in pain, or the immediate ability of the horse to safely perform athletically is threatened" (FEI Rules of Endurance Events, 2017). The horse may also be eliminated for metabolic reasons if the veterinary inspector decides that its metabolic status is compromised. Elimination of horses can be based on abnormal general appearance, heart rate, cardiac recovery index (CRI), color of mucous membrane, capillary refill time (CRT), hydration status, intestinal activity, or wounds that may affect the horse's ability to continue.

1.3 Hypothesis

a) Poor performance horses have higher packed cell volume (PCV), blood creatine kinase (CK), and interleukin-6 (IL-6) as well as lower Cl^- and blood glutathione reductase (GR) concentrations than good performance horses at pre-race period.
b) Metabolic Disorder Index (MDI) is an accurate predictor of a horse's performance in endurance races.

1.4 Problem statements

a) There is a high rate of elimination in endurance horses in Malaysia due to participation of poor performance horses.
b) There is no specific method to screen the horse's performance before the race.

1.5 Objectives

a) To determine the rate of elimination and completion of horses in Malaysian endurance races.
b) To determine the Metabolic Disorder Index (MDI) of good and poor performance endurance horses prior to races.
c) To validate MDI as a predictor for potential performance of horses in endurance races.

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