Pferdeheilkunde 12 (1996) 4 (Juli August) 463–465

Characterization of a standard exercise to fatigue test in Thoroughbred horses

C. W. Travers, A. J. Guthrie and *R. J. Lund*

Equine Research Centre, Faculty of Veterinary Science, Onderstepoort, South Africa

Summary

A practical standard exercise to fatigue (SEF) test was used to assess the performance abilities of equine athletes. The results of this test performed by Thoroughbred horses (n = 5) at speeds of 7.5, 9, 11, 13 or 14.5 m/s at a 5.2 % inclination on a high speed treadmill are presented. The results indicate that there is an excellent relationship between the logarithm of time to fatigue and treadmill speed. Due to this relationship, it is possible to characterize this relationship for an individual horse using only two different SEF tests. Treadmill speeds of 9 m/s and 13 m/s at a 5.2 % inclination, were best accepted by the horses. The large differences in both the slope and intercept of the regression equations between individuals may be an indication of differences in the power and endurance capabilities of the subjects. Further studies using this test in race and endurance horses will be necessary to fully evaluate the importance of these findings.

Keywords: horse, exercise test, fatigue, treadmill run time, performance

Charakterisierung eines üblichen Belastungstests bis zur Ermüdung bei Vollblutpferden

In dieser Studie wurde ein üblicher Test, in dem die Pferde bis zur Ermüdung belastet wurden (= standard exercise to fatigue test (SEF)), eingesetzt, um die Leistungsfähigkeit von Sportpferden zu erfassen. Fünf Vollblutstuten, im Alter von 3 bis 12 Jahren, absolvierten an verschiedenen Tagen je einen SEF bei einer Geschwindigkeit von 7,5; 9; 11; 13 oder 14,5 m/s. Alle Belastungen wurden auf einem Hochgeschwindigkeitslaufband bei einer Steigung von 5,2% durchgeführt. Während des SEF wurde die Zeit bis zur Ermüdung aufgezeichnet. Die Ergebnisse weisen auf eine sehr gute Beziehung zwischen dem Logarithmus der Ermüdungszeit und der Laufgeschwindigkeit hin. Aufgrund dieser guten Regression ist es möglich, die Beziehung zwischen dem Logarithmus der Ermüdungszeit und der Laufgeschwindigkeit für ein individuelles Pferd nach Durchführung von nur zwei SEF zu charakterisieren. Die Laufgeschwindigkeiten von 9 und 13 m/s bei einer Steigung von 5,2% wurden am besten von den Pferden akzeptiert. Sowohl die Steigung der Regressionsgleichung als auch deren Schnittpunkt mit der Y-Achse wiesen großen Unterschiede zwischen den Individuen auf. Dies könnte ein Hinweis auf Unterschiede im Leistungs- und Ausdauervermögen der Tiere sein. Um die Bedeutung dieser Ergebnisse vollständig einschätzen zu können, müssen weitere Untersuchungen, in denen dieser Test bei Renn- und Distanzpferden angewendet wird, durchgeführt werden.

Schlüsselwörter: Pferd, Belastungstest, Ermüdung, Laufzeit auf dem Laufband, Leistung

Introduction

Treadmill standard exercise tests (SETs) are widely used in equine sports medicine and are well documented (*Persson*, 1983; *Thornton,* 1985; *Rose* et al., 1988; *Seeherman* and *Morris,* 1990). These SETs usually involve incremental increases in speed every 60 to 120 seconds until the horse fatigues or a certain goal is reached (a desired heart rate, core temperature or duration of exercise). Treadmill exercise tests are considered by many to be superior to those performed on a track as it is far easier to standardize conditions on a treadmill and measurement of various physiological variables before, during and after exercise are simplified. Incremental-type SETs have traditionally been used for the evaluation of performance horses. Data like oxygen consumption, heart rate, blood lactate concentration, blood gas partial pressures, indicators of plasma and red cell volume (haemoglobin, haematocrit, plasma protein), treadmill run time and stride length collected during these tests have been used to compare the performance of different horses. Treadmill run time or time to fatigue of an incremental exercise test has been described as a useful indicator of overall performance in horses (*Seeherman* and *Morris,* 1990). In man, time to fatigue is regarded by some as being superior to measurement of $\dot{V}O_{2max}$ in the characterization of exercise performance (*Noakes* 1988).

Rose et al. (1995) suggested that although an incremental-type SET allows the collection of data during submaximal and maximal exercise intensities, it may not be a reliable indicator of racing performance. During a recent workshop discussion on submaximal exercise tests it was noted that there is a need for exercise tests that can assess performance in endurance horses (*Rose* and *Christley,* 1995). Although non-incremental exercise to fatigue tests have previously been used (*Thornton,* 1985; *Rose* et al., 1988; *Pösö* et al., 1991; *Eaton* et al. 1995), their use as performance predictors have not been characterized.

The aim of this study was to characterize a standard exercise to fatigue (SEF) test that could be used to measure treadmill time to fatigue in horses. This was accomplished by performing a non-incremental exercise to fatigue test on five conditioned Thoroughbred horses at five different speeds ranging from 7.5 to 14.5 m/s at a 5.2% incline on a treadmill.

Materials and methods

Five conditioned Thoroughbred mares ranging from three to twelve years of age were used in this study. All horses were accustomed to running on the treadmill. The horses were housed and managed according to the Equine Research Centre's standard operating procedure that involves stabling at night, paddock exercise during the day, and a ration consisting of ad lib tef hay, alfalfa hay and 10% protein pelleted concentrates. Heart rate was monitored during the exercise tests using a telemetric electrocardiogram system with a recording facility (Lifescope 6, Nihon Kohden). A base-apex lead system as described by *Hill* et al. (1977) was used. The electrodes were fixed to the skin using an adhesive and elastoplast to prevent dislodging during intense exercise. Before each SEF test the horses were warmed up by walking for five minutes and trotting at a speed of 4 m/s for five minutes on a high speed treadmill (Mustang 2200, Kagra AG, Switzerland) at a 0 % inclination.

The fatigue tests were performed on the treadmill according to the following protocol:

Day 1: Following warm-up the horses performed a SEF test at 11 m/s at a 5.2% incline according to a predetermined random order
Day 2: Horses repeated the warm-up as described previously, with the exception that trotting continued for 10 minutes
Day 3: Same as day 2
Day 4: Horses performed a SEF test at 9 m/s at a 5.2% incline
Day 5: Same as day 2
Day 6: Same as day 2
Day 7: Rest day
Day 8: Horses performed a SEF test at 7.5 m/s at a 5.2% incline
Day 9: Same as day 2
Day 10: Same as day 2
Day 11: Horses performed a SEF test at 13 m/s at a 5.2% incline
Day 12: Same as day 2
Day 13: Same as day 2
Day 14: Rest day
Day 15: Horses performed a SEF test at 14.5 m/s at a 5.2% incline.

The time to fatigue for each SEF test was recorded using a stopwatch. The horses were judged to be fatigued when they could no longer keep up with the treadmill belt speed in spite of verbal encouragement. The same observer recorded the time to fatigue for each fatigue test. Regression analysis was performed on the data using a software package (Sigmaplot 5.0, Jandel Scientific, USA) on a personal computer.

Results

The time to fatigue ranged from 39 minutes at 7.5 m/s to one minute at 14.5 m/s. It must be noted that only one horse achieved a time to fatigue of 39 minutes at a speed of 7.5 m/s. The other horses fatigued in approximately 30 minutes at this speed. Regression analysis showed that there was an excellent linear relationship between the logarithm of the time to fatigue and treadmill speed in all subjects. The plots of the regressions for the individual subjects are depicted in Fig. 1. Tab. 1 summarizes the slope, intercept and coefficient of determination of each subject's regression equation. The coefficients of determination of this relationship for individual subjects ranged from 0.988 to 0.997. The intercept of the regression equations ranged from 4.36 to 5.02 and the slope ranged from –0.14 to –0.21.

Tab. 1: The slope, intercept and coefficient of determination (r^2) for each subject's regression equation expressed as Log(time to fatigue in sec.)=Intercept + Slope (speed in m/s).

Horse	Slope	Intercept	r^2
1	–0.21	5.02	0.994
2	–0.14	4.36	0.997
3	–0.16	4.55	0.991
4	–0.19	4.51	0.988
5	–0.20	4.64	0.992

Discussion

The SEF test described in this study was practical to perform. The large differences in both the slope, and intercept of the regression equations between individuals in this study are possibly an indication of differences in the power and endurance capabilities of the subjects. The regression plots in Fig. 1 indicate that horse 1 may have better power capabilities than horse 3 due to longer times to fatigue at higher treadmill speeds. In contrast, horse 3 may have better endurance capabilities due to longer times to fatigue at lower treadmill speeds.

Due to the excellent log-linear relationship between time to fatigue and treadmill speed, it is possible to reliably characterize this relationship for an individual horse using only two fatigue tests. In our study, SEF tests at treadmill speeds of 9 m/s and 13 m/s at a 5.2 % inclination were best tolerated by the horses. The time to fatigue at 9 m/s did not exceed 24 minutes. This is in contrast to a fairly time consuming submaximal exercise to fatigue test described by *Pösö* et al. (1991) where the time to fatigue varied bet-

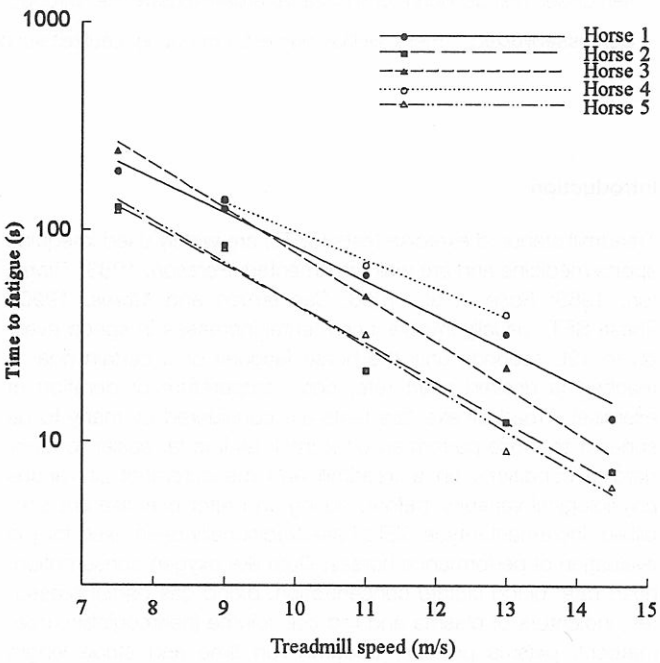

Fig. 1: The regression plots of the individual subjects drawn through the time to fatigue of standard exercise to fatigue (SEF) tests done at 7.5, 9, 11, 13 and 14.5 m/s at a 5.2% incline on a high speed treadmill.

ween 35 and 75 minutes. Depending on the type of SEF test used, the time to fatigue may indicate either endurance or power capacity. *Seeherman* and *Morris* (1990) suggested that the ability to maintain peak aerobic power output is critical in the later stages of all Thoroughbred races that last longer than 60 s, and that the most direct measure of this would be to measure the time to fatigue during constant-load exercise requiring peak power. The same principal could be applied to endurance ability during a constant load submaximal exercise test. Another factor that is crucial to good racing performance is a rapid transition from rest to peak aerobic power. The maximal SEF tests described above may prove to be useful to assess the time required to reach peak aerobic output.

These tests may also be of benefit in the assessment of anaerobic exercise capacity, a subject that has not been addressed using the traditional incremental-type exercise tests. The maximal SEF tests could be used to determine indices of anaerobic capacity like the maximal accumulated oxygen deficit (MAOD) and treadmill work during supra maximal exercise. *Eaton* et al. (1995) used a non-incremental fatigue test on the treadmill to measure MAOD in a group of horses. It was noted that a number of the MAOD test run times were in the range of 24–60 s. This may be ascribed to the work required to run at a steep (10%) incline and may provide insufficient time for the horses to utilize maximal anaerobic capacity. The SEF test in this study performed at 13 m/s at a 5.2% incline did not have a recorded time to fatigue of less than 90 s, and may therefore be more suitable for the measurement of MAOD.

In conclusion, SEF tests performed at 9 and 13 m/s described in this study may be useful in characterizing a horse's endurance and power capabilities, respectively. Further studies using this test in race and endurance horses will be necessary to fully evaluate the importance of the findings in this study. The test may also be useful in characterizing the power and endurance abilities of young horses in training for racing.

References

Eaton, M. D., Rose, R. J., Evans, D. L., and *Hodgson, D. R.* (1995) Assessment of anaerobic capacity using maximal accumulated oxygen deficit in fit Thoroughbreds. Equine Vet.J.Suppl. 18: 29–32.

Hill, G., Atkins, R., Littlejohn, A., Kruger, J. M., and *Bowles, F.* (1977) Exercise studies in horses: 1. A simple telemetry system for recording exercise ECGs in horses. Equine Vet.J. 9: 72–74.

Noakes, T. D. (1988) Implications of exercise testing for prediction of athletic performance: a contemporary perspective. Med.Sci.Sports Exercise. 49: 319–330.

Persson, S. G. B. (1983) Evaluation of exercise tolerance and fitness in the performance horse. In: Equine Exercise Physiology, edited by *Snow, D. H., Persson, S. G. B.* and *Rose, R. J.*, Burlington Press, Cambridge: p. 441–457.

Pösö, A. R., Essen-Gustavsson, B., Lindholm, A. and *Persson, S.G.B.* (1991) Exercise-induced changes in muscle and plasma amino acid levels in the Standardbred horse. Equine Exercise Physiology 3 ICEEP Publications, Davis. 202–208.

Rose, R. J., Hodgson, D. R., Kelso, T. B., McCutcheon, L. J., Reid, T., Bayly, W. M. and *Gollnick, P. D.* (1988) Maximum O_2 uptake, O_2 debt and deficit, and muscle metabolites in Thoroughbred horses. J.Appl.Physiol. 64: 781–788.

Rose, R. J., Hodgson, D. R., Bayly, W. M. and *Gollnick, P. D.* (1988) Kinetics of $\dot{V}O_2$ and $\dot{V}CO_2$ in the horse and comparison of five methods for determination of maximum oxygen uptake. Equine Vet.J. 20: 39–42.

Rose, R. J., King, C. M., Evans, D. L., Tyler, C. M. and *Hodgson, D. R.* (1995) Indices of exercise capacity in horses presented for poor racing performance. Equine Vet. J Suppl. 18: 418–421.

Rose, R. J. and *Christley, R. M.* (1995) How useful are submaximal exercise tests to forecast performance? Equine Vet.J.Suppl. 18: 471–479.

Seeherman H. J. and *Elisabeth A. Morris.* (1990) Application of a standardised treadmill exercise test for clinical evaluation of fitness in 10 Thoroughbred racehorses. Equine Vet.J Suppl. 9: 20–25.

Seeherman, H. J. and *Elisabeth A. Morris.* (1990) Application of a standardized exercise test for the clinical evaluation of performance in Thoroughbred racehorses. Equine Vet.J Suppl. 9: 26–34.

Thornton, J. R. (1985) Exercise testing. Vet. Clin. North Am. Equine Pract. 1: 573–595.

Acknowledgements

This study was supported as project ERC 94/05 by the Equine Research Centre, the Highveld Racing Authority and the University of Pretoria. The authors wish to thank all the staff, students and temporary workers at the Equine Research Centre for their friendly assistance.

C. W. Travers
A. J. Guthrie
R. J. Lund

Equine Research Centre
Faculty of Veterinary Science
Onderstepoort 0110
South Africa