**The use of a standardized swimming test to evaluate race performance in Thoroughbred racehorses**

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**Key words:** swimming test, performance, heart rate, speed, Thoroughbred racehorse

**Abstract**

Swimming has become an accepted tool in the training programme of race horses. The purpose of this study was to evaluate whether fitness indices calculated from a standardized swimming test were related to the performance of the horse on the race track. Fifty-two Thoroughbred racehorses (4.6 ± 1.4 years, 50 geldings, 2 stallions), all participating in races at the Hong Kong Jockey Club (HKJC), were used in this study. All horses underwent a standardised swimming test (SST) consisting of swimming two laps in an oval shaped swimming pool (1 lap = ± 60 m). During the swimming test, heart rate (HR; beats/min) and speed (V; m/s) of the horses were monitored. In addition, of these 52 horses, 22 horses were tested a second time (after 1-21 days), to evaluate the repeatability of the swimming test and from 18 of these 22 horses, plasma lactate concentrations (LA; mmol/L) were obtained directly after SST. Race performance of horses was defined as a rating score determined by the HKJC, based on the race performance. Horses were divided into ‘good performers’(placed in 1 to 5 rank at competition in the period 1 month before to 1 month after SST) and ‘average performers’(placed at lower rankings). Mean HR during the SST was 178 ± 14 bpm, mean V was 1.06 ± 0.10 m/s and mean LA after the SST was 2.3 ± 1.5 mmol/liter. There was a significant correlation between HR and V (r=0.720, P<0.001, n=52), but HR was not repeatable between tests (r=0.259, P=0.245, n=22). No significant correlation was found between racing performance and HR, V or LA, so it seems a SST is not suitable to predict the performance of the horse on the race track. However, in some horses HR during an SST seemed to reach HRs close to the maximum HR during a race and LA reached in some horses values higher values higher than during track work at 50 km/h. Therefore, swimming might not be such ´mild´ exercise as some trainers expect.

**Der Gebrauch von standartisierten Schwimmtests zur Ermittlung der Rennleistung in Vollblut-Rennpferden**

Schwimmen ist zu einem anerkannten Mittel im Trainingsprogramm von Rennpferden geworden. Das Ziel dieser Studie war es, aufzuzeigen, ob der durch standartisiertes Schwimmtraining errechnete Fitness-Index zusammenhängt mit der Leistung des Pferdes auf der Rennbahn. Es nahmen 52 Vollblut-Rennpferde (4,6 ± 1,4 Jahre, 50 Wallache, 2 Hengste), Teilnehmer an Pferderennen des Hong Kong Jockey Club (HKJC), an dieser Studie teil. Alle Pferde unterzogen sich einem standartisierten Schwimmtest (SST), bei dem sie zwei Runden in einem ovalförmigen Swimmingpool (1 Runde = ± 60 m) schwimmen mussten. Während des Schwimmtests wurde die Herzfrequenz pro Minute (HR; beats/min) und die Geschwindigkeit der Pferde (V; m/Ss) überwacht. Zusätzlich zu diesen 52 Pferden, wurden weitere 22 Pferde ein zweites Mal getestet (nach 1-21 Tagen), um die Reproduzierbarkeit des Schwimmtestes zu beurteilen. Bei 18 dieser 22 Pferde wurde direkt nach dem SST die Plasma-Laktat-Konzentration (LA, mmol/L) bestimmt. Die Rennleistung der Pferde wurde durch den HKJC mit Hilfe eines Bewertungsscore ermittelt, welcher auf den Rennleistungen basiert. Die Pferde wurden in die Gruppen „gute Leistungen“ (auf Platz 1 bis 5 bei einem Wettstreit in der Dauer von einem Monat vor dem SST bis 1 Monat nach dem SST) und “durchschnittliche Leistung” (schlechter platziert) eingeteilt. Der durchschnittliche HR während des SST war 178 ± 14 bpm, V war 1.06 ± 0.10 m/s und der durchschnittliche LA nach dem SST war 2.3 ± 1.5 mmol/L. Es gab einen signifikanten Zusammenhand zwischen HR und V (r=0.720, P<0.001, n=52), jedoch war HR zwischen den Tests nicht reproduzierbar (r=0.259, P=0.245, n=22). Es wurde kein signifikanter Zusammenhang zwischen der Rennleistung und HR, V oder LA gefunden. Ein SST scheint nicht geeignet zu sein, um die Leistung der Pferde auf der Rennbahn zu prognostizieren. Nichtsdestotrotz erreichte HR bei einigen Pferden während des SST beinahe den maximal zu erreichenden HR-Wert während eines Rennens und LA erreichte bei einigen Pferden Werte, höher als die Werte die während eines Rennens bei 50 km/h erreicht werden. Kurzum, schwimmen könnte ein weitaus weniger “sanftes” Training sein als manche Trainer erwarten.

**Schlüsselwörter**: Schwimmtest, Leistung, Herzfrequenz, Geschwindigkeit, Vollblut-Rennpferd

**Introduction**

At some racing stables, swimming has become an accepted tool in the training programme of race horses. Swimming is considered a relatively safe exercise for a horse, because it is thought to provide sufficient workload with only limited strain on the extremities (*Thomas* et al.1980; *Misumi* et al*.* 1994a).

 No specific research has been done about the correlation between swimming and the performance on track in race horses. The same linear increase in HR with increasing workload for horses running on the track has been seen for swimming horses (*Thomas* et al.1980). Horses that were more experienced in their training have a lower HR after swimming than those that were less experienced in their training regimen (*Garcia* and *Beech* 1986). In swimming horses, a positive correlation between maximum heart rate and swimming speed has also been found, but there was no significant difference between the start and the end of a training period (*Misumi* et al.1994b). This can be due to the fact that these horses were not sufficiently accustomed to swimming and stress may have influenced the HRs of horses during swimming (*Misumi* et al.1994b).

During the racing season, the racing results of the individual racehorse are well monitored by the trainer. For horses that get regular swimming exercise it would beuseful to be able to measure general fitness and predict racing performance using a SST, because these horses are well accustomed to swimming. The aim of the present study is to investigate whether in racehorses that get regular swimming exercise, heart rate and speed obtained from a standardized swimming test could be used to evaluate performance on the track.

**Materials and methods**

*Horses*

In this study 52 Thoroughbred racehorses (4.6 ± 1.4 years, 50 geldings, 2 colts) were used. All horses were housed in individual stalls in eight different trainer departments at the HKJC, and their housing, feeding and training was managed their trainers (on average seven horses per trainer). All horses were trained six days a week in the swimming pool and on the track according to the training regimen of the trainer, the seventh day was a resting day.

*Set up*

All 52 horses were tested in a standardized swimming test. Twenty-two out of these 52 horses were tested twice to analyse repeatability of the results (group A), with an average of a 10-day interval (range 1-21 days, depending on availability of the horse) between the two swimming tests (SST-1 and SST-2). In 18 out of these 22 horses a blood samples was taken after SST-2 from the jugular vein using a ten cc syringe and 19 G needle to determine plasma lactate concentration after swimming (group B).

The swimming pool at the HKJC is an oval shaped pool with straights of 22 meters and has a separate entrance and exit (fig. 1). The water in the pool is 2.6 meter deep, so the horses have no contact with the ground while swimming. During swimming the horses are guided by their own handler, who walks along with the horse at the outer edge of the pool.

*Swimming test protocol and blood sampling*

All 52 horses were tested using the same protocol. The heart rate equipment was installed in the stable and the horse was hand-walked to the swimming pool. The test consisted of two laps. In the pool horses could take the inside or the outside of the corner, so to standardise distance versus HR only the 22 meter long straights of the pool were used to measure HR and V. To give the horses time to adjust to the exercise, the first straight was not used in the data collection. The data collected during swimming consisted of the average HR and V for the second, third and fourth straight of the pool. In group B horses, a single blood sample was taken at 1 minute after completing the swimming test. Samples were taken in heparinised tubes and cooled immediately, and plasma lactate concentration was measured in whole blood using a portable Lactate Pro device (*Sloet* et al. 2008) after 15 minutes.

*Heart rate measurements*

To measure heart rate (HR) during swimming, horses were equipped with a HR monitor (Polar RS400, Polar Electro Oy, Kempele, Finland) with two plastic transmitters containing the electrodes. The two electrodes were placed on wet skin under the girth behind the left elbow and behind the left withers. Electrodes were hold in place by an elastic strap and a small racing breastplate. HR monitors continuously recorded heart rate (HR; beats/min)each second during the swimming test. Time was recorded and noted for each straight with a stopwatch and V (m/s) was calculated.

*Evaluation of racing performance*

To define racing performance the following parameters were obtained for each horse: rating, as calculated based on outcomes of race competitions for each horse by HKJC at swim date, whether the horse has raced in the period from 1 month prior to 1 month after swim date, and whether the horse was placed or not in place 1 to 5 during these races.

After *Couroucé* et al. (1997), horses were defined as good performers if they made top 5 in a race or as average performers if they finished after fifth place (*Couroucé* et al. 1997). Only races in the period from 1 month prior to 1 month after swim date were evaluated.

*Data analysis*

Data of all horses was used to calculate the correlation between HR and speed, using a Pearsons product-moment correlation. For the relationship between HR, speed, rating en performance a linear model was used, residues were checked for normality with QQ-plots. In group A, the correlations between HR and speed of these horses performing in both tests (SST-1 and SST-2) were calculated; correlations between HRs in both tests and swimming speeds in both tests , were calculated using a Pearsons product-moment correlation. In group B, the correlation between HR and speed, HR and LA and speed and LA was calculated using a Pearsons product-moment correlation. In group B, also the relationships between LA, rating and performance were analysed using a linear model and residues were checked for normality with QQ-plots.

**Results**

*All horses*

HR values of all horses ranged from 130 to 209 bpm with an average of 178 ± 14 bpm (table 2). Swimming speed ranged from 0.79 to 1.28 m/s with an average of 1.059 ± 0.095 m/s (table 2). HRs of the horses was significantly correlated with swimming speed (r=0.720, P<0.001) (fig. 2). Rating is not correlated to HR nor swimming speed, nor with horses being a good performer or a poor performer.

*Group A*

In this group of horses (n=22), HR values ranged from 132 to 209 beats per minute (bpm) with an average of 175 ± 12 bpm (table 2). In this group of horses, HR and swimming speed were not significantly correlated (r=0.239, p=0.284).

*Group B*

Lactate concentrations (LA; mmol/L) obtained ranged from 0.90 to 6.6 mmol/liter, with an average of 2.3 ± 1.5 mmol/liter. Mean HR in this group was 177 ± 12 bpm and mean swimming speed was 1.054 ± 0.073 m/s. No significant correlation was found between HR and LA (r=0.329, p=0.183) (fig. 3), but the correlation between swimming speed and LA was weak, but significant (r=0.550, p=0.018). Rating by HKJC is not correlated to LA, nor is being a good performer or poor performer.

**Discussion**

The HR values of 130-209 bpm obtained during the SST were comparable with data found in literature: 130-210 bpm (*Hobo* et al.1998; *Misumi* et al.1994a,b*; Thomas* et al. 1980). In this study, it was found that HR is not a good parameter to predict performance on the race track using the SST. Other previous studies about swimming test and race performance were also not able to find this correlation (*Misumi* et al. 1994a,b; *Evans* et al. 1993). Therefore, it seems that there is no relationship between HRs of horses during a swimming test and race performance on the race track. However, maximum HRs during the swimming test found in the present study (209 bpm) are comparable with the average maximum heart rate of 223 bpm in Thoroughbred horses during a race (*Krzywanek* et al.1970). This has also been found in previous studies (*Thomas* et al*.* 1980; *Misumi* et al. 1994b).

The present study HRs of horses did not seem to be repeatable between two swimming tests. However, *Garcia* et al. (1986) described also repeated swimming tests and they found that HRs of horses between two tests were comparable (117 ± 8 bpm and 110 ± 5 bpm).. Why HRs in the present study were not comparable is not completely clear, however it may be partly explained by the fact that there was a long period between the repetition of the two tests as horses were often not earlier available to perform the second test.

In contrary with the HRs of horses, their swimming speed was consistent and repeatable between the two swimming tests. Each horse seems to swim at its own ‘preferable’ swimming speed, and from the authors experience it was found that it is very difficult to change a horses’ speed during swimming. However, there was also no relationship between swimming speed of the horses and rating or race performance.

The average LA of 2.3 ± 1.5 mmol/liter that were obtained in this study are comparable with data found in earlier studies (*Hobo* et al.1998; *Gatta* et al*.* 1999). Although, two horses had much higher LA values after the swimming test (4.8 and 6.6 mmol/liter), this reflects that these horses worked above their anaerobic threshold (4 mmol/L) which is comparable with race track work at 50 km/h (*Gatta* et al. 1999).

A correlation between LA and racing performance of thoroughbred race horses was found during a standardised treadmill test (*Evans* et al., 1993), however, in the present study, LA of horses were not correlated to rating or performance during the swimming tests. *Misumi* (1994a and 1994b) found no differences in LA of horses between a swimming test at the beginning of a training period and after four months of training. Therefore, it seems that a correlation between LA and performance may not exist for swimming race horses.

All horses participating in this study got daily swimming exercise. They are swum as means of a mild warming up or cooling down before or after track work. However, during swimming maximum HR values can be the same as on the track (*Krzywanek* et al*.* 1970), and LA values are comparable to track work at 35 km/h (1.94 mmol/l - *Gatta* et al*.* 1999) or a 1500 meter race (2.45 mmol/l - *Piccione* et al. 2010). It might be important for horse trainers to realise that swimming is not such mild exercise for all horses as some might expect, which is also concluded by other authors (*Thomas* et al*.* 1980).

**Conclusions**

A standardised swimming test using HR, speed and LA as parameters was not useful to evaluate racing performance in the horse. The physiologic demands of swimming exercise on some horses proved to be significant and comparable to overground training and swimming exercise may not be such ‘mild’ exercise for all horses as some trainers may expect.

**Acknowledgements**

The authors would like to thank Greg Sommerville and the Veterinary Department at the Hong Kong Jockey Club for their assistance with this project, and Moxie Sports & Analysis for the heart rate equipment.

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Figure 1: Schematic representation of the horse swimming pool at the HKJC. The pool is oval shaped with a separate entrance and exit. Horses are guided in and out by a steep ramp which is covered with rubber tiles. In the middle of the pool is an island, so horses are forced to swim the full circle.

*Figur 1: Schematische Repräsentation des Pferdeswimmingpools bei HTKJC. Der Pool ist oval-förmig mit einem separaten Ein- und Ausgang. Die Pferde können durch eine steile, mit Gummi überzogene Rampe ein- und aussteigen. In der Mitte des Pools befindet sich eine Insel, sodass die Pferde gezwungen sind, eine ganze Runde zu schwimmen.*



Figure 2: Correlation between HR and swimming speed in all horses.

*Figur 2: Der Zusammenhang zwischen HR und der Schwimmgeschwindigkeit aller Pferde.*

Figure 3: Correlation between LA and HR in group B.

*Figur 3: Der Zusammenhang zwischen LA und HR in Gruppe B.*

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