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Survey of trainers on the use of swimming exercise for Standardbred racehorses in Australia

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Objectives To determine swimming training practices in Australian harness racing horses and potential targets for future research.

Methods An online survey of Australian Standardbred trainers and telephone interviews with 20 leading trainers were conducted. Questions relating to swimming facility and protocol, perceived benefits and contraindications were included. Descriptive data analysis was performed.

Results Data were collected from 270 trainers: 250 by online survey (250/1,770, response rate 14.1%) and 20 by interview. Of these, 103 trainers (38.1%), including 91 surveyed trainers (91/250, 36.4%) and 12 interviewed trainers (12/20, 60.0%), used swimming exercise. The most popular reasons for swimming were to replace trackwork for horses with limb injuries (79.4%), improve or maintain fitness (62.7%) and provide mental stimulation through variety in training (40.0%). Free swimming (78.4%) was more common than tethered, but the frequency and duration for horses in full training varied widely between trainers, with a median of four swim sessions per horse each week (range 0.5–12) for a median of 7 min (range 1.5–30 min) per session, mostly as a continuous swim, but sometimes as intervals. The main reasons given by those not swimming horses were lack of an adequate facility (60.5%) and lack of perceived benefit (16.2%). Reasons for not swimming individual horses varied widely.

Conclusions Trainer opinions and protocols varied widely with respect to swimming exercise for Standardbred race horses. The role of swimming exercise requires further study so that evidence-based recommendations can be made.

Keywords cross-training; harness racing; training

Abbreviations EIPH, exercise-induced pulmonary haemorrhage; HR_{max}, maximum heart rate; IQR, interquartile range; MSI, musculoskeletal injury

Swimming may be used as a cross-training tool in the preparation of horses for racing, yet there are limited published studies examining the extent to which it is used, how it is used and its perceived role in current training practices. The optimal use of swimming exercise for the training of horses and in the rehabilitation of horses after injury is unclear. Cardiovascular and respiratory responses to swimming^{1–6} and, to a limited extent, muscle activation during swimming⁷ have been described. Changes in physiological parameters,^{8–10} insulin–glucose metabolism¹¹ and skeletal muscle fibre composition¹² indicate that swimming improves fitness for swimming exercise, but its usefulness in preparing horses for racing is unclear.⁹ Other potential advantages of swimming as cross-training (i.e. reduction in the frequency of musculoskeletal injury (MSI)¹³ and the volume of track-based exercise; improved mental stimulation by providing variety in training) have not been well studied. Swimming horses also has potential disadvantages, including post-swimming colic¹⁴ and skin disease,¹⁵ and there are anecdotal reports of infrequent epistaxis, back soreness, injury or even drowning, the risk of the latter occurring especially during the initial introduction of the horse to swimming exercise. Veterinarians lack the information required to confidently recommend a swimming protocol as part of a horse's training and rehabilitation program.

The aims of this study were to determine (1) the extent to which swimming is used in training Standardbred racehorses in Australia; (2) how swimming is used; (3) perceived benefits, adverse effects and contraindications

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of swimming horses; and (4) whether other forms of water-based exercise are used, with the view to informing future studies. We hypothesised that swimming is commonly used, but that protocols and opinions would vary widely because of unclear beneficial effects and lack of available guidelines. Understanding the range of current practice is the first step towards being able to determine and recommend appropriate practices for specific cases.

Materials and methods

An online survey, digitalised using REDCap (Research Electronic Data Capture, version 6.10.8), was developed after detailed telephone interviews with a trainer with over 50 years' industry experience and a veterinarian/licensed Standardbred trainer. A pilot questionnaire was then refined after trialling it on five trainers. An email outlining the goals of the study with the survey link was sent on 27 May 2017 to 1953 Australian Standardbred trainers listed in the Australian Harness Racing Licencee Directory.¹⁶ A reminder was emailed 2 weeks later. The survey was active for 4 weeks and consisted of 23 questions (Supplementary material), only 5 of which were available if participants selected the response indicating that they did not currently swim horses. Questions required a numerical value to be entered, a 'yes' or 'no' response, a single response from a list of options (with some questions also including a free text option to expand 'other' as a response), a selection of multiple responses from a list with a free text option if 'other' was selected or allowed only a free text response. If trainers provided a range of values (e.g. for number of minutes or days per week swimming), then the mid-point of the range was used for data analysis. Study data were collected and managed using REDCap electronic data capture tools hosted at the University of Melbourne,¹⁷ converted to an Excel spreadsheet (Excel, Microsoft, Redmond, WA, USA) and manually cross-checked for accuracy. Trainers were contacted to clarify incomplete responses and to discuss the swimming technique used if it was not described as free-swimming, if they had provided contact details.

Statistical analysis

Responses to categorical questions are presented as counts and percentages. Data distribution of continuous variables was assessed for normality by examining histograms and Shapiro-Wilk tests using Stata version 15.1 (StataCorp LP; StataCorp, College Station, TX, USA). Data that were not normally distributed are presented as median and range. Differences between interviewed trainers and survey participants were evaluated using Wilcoxon–Mann-Whitney tests. Based on a prevalence of use of swimming exercise by Victorian Thoroughbred trainers of 67%,¹⁸ using a confidence interval of 90% with 80% power and a 5% margin of error, we determined that 213 survey respondents were required to estimate the proportion of trainers swimming in the total registered population.

Twenty trainers (Tr_{interv}) listed in order of wins for the 2016–17 season and/or for the current season as of 1 April 2018,¹⁹ who had not already completed the online survey, were telephoned between 1 April 2018 and 30 April 2018 and invited to participate in a telephone interview conducted by the first author. During the interview, trainers were asked the same questions as the electronic online survey and to outline alternative forms of exercise to traditional track work (jogging and medium to fast work in gear (hopples) similar to racing harness) that were used, notes were made by the interviewer and data was later entered on separate Excel spreadsheet. For describing the protocols used for swimming horses, participants were categorised and analysed in three groups: (1) those responding to the online survey (Tr_{surv}); (2) trainers interviewed (Tr_{interv}) and; (3) the 15 most successful trainers ($Tr_{leading}$) based on number of wins for the 2016–17 and the 2017–18 seasons¹⁹ that used swimming and had either responded to the online survey ($n = 3$) or had been interviewed ($n = 12$). Approval for surveying and interviewing trainers was obtained from the University of Melbourne Human Research Ethics Committee (reference no. 1647536.3).

Results

Of 1953 questionnaires sent, 183 emails failed to send because the addresses were incorrect or no longer in service, resulting in 1770 trainers contacted with 250 trainers responding to the survey link (Tr_{surv} , response rate 14.1%). Of the 20 leading trainers for 2016–17, 14 were interviewed, 4 had responded to the survey link, 1 was not currently registered and 1 was unable to be contacted. An additional 6 of the top 24 trainers for the 2017–18 season were interviewed, resulting in 20 trainers interviewed ($Tr_{interv} = 20$). No trainers declined to participate in telephone interviews and interviews lasted between 10 and 35 min.

Responses from the total of 270 trainers relating to number of years' training experience, number of horses in training during the survey week, whether swimming was currently used, perceived benefits and how trainers developed their protocols are provided in Tables 1 and 2. Tr_{interv} had fewer years' experience, had more horses in training and were more likely to swim horses compared with Tr_{surv} ($P < 0.01$); 91 Tr_{surv} (36.4%) and 12 Tr_{interv}

(60.0% of leading trainers interviewed) used swimming. The proportion of the stable that was swimming was a median of 37.5% and 67.0% for Tr_{surv} and Tr_{interv}, respectively, ranging from 12.5% to 100% according to reasons for swimming. For Tr_{interv}, if the main reason for swimming was to replace some track-based exercise for horses with limb injuries, then $\leq 25\%$ of all horses in the stable swam, whereas if the main reason was to provide an additional training stimulus (typically described as a 'top-up' to track-based exercise) or the trainer perceived that swimming was useful for multiple reasons, then swimming was used in the training of most or all horses in the stable. Of Tr_{surv} and Tr_{interv}, 159 (63.9%) and 8 (40.0%), respectively, did not use swimming for any horses, listing various reasons (Table 2). The two groups were not statistically different in terms of the number of responses giving specific reasons for or against swimming, except that Tr_{interv} were more likely to swim horses for weight management, limb injury prevention and on recovery days ($P = 0.01$) and Tr_{surv} were more likely to swim for mental freshness/variety ($P = 0.01$) (Table 2).

Among the trainers using swimming, reasons reported by 10 trainers not to swim an individual horse were a history of exercise-induced pulmonary haemorrhage (EIPH), horse considered too young (yearlings or 2-year-olds), too stressed/difficult or refuses to get into the pool (10/91, 11.0%; 3/12, 25.0%) and cold weather (8/91, 8.8%; 5/12, 41.7%) (Table 2). Trainers whose main or only reason for swimming was to replace some trackwork for horses with limb injuries did not swim horses they considered sound. Two trainers each reported having a near-drowning and two reported single cases of lacerations or injury associated with swimming. Six Tr_{surv} and four Tr_{interv} stated they had no reason(s) for not swimming a horse.

Data relating to the type of facility and swimming technique used are provided in Table 1. Free-swimming was usually conducted with the horse fitted with a head collar and lead so that the handler could walk beside the horse on the dam-bank, pontoon or jetty ($n = 27$) or pool-side ($n = 28$). Pools used for free-swimming were described as circular ($n = 20$), straight ($n = 7$) or other ($n = 5$). Tr_{surv} swimming at the beach or river without use of a boat ($n = 13$) described a technique with the handler in the water in front of the horse facing it and guiding the horse by the head collar with their feet either side of the horse's neck or on the chest or riding the horse into the water then floating above the horse's forequarters once it was swimming. Tethered swimming was performed with the horse attached by the tail to a rubber bungy so that it swims effectively stationary in a pool ($n = 7$) or dam ($n = 12$).

The stage of training when swimming was introduced varied (Table 1). Most used swimming all year (as proportion and percentage of Tr_{surv}; proportion and percentage of Tr_{interv}) (63/91, 69.2%; 8/12, 66.7%) and the remainder did not swim in winter. Approximately half (44/91, 48.3%) of Tr_{surv} and all Tr_{interv} trained pacers and trotters and reported that the duration, frequency and intensity of swimming exercise when training was similar for each group. Three (3/12, 25%) Tr_{interv} swam 2-year-old horses, but the others did not, preferring to swim older horses.

Frequency and duration of swimming sessions varied widely, with a median of four swim sessions per horse per week (range 0.5–12) for a median of 7 min (range 1.5–30 min). Trainers assessed the intensity of swimming exercise by determining the heart rate after the swim (43/91, 47.2%; 0/12, 0%), respiration rate and effort during and after swimming (30/91, 37.0%; 12/12, 100%), by observation of recovery time (25/91, 27.5%; 0/12, 0%) and by observation of swimming effort (10/91, 11.0%; 10/12, 83.3%). Responses to the questions relating to swimming protocol used when horses were race-fit stratified by Tr_{surv} and Tr_{interv} are summarised in Table 3.

Interviewed trainers indicated that horses were habituated to free-swimming over 2–3 sessions, generally starting with a brief swim of approximately 15 s in duration, increasing to 1 min after around three sessions and then gradually increasing to 4–5 min over about 3 weeks. Habituation to tethered swimming started with several brief free-swimming sessions before the horse was attached to the 'bungy' on the second or third day, swimming tethered for 15–30 s initially, then increasing to 1 min after around three sessions, with any further increases made gradually after that. Tethered swimming was considered more strenuous than free-swimming, with a 2-min tethered swim replacing a 'slow work' jogging day and a 5–8-min (depending on the individual horse) tethered swim the maximum used to replace a 'fast work' session in a fully race-fit horse.

Use of other forms of water-based exercise are indicated in Table 1. Of the 20 leading trainers interviewed, 41.7% (5/12) that used swimming also used a water-walker and 50.0% (4/8) that did not use swimming used a water-walker.

Of the 20 Tr_{interv}, when training horses that had been sufficiently educated and had a balanced gait in hobbles, 12 used swimming as the only form of cross-training or together with use of a heavier jog cart on a flat, medium-depth sand track ($n = 5$), inclined, medium-depth sand track ($n = 2$), water-walker ($n = 3$) or above-ground

treadmill (n = 1). Of the eight leading trainers not using swimming, all but one regularly used an alternative to training on a traditional track surface, including water-walker (n = 3), alternative track described as a medium sand track (n = 2), deep sand (n = 1) or an incline track (n = 3), above-ground treadmill (n = 1) and resistance cart (n = 1).

Discussion

Swimming was an important form of cross-training used by 38.1% of all trainers, including 60% of leading trainers interviewed. Almost two-thirds of those not swimming horses reported lack of an available facility as the reason, suggesting that more trainers would use swimming if they had access to a suitable venue. However, the role of swimming exercise in training horses is unclear, with approximately 16% of all trainers indicating they do not use swimming because of a lack of beneficial effect. Furthermore, of those using swimming, the perceived benefits and contraindications varied.

As hypothesised, there was wide variation in the duration and frequency of swimming exercise used, even despite trainers being asked about protocols for race-fit horses. This may be in part explained by differing facilities, as well as the fact that most trainers reported learning swimming protocols from a mentor or being self-taught, and published guidelines and recommendations appear to be lacking. A common free-swimming program used by leading trainers was, after an acclimation phase of 3 weeks, 4–5 min after slow work and up to 7–10 min once or twice for replacing overground work on some or all slow work days for a horse with a limb injury. Continuous free-swimming was used by all but one leading trainer utilising swimming, yet some trainers preferred to swim in intervals with a variable recovery duration between, regardless of pool design. Whether horses swam continuously or in intervals with rest periods between was likely to depend on facility design and technique used, where, for example, a horse swimming in a straight pool will need to exit the pool after each lap. Pool design may also affect the protocol used, as horses swimming in a round pool, particularly one with a central island, may create a circular current (a ‘whirl pool effect’), which could potentially reduce resistance and make swimming less strenuous. The intensity of swimming exercise can vary and although free-swimming is used most commonly, and was the only method used by leading trainers interviewed, tethered swimming is also used and is likely to be more strenuous.³ A typical swim duration for fit horses conditioned to tethered ‘bungy’ swimming was only 2 min, after work on a ‘slow work’ day, although a maximum duration bungy swim of 7–8 min was recommended.

Another common reason for swimming was to improve or maintain fitness, although as indicated earlier, not all trainers considered swimming to be of benefit. Swimming develops basic aerobic fitness,^{8,12,20,21} yet clear evidence that swimming provides an intense training stimulus is lacking. Davie et al. were unable to demonstrate a beneficial effect for fitness and cardiac dimension changes above that from regular trackwork training after a 9-week swimming program with horses swimming untethered up to 6–8 minutes at their own pace 5 days per week.⁹ The study assessed fitness using a standardised treadmill test in Thoroughbred horses trained under Australian conditions, but was limited to a small number of horses and was disrupted to some extent by the equine influenza outbreak.⁹ Most of the trainers interviewed who used swimming considered it useful for providing a ‘top-up’ to trackwork and maintaining fitness between races, but believed race fitness would start to decline after several weeks if swimming completely replaced trackwork. Some trainers reported improved fitness benefits through increased resistance by using tethered swimming, walking against a current or ridden ‘surging’ through shoulder-depth water at the beach as alternative forms of water-based exercise, but further study is required before recommendations can be made.

Several studies using Standardbred horses suggest that swimming is strenuous yet usually submaximal exercise, associated with a lower maximum heart rate (HR_{max}) and lactate level than strenuous track based exercise.^{1,6} For example, when 10 Standardbred trotters completed 3 × 4 min (900 m) ‘driven’ interval swims (with 3-min rest between), the HR_{max} did not reach that achieved during a fast track work (218–238 beats/min), although it was only 8–10 beats/min less in some cases.¹ When the same horses swam continuously for 800–1200 m at their own pace (a lower speed) HR was 30–40 beats/min less than HR_{max} (158–210 beats/min). Swimming also resulted in a mild to moderate elevation in blood lactate compared with track work: 3–9 mmol/L after swimming, with the higher end of the range occurring after ‘driven’ interval swimming, and 11–19 mmol/L after strenuous trotting.¹ However, despite the lower HR_{max} and lactate associated with swimming exercise, it is possible that the perceived level of exertion is as great when swimming as when exercising over ground. Although some trainers indicated they assess HR in association with swimming exercise, most do not and rely

on observation of the breathing effort during and recovery after swimming. These trainers presumably assess HR immediately after horses exit the pool rather than during swimming, as in our experience few trainers have a fully waterproof HR monitor and assessment of HR during swimming is difficult and often unreliable. The most common reason for swimming was to replace some track-based exercise for horses with limb injuries. However, few trainers specified that swimming was used to prevent MSI. Most leading trainers used an alternative form of exercise that employed resistance training for mature horses, at least to some extent, with exercise in sand being most popular, indicating that injury prevention may be a consideration even if they did not specify this. This is of interest because distance covered at speed is a risk factor for MSI, at least in Thoroughbred race horses.^{22–28} In comparison, the effect of the accumulation of exercise at speed on risk of MSI in Standardbreds has not been well studied. Limited reports indicate that the risk is greatest with training programmes that are most intense in terms of weekly duration and weekly duration of exercise performed at maximal effort.^{29,30} A training program with a 30% reduction in the high-intensity distance covered during the first few years of training in Swedish Standardbreds was equally as effective in achieving performance goals and was associated with fewer lost training days.^{31,32} Variation in training (cross-training) reduced the days-lost to training and competition from orthopaedic injury in elite show-jumpers,³³ yet benefits of variation in activity have not been studied in Standardbreds. Therefore, although strong evidence is lacking, it seems logical to replace some trackwork with other forms of training that would result in less overloading and cumulative stress on the musculoskeletal system rather than to subject horses to excessive track-based workloads, particularly those with MSI. However, the optimal means of achieving this is largely unknown and likely to vary among individual horses.

Using swimming to provide variety in the training program and to enhance ‘mental freshness’ were also popular reasons for swimming. This effect in horses would be difficult to measure; however ‘staleness’ or overtraining is recognised in human athletes.³⁴ Even this potential benefit of swimming was not accepted by all trainers interviewed, with several believing that horses responded better to a consistent routine with a lack of variety. To date there is minimal evidence to recommend specific alternative forms of exercise for the prevention or rehabilitation of various injuries. Underwater treadmills have received more attention as water-based rehabilitation tools for use in horses,¹⁵ yet were not used by trainers in this study, presumably because of the cost of purchase and maintenance. Some trainers used water-walkers, in which horses walk in a channel of water (usually circular) at variable speed (10–25 km/h) and resistance (water depth 0.95–1.1 m, with or without a mechanism to reduce the ‘whirl pool’ effect or to create a current against the direction of walking), either regularly or occasionally for individual horses, particularly for rehabilitation of leg injuries, and/or waded horses at the beach. Further investigation into the role of swimming compared with other forms of water-based exercise is warranted as it is the most widely used water-based training tool among Australian Harness Racing trainers. It should be kept in mind that some track-based speed work is necessary to adapt the musculoskeletal system to the loads sustained in racing,^{28,35} although this consideration has not been well studied in harness racing horses. Land-based exercise (track or treadmill) is also likely needed to adapt mechanisms of thermoregulation because water has greater thermal conductivity than air and can therefore have a significant effect on body temperature during exercise.³³ Swimming may not recruit muscle groups used in racing in the same way as track-based exercise. Further work is required to determine whether regular swimming exercise affects the way horses move over land, considering factors such as stride variables and postural stability and implications for risk of injury. The extent to which swimming may be a suitable substitute for trackwork may also vary according to the age of the horse and its stage of fitness.

Swimming was considered relatively safe and suitable for most horses, yet not completely without risk of drowning or serious injury. Contraindications were only reported by a minority of trainers who utilised swimming. Although 13% of Tr_{surv} and one Tr_{interv} did not swim horses with previously diagnosed EIPH, the others did not believe swimming increased the risk of EIPH. Only 6% of Tr_{surv} believed back soreness was a contraindication to swimming. Responses varied among Tr_{interv} , with trainers having no opinion, believing it helped some cases or exacerbating the condition. The ‘head up’ posture and buoyancy of the trunk when horses walk in stifle-depth water is associated with an increased range of motion of the thoracolumbar spine because of the increased cranial thoracic extension and thoracolumbar flexion.³⁷ However, the effect of swimming on the kinematics of the back has not been studied to our knowledge and the role of swimming exercise in inducing or conversely in preventing or managing back soreness is unknown.

Trainers were asked to comment on the average frequency and duration of swimming sessions, yet the swimming ability and effort of individual horses may vary and should be considered. A further limitation was the low response rate to the survey, although we did collect data from a larger number of trainers than estimated from our power calculation. The email distributed to all trainers contained the statement ‘even if you do not swim horses we still value this information greatly for our research’ to try to reduce non-response bias. An online survey has the potential for poor reliability and validity because of the inability to explain questions, with results dependent on how questions are interpreted, inability to clarify responses, including incomplete responses, and access to the internet being required. As interviews are time-consuming, they were only used for a smaller subset of leading trainers. The use of open-ended questions allowed trainers to answer without bias and provided a wider variety of answers; however, sometimes responses were unclear and difficult to interpret.

Conclusions

The variety of opinions and protocols used indicated that optimal methods and benefits of swim training in Standardbred racehorses are unclear. An individual horse’s responses to swimming should be monitored within each session and over time to ensure the horse is responding in a way that supports claims of benefits. Possibly aside from the resistance-training effect of work in heavier sand and with a heavier cart, swimming appears to be the most widely used form of cross-training, and therefore a better understanding of its role is needed. More research is needed to determine the benefits, if any, of swimming exercise for racing success and longevity, the effects of variations in intensity, duration, repetition and frequency, and how to best incorporate swimming into a horse’s training program. This knowledge could be important for performance, but also for the welfare of horses.

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References

1. Asheim A, Knudsen O, Lindholm A, et al. Heart rates and blood lactate concentrations of Standardbred horses during training and racing. *J Am Vet Med Assoc* 1970;157:304–312.
2. Milne DW, Muir WW, Skarda RT et al. The hemodynamic response of the horse to swimming with and without furosemide. *J Equine Med Surg* 1977;1:331–335.
3. Thomas DP, Fregin F, Gerber NH et al. Cardiorespiratory adjustments to tethered-swimming in the horse. *Pflug Arch Eur J Phys* 1980;385:65–70.
4. Jones JH, Cox KS, Takahashi T et al. Heterogeneity of intrapleural pressures during exercise. *Equine Vet J Suppl* 2002;34:391–396.
5. Hobo S, Yoshida K, Yoshihara T. Characteristics of respiratory function during swimming exercise in thoroughbreds. *J Vet Med Sci* 1998;60:687–689.
6. Jones S, Steel C, Franklin S. Respiratory responses to tethered swimming exercise in horses. In: Proceedings of the World Equine Airway Symposium, Copenhagen, Denmark. July, 2017:140.
7. Tokuriki M, Ohtsuki R, Kai M et al. EMG activity of the muscles of the neck and forelimbs during different forms of locomotion. *Equine Vet J* 1999;31:231–234.
8. Garcia MC, Beech J. Endocrinologic, hematologic, and heart rate changes in swimming horses. *Am J Vet Res* 1986;47:2004–2006.
9. Davie A, Savage CJ, Fennel L. *The effect of swimming training on the cardiac dimensions in thoroughbred horses*. Rural Industries Research and Development Corporation, Barton, ACT, 2008.
10. Kang O-D, Ryu Y-C, Yun Y-M et al. Physiological changes in Jeju crossbred riding horses by swim training. *Asian-Aust J Anim Sci* 2012;25:200–206.
11. Bonelli F, Sgorbini M, Meucci V et al. How swimming affects plasma insulin and glucose concentration in Thoroughbreds: a pilot study. *Vet J* 2017;266:1–3.
12. Misumi K, Sakamoto H, Shimizu R. Changes in skeletal muscle composition in response to swimming training for young horses. *J Vet Med Sci* 1995;57:959–961.
13. Walmsley E, Steel C, Haines G et al. Colic after swimming exercise in racehorses: an investigation of incidence, management, surgical findings and outcome. *Aust Vet J* 2011;89:180–183.

14. Misumi K, Sakamoto H, Shimizu R. The validity of swimming training for two-year-old Thoroughbreds. *J Vet Med Sci* 1994;56:217–222.
15. Tranquille CA, Tacey JB, Walker VA et al. International survey of equine water treadmills: why, when and how? *J Equine Vet Sci* 2018;69:34–42.
16. Australian Harness Racing. Licensee directory. <https://www.harness.org.au/apps/lhd:main>. Accessed January 2017.
17. Harris PA, Taylor R, Thielke R et al. Research electronic data capture (REDCap): a metadata-driven methodology and workflow process for providing translational research informatics support. *J Biomed Inform* 2009;42:377–81.
18. Morrice-West AV, Hitchens PL, Walmsley EA et al. Track surfaces used for ridden workouts and alternatives to ridden exercise for Thoroughbred horses in race training. *Animals* 2018;8:221.
19. Harness Racing Australia. National top 20 statistics 2016/17. <https://www.harness.org.au/ausbreed/reports/top20/index.cfm/trainers/default/sort/wins/seasonId/499?d=31072018>. Accessed April 2018.
20. Misumi K, Hirakawa A, Sakamoto H et al. Principal component analysis, using the measurements during running and swimming test, in thoroughbred horses. *J Vet Med Sci* 1994;56:1075–1080.
21. Misumi K, Sakamoto H, Shimizu R. Changes in blood lactate and heart rate in thoroughbred horses during swimming and running according to their stage of training. *Vet Rec* 1994;135:226–228.
22. Boston RC, Nunemaker DM. Gait and speed as exercise components of risk factors associated with onset of fatigue injury of the third metacarpal bone in 2-year-old Thoroughbred racehorses. *Am J Vet Res* 2000;61:602–608.
23. Estberg L, Gardner IA, Stover SM et al. Cumulative racing-speed exercise distance cluster as a risk factor for fatal musculoskeletal injury in Thoroughbred racehorses in California. *Prev Vet Med* 1995;24:253–263.
24. Parkin TD, Clegg PD, French NP et al. Horse-level risk factors for fatal distal limb fracture in racing Thoroughbreds in the UK. *Equine Vet J* 2004;36:513–519.
25. Parkin TD, Clegg PD, French NP et al. Race and course level risk factors for fatal distal limb fracture in racing Thoroughbreds. *Equine Vet J* 2004;36:521–526.
26. Pinchbeck GL, Clegg PD, Boyde A et al. Horse-, training- and race-level risk factors for palmar/plantar osteochondral disease in the racing Thoroughbred. *Equine Vet J* 2013;45:582–586.
27. Martig S, Chen W, Lee PVS et al. Bone fatigue and its implications for injuries in racehorses. *Equine Vet J* 2014;46:408–415.
28. Verheyen K, Price J, Lanyon L et al. Exercise distance and speed affect the risk of fracture in racehorses. *Bone* 2006;39:1322–1330.
29. Hamlin MJ, Hopkins WG. Retrospective trainer-reported incidence and predictors of heath and training-related problems in Standardbred racehorses. *J Equine Vet Sc* 2003;23:443–452.
30. Steel CM, Hopper BJ, Richardson JL et al. Clinical finding, diagnosis, prevalence and predisposing factors for lameness localised to middle carpal joint in young Standardbred racehorses. *Equine Vet J* 2006;38:152–157.
31. Ringmark S, Jansson A, Lindholm A et al. A 2.5 year study on health and locomotion symmetry in young Standardbred horses subjected to two levels of high intensity training distance. *Vet J* 2016;207:99–104.
32. Ringmark S, Roepstorff L, Hedenström U et al. Reduced training distance and a forage-only diet did not limit race participation in young Standardbred horses. *Comp Exerc Physiol* 2017;13:265–272.
33. Egenvall A, Tranquille CA, Lönnell AC et al. Days-lost to training and competition in relation to workload in 263 elite show-jumping horses in four European countries. *Prev Vet Med* 2013;112:387–400.
34. Tanaka H. Effects of cross-training. Transfer of training effects on VO₂max between cycling, running and swimming. *Sports Med* 1994;18:330–339.
35. Firth EC. The response of bone, articular cartilage and tendon to exercise in the horse. *J Anat* 2006;208:513–526.
36. Lindinger, MI. Exercise in the heat: thermoregulatory limitations to performance in humans and horses. *Can J Appl Physiol* 1999;24:152.

37. Nankervis K, Finney P, Launder L. Water depth modifies back kinematics of horses during water treadmill exercise. *Equine Vet J* 2016;48:732–736.

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Table 1. Trainer responses to questionnaire regarding use of swimming as median (range) and counts (percentages)

Outcomes or responses to questionnaire	Surveyed trainers (Tr _{surv}) (n = 250)	Interviewed trainers (Tr _{interv}) (n = 20)	P value ^a	All trainers
No. years' experience in the industry	20 (IQR 4–40; range 4–60)	15 (IQR 10–25; range 5–50)	<0.001	30 (IQR 20–40; range 4–60)
No. horses currently in training	3 (IQR 2–7; range 0–60)	38.5 (IQR 27.5–45; range 20–90)	<0.001	4 (IQR 2–9; range 0–90)
Currently swimming horses?	91 (36.4%)	12 (60.0%)	0.04	103/270 (38%)
How trainer learnt swimming protocol ^a				76/103 (73.8%)
From mentor (family member or another trainer)	66/91 (72.5%)	10/12 (83.3%)	0.42	40/103 (38.8%)
Self-taught over time	32/91 (35.2%)	8/12 (66.7%)	0.04	14/103 (13.6%)
Heard about how another trainer does it	14/91 (15.4%)	0/12 (0%)	0.14	3/103 (2.9%)
Read about it	3/91 (3.3%)	0/12 (0%)	0.52	1/103 (0.9%)
Other	1/91 (1.1%)	0/12 (0%)	0.72	
Facility used				58/103 (56.3%)
Private dam	48/91 (52.7%)	10/12 (83.3%)	0.62	16/103 (15.5%)
Private pool	15/91 (16.5%)	1/12 (8.3%)	0.46	12/103 (11.7%)
Shared pool at track	12/91 (13.2%)	0/12 (0%)	0.18	13/103 (12.6%)
Beach	13/91 (14.3%)	0/12 (0%)	0.16	4/103 (3.9%)
Other (river, creek)	3/91 (3.3%)	1/12 (8.3%)	0.40	
Swimming technique				81/103 (78.6%)
Free	69/91 (75.8%)	12/12 (100%)	0.05	19/103 (18.4%)
Tethered by 'bungy'	19/91 (20.9%)	0/12 (0%)	0.08	3/103 (2.9%)
Behind boat	3/91 (3.3%)	0/12 (0%)	0.52	
Use of other water-based exercise				17/111 (15.3%)
Water walker	8/91 (8.8%)	9/20 (45.0%)	<0.001	20/111 (18.0%)
Beach wading or surging	20/91 (22.0%)	0/20 (0%)	0.02	1/111 (0.9%)
Underwater treadmill	0/91 (0%)	0/20 (0%)	0.64	
Wading in dam	1/91 (1.1%)	0/20 (0%)		

^aDifferences between interview and surveyed groups assessed by Wilcoxon–Mann–Whitney tests (non-normally distributed data). Count data between groups were assessed by chi-square tests.

^bMultiple responses could be selected to the question so percentages of trainers selecting each response may total > 100%.

Table 2. Reasons given by Australian Standardbred horse trainers for and against swimming horses, collected through online survey and interviews

Outcomes or responses to questionnaire	Surveyed trainers (Tr _{surv}) (n = 250)	Interviewed trainers (Tr _{interv}) (n = 20)	P value ^a	All trainers
Main reasons for not swimming any horses^a				
Facility not available	97/159 (61.0%)	4/8 (50.0%)	0.53	101/167 (60.5%)
Perceived lack of benefit	24/159 (15.1%)	3/8 (37.5%)	0.09	27/167 (16.2%)
Unfamiliar with use	7/159 (4.4%)	0/8 (0%)	0.36	7/167 (4.2%)
None with limb injuries	8/159 (5.0%)	1/8 (12.5%)	0.40	9/167 (5.4%)
Stage training or too young	10/159 (6.3%)	0/8 (0%)	0.47	10/167 (6.0%)
Weather too cold	4/159 (2.5%)	0/8 (0%)	0.65	4/167 (2.5%)
Too time-consuming	3/159 (1.9%)	0/8 (0%)	0.70	3/167 (1.9%)
Water-walker instead	4/159 (2.5%)	0/8 (0%)	0.65	4/167 (2.5%)
Cost	1/159 (0.6%)	0/8 (0%)	0.82	1/167 (0.6%)
Risk	1/159 (0.6%)	0/8 (0%)	0.82	1/167 (0.6%)
Main reasons for not swimming certain horses				
EIPH	12/91 (13.2%)	1/12 (8.3%)	0.63	13/167 (7.8%)
Too young	11/91 (12.1%)	2/12 (16.7%)	0.65	13/167 (7.8%)
Stressed/difficult/refuses	10/91 (11.0%)	3/12 (25.0%)	0.17	13/167 (7.8%)
Cold weather	8/91 (8.8%)	5/12 (41.7%)	0.001	13/167 (7.8%)
Poor swimming ability	6/91 (6.6%)	0/12 (0%)	0.36	6/167 (3.6%)
Lack of time/personnel	5/91 (5.5%)	0/12 (0%)	0.41	5/167 (3.0%)
Back issues	5/91 (5.5%)	1/12 (8.3%)	0.69	6/167 (3.6%)
Open wounds	5/91 (5.5%)	0/12 (0%)	0.41	5/167 (3.0%)
Lack improvement/decreased performance	4/91 (4.4%)	0/12 (0%)	0.46	4/167 (2.4%)
Performing satisfactorily without swimming	1/91 (1.1%)	0/12 (0%)	0.72	1/167 (0.6%)
Previous swim colic	3/91 (3.3%)	0/12 (0%)	0.40	4/167 (2.4%)
Inability to hold condition	3/91 (3.3%)	1/12 (8.3%)	0.24	3/167 (1.8%)
Previous throat surgery	2/91 (2.2%)	1/12 (8.3%)	0.00	2/167 (1.2%)
Exertional myositis	0/91 (0%)	2/12 (16.7%)	0.74	1/167 (0.6%)
Lazy swimmer ("floater")	1/91 (1.1%)	0/12 (0%)	0.74	1/167 (0.6%)
	1/91 (1.1%)	0/12 (0%)		
Main reasons for swimming^b				
To improve fitness	58/91 (63.7%)	7/12 (58.3%)	0.72	65/103 (63.1%)
Maintain fitness between races	41/91 (45.1%)	3/12 (25%)	0.19	44/103 (42.7%)
Before track exercise for horses prone to myositis	2/91 (2.2%)	0/12 (0%)	0.60	2/103 (1.9%)
Replace some trackwork for horses with limb injury	71/91 (78.0%)	11/12 (92%)	0.27	82/103 (79.6%)
Mental freshness/variety	48/91 (52.7%)	2/12 (16.7%)	0.01	50/103 (48.6%)
Manage heavy horses	8/91 (8.8%)	5/12 (41.7%)	0.001	13/103 (12.6%)
Prevention of limb injuries	2/91 (2.2%)	5/12 (41.7%)	<0.001	7/103 (6.7%)
Cool down after track work	14/91 (15.4%)	1/12 (8.3%)	0.52	15/103 (14.6%)
Recovery day after hard work	0/91 (0%)	2/12 (16.7%)	<0.001	2/103 (1.9%)
Muscle development/strength	3/91 (3.3%)	0/12 (0%)	0.52	3/103 (2.9%)
Help respiratory function	2/91 (2.2%)	0/12 (0%)	0.60	2/103 (1.9%)

^aDifferences between groups for count data assessed by chi-square tests.

^bMultiple responses could be selected to the question so percentages of trainers selecting each response may total > 100%. EIPH, exercise-induced pulmonary haemorrhage.

Table 3. Swimming protocols used for Australian Standardbred horses in full race training as median

Type of training	Surveyed trainers (Tr _{surv})			Interviewed trainers (Tr _{interv})		
	n = 91			n = 12		
Continuous	Free n = 52	Tethered n = 17	Behind boat n = 1	Free n = 11	Tethered n = 0	Behind boat n = 0
Frequency (times per week) ^a	4 (IQR 3–5; range 1–12)	4 (IQR 3.5–6; range 2–7)	3 ^b	4.0 (IQR 2.5–6.0; range 2–6)	–	–
Duration (min)	8.0 (IQR 5–15; range 1.5–30)	4 (IQR 3–5; range 2–12)	4	4.5 (IQR 4–8; range 3–10)	–	–
Interval	n = 16	n = 2	n = 2	n = 1	n = 0	n = 0
Frequency (times per week)	3 (IQR 2–4; range 0.5–7)	6, 7	2, 3	2.5	–	–
Duration (min)	10.0 (IQR 10–20; range 3–30)	4, 7	10, 30	4.5	–	–
No. of intervals	2	2	2	2	–	–
Rest between intervals (min)	5.0 (IQR 3–5; range 0.75–12.5)	3.5, 5	0.5, 10	1	–	–

^aIf trainers provided a range then the mid-point was taken for analysis.

^bWhere n d 2, individual responses are reported. IQR, interquartile range.

Supporting information

Additional supporting information may be found in the online version of this article at the publishers website: ?????

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