

Physiological responses of the Australian cattle dog to mustering exercise

BA Hampson and CM McGowan^{†,*}

The Faculty of Natural Resources, Agriculture and Veterinary Science, The University of Queensland, Gatton 4343, Brisbane, Australia

* Corresponding author: catherine.mcgowan@helsinki.fi



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Research paper

Abstract

The aim of this study was to determine the heart rate (HR) and work variables of working cattle dogs during actual mustering exercise using a global positioning satellite (GPS) tracking unit[‡] with an integrated HR monitor[§]. The GPS units allowed tracking of seven different Collie and Kelpie working cattle dogs over a total of ten sessions while employed in their usual role of mustering cattle in three locations in Queensland, Australia. Speed, distance and HR data were collected from the dogs during mustering in a variety of working situations. The working dogs covered distances between 13.3 and 30.2 km during mustering sessions ranging from 1 h 59 min to 4 h 24 min at working speeds of up to 43.7 km h⁻¹. Working temperatures ranged from 29 to 38°C. HR during working exercise ranged between 120 and 237 bpm and was above 180 bpm for 51–68% of the duration of work sessions. There was a positive linear relationship between speed and HR until HR_{max} (speed 26.0 km h⁻¹, 233 ± 4.2 bpm), then HR plateaued ($R^2 = 97.14\%$, $P < 0.001$). This study has documented the type of work done by cattle dogs and has shown that GPS devices and HR monitors can be utilized in field conditions to assess the exercise physiology of dogs.

Keywords: exercise; heart rate; velocity; Australian cattle dog; GPS

Introduction

Very little is documented about the physiology of exercise of Australia's working cattle dogs despite their vital role in the cattle and sheep industries. The majority of graziers and drovers employ the working dog to assist in control of and movement of stock.

Global Positioning Satellite (GPS)-based technology has been used by human athletes for some time as a training tool to accurately measure position, distance and speed variables during training^{1–4}. Witte and Wilson³ reported speed accuracy of 0.4 m s⁻¹ in agreement with GPS manufacturers' reports. Integrated heart rate (HR) monitors have been used in combination with GPS systems to assess the human athlete's physiological responses to exercise⁵. More

recently, GPS technology has been validated and used in equine training^{6–8}. GPS technology has also been used to track small mammals and birds⁹. Ahlstrom *et al.*¹⁰ demonstrated that GPS can accurately measure running distance in hunting dogs.

It was hypothesized that the same technology could be used to measure these variables in the cattle-working dog. The collection of HR and workload data in canine studies is limited. One study by Van Citters and Franklin¹¹ reported using implanted measuring equipment combined with radiotelemetry to investigate physiological responses of Huskies to sled pulling. This study produced some fascinating data but was limited by the robustness of the measuring devices (169.9 kg) and could not be repeated today due to ethical reasons. The GPS system in contrast is lightweight (110 g) and non-invasive.

The aim of this study was to investigate the use of GPS and HR monitor transmitter technology to measure the work variables and HR response of the working cattle dog during mustering.

[†]Present address: Department of Equine and Small Animal Medicine, Faculty of Veterinary Medicine, University of Helsinki, PO Box 57 (Viikintie 49), 00 014 University of Helsinki, Finland.

[‡]The SPI 10 Sports Performance Indicator global positioning satellite unit, GPSports, Canberra. www.gpsports.com

[§]Polar HR monitor, Polar Electro Europe, Switzerland.

Materials and methods

The study was approved by the Institutional Animal Ethics Committee.

GPS tracking device

The GPSports Systems SPI 10 Sports Performance Indicator, utilizing GPS technology and HR measuring technology, was used to measure and record position, speed, distance and HR throughout an exercise session. Software adjustments by the manufacturer allowed the technology designed for human sports use to be modified for the purpose of tracking the working dog by increasing maximum HR recording from 240 to 300 bpm and maximum tracking time from 4 to 8 h duration.

GPS speed, distance, altitude and position data were logged at 1-s intervals. HR was recorded continuously. The analysis software allowed storage and presentation of the data.

The SPI 10 GPS unit weighed 110 g and was mounted on the back of the dogs inside a lycra suit designed for the study (Fig. 1). The unit had a minimal distance and positioning accuracy of 0.5% under ideal unobscured conditions during manufacturer trials of cycling events. The HR monitor had an accuracy of 1% up to 300 bpm (manufacturer's specifications) and was tested by the supplier. Due to the tendency of working dogs to stand or lie in water when able while they are working, it was necessary to waterproof the GPS unit inside a zip-lock plastic bag. The GPS unit must have a clear view of the sky to allow satellite tracking, so must be located on the dog's back and is designed for mounting inside a material backpack.

HR monitors

Several HR monitors were trialled during the pre-trial period with the best recordings from the Polar



FIG. 1 Border Collie dog wearing the lycra suit designed for the study with the SPI 10 GPS unit mounted on its back inside the suit and the Polar Equine Heart Rate Monitor transmitter attached to the lycra suit over the shoulder

Equine HR Monitor. Electrode placement was important to obtain a good signal, with the positive electrode positioned caudal and dorsal to the right scapula, the negative electrode positioned just caudal to the left axilla, while the transmitter was placed on the lycra suit over the shoulder. Dogs had hair clipped over electrode placement sites and electrode gel was used to improve contact. Electrodes were secured by velcro to the inside of the lycra suit so that the suit held the position of the electrodes on the dog.

Dogs

Dogs ($n = 7$) aged 4.9 ± 2.7 years consisted of three teams:

Team A consisted of two purebred Border Collies, selectively bred for cattle handling. The dogs were owned by a full-time grazier and used for mustering cattle on an average of 3 days per week throughout the year. Cattle mustering sessions typically averaged 3-h duration. On rest days, dogs ran freely for *c.* 1 h and were otherwise tethered on a long chain. The 2000 acres property on which Team A trials were run was in the Brisbane Valley, South East Queensland. Mustering occurred over 2 days and cattle included 50 Brahman cows and calves, 100 Charolais cows and calves and 44 bulls.

Team B consisted of a purebred Kelpie and a Border Collie. These dogs ran an estimated 5–20 km daily throughout the year and mustered cattle weekly. Team B dogs were measured at work on a 15 000 acres block at Marlborough, Central Queensland. Cattle worked were 300 head of 2-year-old Brahman cross heifers.

Team C consisted of three Border Collie/Kelpie cross dogs working at Nebo, on a 35 000 acres Brigalow block in Central Queensland. These dogs were active with property work daily throughout the year and mustered cattle seasonally. Day 1 featured mustering of 530 head of Brahman cross cows and calves, while dogs mustered 350 Brahman cows and calves on day 2.

Cattle-mustering sessions

Two dogs were tracked on each cattle-mustering session which included all of the herding work performed on the day. Tracking commenced as stockmen were heading off for cattle mustering and finished when stockmen completed the session. On two occasions when dogs were not working for extended periods, while yard work and dipping was being done on foot without dogs, dogs were tied up and GPS units paused. GPS units were then restarted as the dogs' work recommenced, giving a complete time and activity statement for the dog for the day's work. The dogs remained under the control of the usual handler

who was on horseback and performed their normal work routine, unrestricted by the tracking activity. The researcher was also on horseback and kept in touch with the dogs to ensure the safety of the tracking equipment and to observe the dogs' activity during tracking.

Dogs were allowed to drink and swim to cool off at will, whenever water was available. Any effect on HR recording was observed to be minimal.

The line of best fit was modelled for HR and speed data and assessed using the coefficient of determination (R^2) in Microsoft excel (2003, Microsoft corporation).

Results

GPS tracking

Seven dogs were tracked during ten mustering sessions in three different locations with topography ranging from flat to mountainous. GPS speed and position data were never interrupted and allowed continuous recording for mustering exercise sessions ranging from 1 h 59 min to 4 h 24 min at 1-s intervals. Both horizontal and vertical travels were recorded. Dogs covered a range of distances from 13.3 to 30.2 km, while vertical displacement ranged from 20 to 113.5 m. Maximum speed recorded was 43.7 km h^{-1} , but averaged $34.6 \pm 5.1 \text{ km h}^{-1}$ (Table 1). Despite the intensity and duration of exercise and the high ambient temperature, the dogs did not display any signs of fatigue at the end of the mustering sessions.

HR data

HR data were occasionally interrupted when dogs swam in water holes to cool down, but were quickly regained when the dog left the water. Ambient temperature ranged $35\text{--}36^\circ\text{C}$ at property A, $29\text{--}36^\circ\text{C}$ at property B and $37\text{--}38^\circ\text{C}$ at property C. Due to the high ambient temperature, dogs were regularly swimming when water was available. Maximum HR for all dogs was $233 \pm 4.2 \text{ bpm}$ (range 226–237 bpm). Time

spent at maximum HR was brief and coincided with short intermittent high-speed sprints. The majority of work (51–68%) was performed at HRs over 180 bpm. The time spent between 90 and 100% HR_{max} (203–237 bpm) was 32–39%, 80 and 90% HR_{max} (180–203 bpm) was 19–29%, 70 and 80% HR_{max} (158–180 bpm) was 21–26%, and 60 and 70% HR_{max} (135–158 bpm) was 6–14% with 0–14% of the time spent at $<60\% \text{HR}_{\text{max}}$ ($<135 \text{ bpm}$).

Speed versus HR

The speed *versus* HR relationship was determined for six dogs (Fig. 2) during mustering sessions of 2 h to 4 h 24 min. The seventh dog was not included due to prolonged loss of electrode contact.

The line of best fit for the relationship between speed and HR was represented by bisecting lines ($R^2 = 97.14\%$, $P < 0.001$). The relationship between HR and speed was positive, with the slope of HR represented by $104.2 + 4.87 \times \text{speed} (\text{km h}^{-1}) \text{ bpm}$. At 26.0 km h^{-1} , the line plateaued at the maximum HR between 226 and 237 bpm (233 ± 4.2) (Fig. 2).

Discussion

This study has described the HR speed relationship in working dogs with the line of best fit representing a linear increase of HR with increasing speed up until a speed of 26 km h^{-1} and then a plateau (HR_{max}). The GPS tracking unit proved a reliable source of speed, position and distance data in the real mustering situation, with no effect reported on the dogs' performance as observed by the dog owners present during all sessions. Derived variables including HR_{max} , speed at HR_{max} and the HR speed relationship were easily obtained. The dogs appeared to ignore the application of the lycra suit and dog owners reported no variation in the dogs' normal mustering behaviour. While the effect of the lycra suit in dogs is unknown, Gavin *et al.*¹² in assessing the thermoregulation, HR and comfort response of lycra fabric clothing in

Table 1 Duration, distance, maximal speed and HR for seven dogs during ten mustering sessions on three different properties

Dog	Duration	Max speed (km h^{-1})	HR_{max} (bpm)	Distance (horizontal) (km)	Vertical range (m)
Buddy	3 h 22 min	43.7	235	16.9	55
Wally	3 h	30.5	227	18.6	113.5
Wally	2 h	34.8	230	14.5	65
Daf	4 h 24 min	37.0	233	27.6	40
Daf	3 h 37 min	37.4	–	21.5	52
Joker	3 h 31 min	41.1	–	24.1	85
Tip	4 h 21 min	31.6	237	30.2	20
Buddy	1 h 59 min	28.0	–	13.3	102
Darcy	2 h 6 min	29.1	226	16.9	34
Coco	2 h	32.8	236	17.57	28
Average	3 h 2 min	34 ± 5.1	232 ± 4.4	20.1 ± 5.6	59.5 ± 31.7

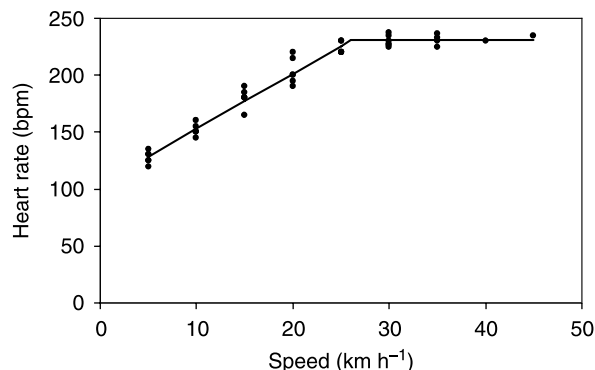


Fig. 2 Speed (km h^{-1}) versus heart rate (HR) (bpm) response for six dogs during mustering sessions of 2–4 h 24 min duration (scatterplot and line of best fit). The relationship between HR and speed is positive until the speed of 26.0 km h^{-1} , where it plateaus ($R^2 = 97.14\%$, $P < 0.001$)

warm conditions in human athletes also found no effect on performance.

Up to 4.5 h, tracking time was recorded during a single mustering session at 1-s sample intervals. Downloading of data from the tracking unit to laptop software and recharging of the GPS units in remote locations were simple with availability of 12 V car chargers. Recharging required 2 h for completion. The Equine Polar HR Monitor served the purpose of giving constant and reliable data while the dogs were on dry land. When dogs swam to cool down, which was frequent when water was available, ballooning of the suit and perhaps polarizing disabled the electrode contact and interrupted monitoring. This effect was only short term. The velcro-mounted lycra suit electrode attachments maintained electrode contact consistently at other times.

The workload produced by the dogs was considerable. The distances travelled by dogs in this study were between 13.3 and 30.2 km in 2.0–4.5 h mustering sessions. Stepien *et al.*¹⁵ trained a group of 77 Huskies pulling a sled for an average of 20 km day^{-1} for 5 months, with no dropout during this 5-month period. While the current study did not follow the cattle dogs in the longer term, daily work distances were comparable to the athletic Husky dogs in training¹⁵.

Cattle-working dogs in this study had maximum HRs recorded at 226–237 bpm. This was shown by no further increase despite increasing speed¹⁴. This is lower than has been previously reported in athletic dogs. Alaskan sled dogs have been measured while performing sled pulling at 25 km h^{-1} for several hours with typical HRs of 280–300 bpm¹³. The mongrel dog has a HR_{max} of $c. 301 \pm 12 \text{ bpm}$ that was measured in dogs working at $\text{VO}_{2\text{max}}$ on a 16 or 20% incline at 15.8 and 11.7 km h^{-1} , respectively¹⁵. The racing greyhound has a HR_{max} of up to 318 bpm¹⁶. Despite the lower mean HR_{max} , dogs in this study had similar HR_{max} values, and speed at which HR_{max} was achieved was consistent between

the six dogs. The dogs were not all the same breed, with Border Collies, Kelpies and crossbred dogs in the study, but the similarity between their HR variables may indicate consistent baseline fitness in all dogs. Cattle-working dogs are largely selected for independent herding ability, cattle sense and obedience rather than purely athletic ability. This may be the reason that this type of dog possesses lower maximum HR ranges than other athletic breeds. This view is supported by the observation of dog owners that, as herding dogs become more experienced, they travel less distance and at lower speeds to accomplish the same job. Younger, less experienced dogs tend to waste energy on unnecessary travel and tend to increase stress on stock. This quality is deselected from breeding programmes. It is also noteworthy that cattle-working dogs are generally not regularly trained as are greyhounds and sled dogs. Most dogs living on cattle properties in Queensland spend the majority of the day tethered, with a short run twice daily for hygiene. Cattle-mustering work is seasonal, occurring four to six times annually for 1- to 2-week bouts and provides the only active period for dogs to develop cardiovascular fitness.

HRs in excess of 180 bpm (80% HR_{max}) were recorded for over half (51–68%) of the work sessions lasting 2 h to 4 h 21 min (mean, 3 h 2 min), indicating that dogs can maintain work at loads in excess of 80% maximum HR for extended periods of time. This workload was performed by the dogs in challenging conditions with temperatures as high as 38°C without signs of fatigue. This impressive work capability is, however, not surprising when compared to Alaskan sled dogs that have shown typical HRs of 280–300 bpm, which is $>80\% \text{ HR}_{\text{max}}$ ¹³ while performing sled pulling at 25 km h^{-1} for several hours. Perhaps, the unique quality of the Australian cattle dog is the ability to work at high work load for extended periods during high environmental temperatures up to 38°C .

In conclusion, this study has shown that GPS technology can be applied to working cattle dogs allowing speed, position and distance data as well as derived variables. Working cattle dogs work intensely for the duration of their exercise, often in very hot conditions, and highlights the athletic potential of this type of dog.

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