THE EXERCISE PHYSIOLOGY OF THE
RACING GREYHOUND

This thesis is presented for the degree of
Doctor of Philosophy of Murdoch University

by

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I declare that this thesis is my own account of my
research and contains as its main content work which
has not been submitted for a degree at any University.

Ross Staaden
This thesis is dedicated to my parents for their encouragement and above all their sacrifice. What they went without, so that their children could have an education is not readily appreciated in these materially better times.
ABSTRACT

EXERCISE PHYSIOLOGY OF THE RACING GREYHOUND

R. Staaden

Greyhounds were trained to gallop at maximal running speed on a treadmill constructed for the purpose. This speed considerably exceeded maximal aerobic speed and was termed supramaximal.

A mask was used to collect expired gases into bags during runs of 7.5 to 60 seconds and over the first 8-10 minutes of the recovery period. Respiratory parameters measured included VE, VO$_2$, VCO$_2$, $R$, $f_R$, $V_T$, ventilatory equivalent of $O_2$ uptake and ventilatory equivalent of $CO_2$ production. Respiration was found to be synchronised with the gallop stride, enabling both a high $f_R$ and $V_T$. Mean VE reached 6 l.$kg^{-1}.min^{-1}$. Mean VO$_2$ reached 143ml.$kg^{-1}.min^{-1}$ during the 30-45 second segment of running. Lactic acid draining into the blood stream displaced $CO_2$ from the bicarbonate buffer system, so that $R$ rose above 1.0. The highest value of $R$, 2.3 occurred in the second minute of recovery.

The alactacid debt of the greyhound was found to be higher than that of man but was repaid much more rapidly because of the greyhound’s superior oxygen transport system.

The cardiovascular system was studied using electromagnetic and thermodilution flowmeters, and a heart rate telemeter. Changes in blood pressure caused changes in the relationship of the very elastic aortic root and the electromagnetic transducer cuff so that accurate calibration was not possible. Reliable values of cardiac output were obtained by thermodilution. Parameters measured included HR, cardiac output, SV and PCV,
taken before, during and for 1 hour after running. The minimum HR whilst sleeping was also obtained, and averaged 42 b.min\(^{-1}\). The HR was highest during runs of 30 seconds, 318 ± 18 b.min\(^{-1}\). After running it fell sharply to below 160 in the second minute of recovery then rose to 200 b.min\(^{-1}\) 10 minutes after 30 and 45 second runs. HR was close to resting levels 1 hour after running. PCV after 30 seconds of running was 63.5 ± 2.1% and had returned to resting values by 1 hour. Cardiac output during high speed runs was 914 ± 209 ml.kg\(^{-1}\).min\(^{-1}\) while SV at 2.9 ± 0.6 ml.kg\(^{-1}\) was increased 32% above resting SV.

Acid-base balance of jugular venous blood was studied. Comparisons with arterial samples taken at the same time showed a useful relationship of arterial and jugular venous blood for lactate, base excess and pH. The time taken for blood lactate to reach its peak value varied with the intensity and the duration of the run. The jugular venous blood lactate level after 45 seconds of running peaked at 181 ± 15 mg.dl\(^{-1}\) (7 minutes after running), pH fell to 7.094 ± 0.27, base excess to -23.4 ± 2.7 mEq.l\(^{-1}\) and PCO\(_2\) to 23 ± 2 mm Hg. All values had returned to resting level 1 hour after the run.

Oxygen consumption during running, alactacid debt, lactate production and distance covered were used to calculate total energy cost and relative contributions of energy sources and energy cost.m\(^{-1}\). Anaerobic sources were the main contributors in the first 15 seconds but in the 15-30 second segment aerobic sources supplied 53% of the energy required and in the 30 -45 second segment, 79%. The energy source contributions to 30 seconds of running were aerobic 30%, alactacid debt 19% and lactic acid 51%. The energy cost.m\(^{-1}\) at supramaximal speeds was higher than predicted by formulae derived from studies of dogs at submaximal speeds. The first 7.5 seconds of running cost almost
as much as the next 22.5 seconds, indicating a high cost of acceleration. This is the first quantification of the energy cost of acceleration reported.

Compared to man, the greyhound has a very high oxygen uptake during sprinting. Man's major deficiencies as a sprinter are a low maximal heart rate, small heart relative to body size and low PCV. Sprinting impedes respiration in man but aids it in the greyhound. Calculations indicate that when man runs at supramaximal speed, it costs more per metre than predicted by formulae derived at submaximal speeds and that the energy cost of acceleration is of the same order as in the greyhound although man attains a much lower peak speed.
First and foremost I would like to thank Professor Robert Dunlop, who offered me a Murdoch University Postgraduate Studentship and became my supervisor. This gave me an opportunity to indulge my interest in the physiological mechanisms involved in exercise. Having given me that opportunity Professor Dunlop allowed me to "do it my way" and came up with funds for a high speed treadmill. Professor Dunlop appreciated the problems of shifting into a new and vast field, where an enormous amount of background reading and understanding of widely diverse principles was essential. It was necessary at various times to consult with specialists in dozens of specialties ranging from the mathematics and physics of windtunnels, pumps, viscometers, acceleration etc through chemistry, biochemistry, physiology, zoology and clinical medicine to anatomy. I found this very enjoyable if occasionally frustrating but it also meant frequent changes of direction, interspersed with stops and starts. Throughout these years Professor Dunlop listened to my reasons, pruned severely, then let me move on with soundly based experiments. Most importantly he was adamant that slow progress, changes of direction and small amounts of data were normal for a project such as this. (During one period of eight months not one donated greyhound could be lured into a trot let alone a gallop).
In addition I would like to thank the following people: Peter Rae and his successor Steve Callaghan for generously allowing the use of physiological equipment and consumables under their control. John Atherton for assistance in the testing of donated greyhounds. Peter D'Etchen, Ian Jack and Ron Harris of Queen Elizabeth ll Medical Centre for help with equipment and some pretty good jokes. Hugo Dunlop, Sally Staaden, Colleen Henderson, Jenny Harbisher and Derek Mead-Hunter for help with the treadmill experiments. Derek's sense of humour during the long and tedious rituals was much appreciated, side - splitting laughter being a rarity during Ph.D experiments. Ross Young and Paul Miller for scrubbing up and helping with some of the surgery.

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Jo Jennings for computer processing reams of respiratory data through abominable formulae.

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Professor Ray Wales who was lumbered with the task of supervising me when Professor Dunlop was appointed Dean of Minnesota Veterinary School. Professor Wales put much time and effort into reading the manuscript and suggesting ways in which it could be translated into readable English. His attention to details of content and layout through page after page showed stamina bordering on masochism, for which I am very grateful. To all these people and many others including the greyhound fraternity, many thanks. Last but not least to NT (the Nit), a greyhound whose motivation to chase a bit of rabbit flattened by a motor vehicle showed that it was all possible.


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<tr>
<td>ATPS</td>
<td>Ambient temperature, pressure and saturation.</td>
</tr>
<tr>
<td>a-v O₂ diff</td>
<td>Difference in oxygen content of arterial and mixed venous blood.</td>
</tr>
<tr>
<td>BTPS</td>
<td>Body temperature and pressure, saturated.</td>
</tr>
<tr>
<td>BWt</td>
<td>Body weight.</td>
</tr>
<tr>
<td>CO</td>
<td>Cardiac output.</td>
</tr>
<tr>
<td>CP</td>
<td>Creatine phosphate.</td>
</tr>
<tr>
<td>d1</td>
<td>Decilitre (100ml).</td>
</tr>
<tr>
<td>E</td>
<td>Energy.</td>
</tr>
<tr>
<td>E&lt;sub&gt;metab&lt;/sub&gt;</td>
<td>Metabolic energy.</td>
</tr>
<tr>
<td>f&lt;sub&gt;R&lt;/sub&gt;</td>
<td>Respiration rate.</td>
</tr>
<tr>
<td>Hb</td>
<td>Haemoglobin.</td>
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<tr>
<td>HR</td>
<td>Heart rate.</td>
</tr>
<tr>
<td>KE</td>
<td>Kinetic energy.</td>
</tr>
<tr>
<td>l</td>
<td>litre.</td>
</tr>
<tr>
<td>m</td>
<td>metre.</td>
</tr>
<tr>
<td>M or M&lt;sub&gt;D&lt;/sub&gt;</td>
<td>Body mass.</td>
</tr>
<tr>
<td>PA</td>
<td>Ambient pressure i.e, atmospheric pressure at time of the exercise, at which volume of gas collected is measured.</td>
</tr>
<tr>
<td>PCO₂</td>
<td>Partial pressure of carbon dioxide in blood.</td>
</tr>
<tr>
<td>PCV</td>
<td>Packed cell volume, haematocrit.</td>
</tr>
<tr>
<td>PO₂</td>
<td>Partial pressure of oxygen in blood.</td>
</tr>
<tr>
<td>R</td>
<td>Respiratory exchange ratio.</td>
</tr>
<tr>
<td>R.Q.</td>
<td>Respiratory quotient.</td>
</tr>
<tr>
<td>STPD</td>
<td>Standard temperature and pressure, dry.</td>
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\( T_A \)  
Ambient temperature i.e. temperature of collected gases at the time the volume was measured.

\( U_g \)  
Velocity relative to the ground.

\( VCO_2 \)  
Volume of carbon dioxide produced per minute.

\( V_D \)  
Volume of dead space of the airways and lungs.

\( VE \)  
Expired volume per minute at BTPS.

\( V.Eq.CO_2 \)  
Ventilatory equivalent of carbon dioxide production, i.e. the ratio of VE to \( VCO_2 \).

\( V.Eq.O_2 \)  
Ventilatory equivalent of oxygen uptake, i.e. the ratio of VE to \( VO_2 \).

\( VO_2 \)  
Volume of oxygen uptake per minute.

\( VO_2\max \)  
Maximal oxygen uptake per minute.
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