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The Effects of Sago Supplementation for Exercise in a Warm-Humid Environment

A thesis presented in partial fulfilment of the requirements for the degree of Doctor of Philosophy

PhD
In
Health (Sport & Exercise)
at Massey University, Manawatu,
New Zealand.

Mohd Rahimi bin Che Jusoh BSc, MSc.

2016
ABSTRACT

Whilst carbohydrate (CHO) ingestion during exercise with heat stress theoretically has some benefits for performance there is a lack of evidence on the effects of complex-CHO on exercise and recovery in warm-humid (tropical) conditions. The aims of this thesis were to investigate the effects of sago feeding on exercise performance, some physiological parameters, substrate metabolism, and thermoregulatory responses in the condition of exercise with thermal stress. The initial experimental study investigated the reliability of two novel laboratory-based cycling protocols in the presence of significant thermal stress. These protocols would then be employed in the second part of this thesis. The data indicate that the 15 min time-trial pre-loaded with 45 min fixed-intensity (Chapter 5, Study A) and 15 min time-trial pre-loaded with 15 min incremental warm-up (Chapter 5, Study B) were highly reliable when using trained, familiarized males under warm-humid environmental conditions. The second part of this thesis describes experiments which investigated the efficacy of an alternative Malaysian-based CHO, sago, on exercise in conditions which replicate the Malaysian environment (warm and humid).

Chapter 6 describes a study investigating the effect of sago supplementation before and during exercise in a warm-humid environment. The data collected from this study revealed that pre- and during-sago feeding has no differential effects on exercise performance though sago feeding produced a higher glycaemic response during the hour prior to exercise. However, feeding sago before exercise attenuated the rise in core temperature during exercise compared to the control condition, whilst there was a smaller reduction in plasma volume found when consuming sago during steady-state exercise through reduced whole-body sweating, with a concomitant higher plasma sodium concentration. Heart rate was also higher when sago was ingested either before or during exercise compared to control. Then, Chapter 7 further investigated the utility of sago ingestion as a recovery meal on a
subsequent exercise bout in a warm-humid environment. In terms of performance, sago ingestion during short-term recovery seemed to sustain time-trial performance on the second bout of exercise compared to a control condition (no food) where exercise performance degraded. However, no attenuation of physiological, metabolic and thermoregulatory responses was apparent.
ACKNOWLEDGEMENTS

First and foremost, thanks to the Almighty God for giving me strength, courage and opportunity to complete this thesis. I have to thank Universiti Sains Malaysia (USM) and Ministry of Higher Education Malaysia (MoHE) for the scholarship that provided financial support for my family and myself throughout four amazing years overseas in completing my PhD at Massey University, New Zealand.

I would like to express my sincere gratitude and appreciation to my main supervisor Dr Toby Mündel, and co-supervisors, Prof Steve Stannard and Prof Hugh Morton. Without their guidance, advice, and support it would seem impossible to complete this thesis. Thanks also to the Human Performance Laboratory managers, Hayden, Karl and Blake for the equipment guidance and lessons throughout my data collection process in the laboratory. Many thanks to each of participants who were willing to spend their time to contribute to all my studies and without them, there would be no thesis.

Finally, special thanks to my lovely wife Halida and sons Rifqi Harraz and Raaiq Harraz, and my family for their love, support, and encouragement throughout the course of my studies.
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## A

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ANOVA</td>
<td>Analysis of variance</td>
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## B

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>Bpm</td>
<td>Beats per minutes</td>
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## C

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CBF</td>
<td>cerebral blood flow</td>
</tr>
<tr>
<td>°C</td>
<td>Degrees Celsius</td>
</tr>
<tr>
<td>CHO</td>
<td>CHO</td>
</tr>
<tr>
<td>CO₂</td>
<td>Carbon dioxide</td>
</tr>
<tr>
<td>CNS</td>
<td>Central nervous system</td>
</tr>
<tr>
<td>CV</td>
<td>Coefficient of Variation</td>
</tr>
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</table>

## D

## E

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>EMG</td>
<td>Electromyogram</td>
</tr>
<tr>
<td>$E_{\text{max}}$</td>
<td>Maximal evaporative capacity of the environment</td>
</tr>
</tbody>
</table>

## G

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>g</td>
<td>Gram</td>
</tr>
<tr>
<td>GE</td>
<td>Gross energy</td>
</tr>
<tr>
<td>g/min</td>
<td>Gram per minute</td>
</tr>
<tr>
<td>GI</td>
<td>Glycaemic index</td>
</tr>
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## H

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>h</td>
<td>Hour</td>
</tr>
<tr>
<td>Hb</td>
<td>Haemoglobin</td>
</tr>
<tr>
<td>$HR_{\text{max}}$</td>
<td>Maximum heart rate</td>
</tr>
<tr>
<td>Symbol</td>
<td>Description</td>
</tr>
<tr>
<td>--------</td>
<td>-------------</td>
</tr>
<tr>
<td>ICC</td>
<td>Intraclass correlation</td>
</tr>
<tr>
<td>Kg</td>
<td>Kilogram</td>
</tr>
<tr>
<td>kJ</td>
<td>Kilojoule</td>
</tr>
<tr>
<td>km</td>
<td>Kilometre</td>
</tr>
<tr>
<td>km/h</td>
<td>Kilometre per hour</td>
</tr>
<tr>
<td>L</td>
<td>Litre</td>
</tr>
<tr>
<td>L/min</td>
<td>Litre per minute</td>
</tr>
<tr>
<td>LF</td>
<td>Linear factor</td>
</tr>
<tr>
<td>LOA</td>
<td>Limit of agreement</td>
</tr>
<tr>
<td>m</td>
<td>Metre</td>
</tr>
<tr>
<td>min</td>
<td>Minute</td>
</tr>
<tr>
<td>ml</td>
<td>Millilitre</td>
</tr>
<tr>
<td>ml/kg</td>
<td>Millilitre per kilogram</td>
</tr>
<tr>
<td>ml/kg/min</td>
<td>Millilitre per kilogram per minute</td>
</tr>
<tr>
<td>mmol</td>
<td>Millimole</td>
</tr>
<tr>
<td>mmol/L</td>
<td>Millimole per litre</td>
</tr>
<tr>
<td>MCA V&lt;sub&gt;mean&lt;/sub&gt;</td>
<td>Middle cerebral artery mean blood velocity</td>
</tr>
<tr>
<td>O₂</td>
<td>Oxygen</td>
</tr>
<tr>
<td>r</td>
<td>Correlation coefficient</td>
</tr>
<tr>
<td>RPE</td>
<td>Rating of perceived exertion</td>
</tr>
<tr>
<td>RPM</td>
<td>Revolutions per minute</td>
</tr>
<tr>
<td>SD</td>
<td>Standard deviation</td>
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</tbody>
</table>
$T$
- $T_{bicep}$  Skin temperature at the bicep
- $T_{calf}$  Skin temperature at the calf
- $T_{chest}$  Skin temperature at the chest
- $T_{core}$  Core temperature
- $T_{SK}$  Mean skin temperature
- $T_{skin}$  Skin temperature
- $T_{thigh}$  Skin temperature at the thigh
- $T_{DF}$  Total dietary fibre

$V$
- $V_{CO2}$  Volume of carbon dioxide production
- $V_E$  Minute ventilation
- $VO_2$  Volume of oxygen uptake
- $VO_2max$  Maximal oxygen uptake
- $VO_2peak$  Peak of oxygen uptake
- $% \; VO_2peak$  Percentage of the peak rate of oxygen uptake

$W$
- $W$  Watt
- $WBGT$  Wet bulb globe temperature
- $W_{max}$  Watt maximum

$X$
- $\bar{x}$  mean
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