# THE INFLUENCE OF THE MENSTRUAL CYCLE ON EXERCISE PERFORMANCE AND STABLE ISOTOPIC TRACER MEASURES OF FAT METABOLISM

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**DECLARATION**

This thesis is submitted in the optional format, approved by the Faculty, of published work with encompassing introduction and conclusion.

I declare that the work contained in this thesis is my own, unless otherwise acknowledged.

This work has not been submitted before for any degree or examination at any other university,

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Signed on the _____ day of _____, 2006.

**DEDICATION**

In my view, Science is a process of unravelling the mysteries of God's creation. Created in wisdom to appear on the surface simple, but peeling through the outer layer reveals a highly complex, intricate and perfect design. The wonder of God is only truly realized when studying the detail.

## ABSTRACT

Natural secretions of oestrogen and progesterone vary according to menstrual phase in eumenorrhoeic women and have an affect on physiological systems that could consequentially influence exercise performance. In a series of menstrual phase comparative investigations (considering mainly the early follicular (EF), late follicular (LF) and mid-luteal (ML) phase), I aimed to elucidate the physiological relation of oestrogen and progesterone to fat metabolism and ventilation during endurance exercise and exercise performance. I measured plasma free fatty acid (FFA) kinetics during prolonged exercise from an intravenous infusion of $K^+$[1-$^{13}$C]palmitate in eumenorrhoeic women and found the change in palmitate rate of appearance and disappearance between menstrual phases to be related to the oestrogen/progesterone (E/P) ratio. Overall the results from this study suggest that oestrogen promotes increases in FFA availability during exercise, while progesterone mitigates this response. Therefore, a high oestrogen concentration and E/P ratio in the ML phase is required in order to produce a favourable FFA metabolic response for endurance events. In order to estimate plasma FFA oxidation rate using carbon-FFA tracers, the acetate correction factor which accounts for carbon-label retention in secondary metabolic pools, must be applied. When I derived the acetate correction factor by measuring fractional recovery of carbon-13 in expired $CO_2$ from a constant infusion of $Na^+$[1-$^{13}$C]acetate during submaximal exercise we found the acetate correction factor to be significantly lower in the ML than EF phase (average change from EF phase -1.8± 0.5%, $p<0.05$). Failure to account for the lower correction factor in the ML phase will result in a 6% underestimation of plasma FFA oxidation rate. Furthermore, since human serum albumin (HSA) routinely used as a carrier for parenteral delivery of FFA tracers has various disadvantages, I tested the feasibility of using 2-hydroxypropyl-β-cyclodextrin (HP-β-CD) as a possible alternative carrier. A comparison of expired $CO_2$ enrichment following HSA-FFA (7.4±2.0 ‰) and HP-β-CD-FFA (8.6±2.1‰) infusion during exercise showed that the HP-β-CD does not compromise natural in vivo behaviour of the FFA tracer ($p=0.4$). Progesterone-induced hyperventilation is occasionally reported during exercise in the luteal phase. I found that the change in

ventilatory parameters (minute ventilation and respiratory rate) during exercise from EF to ML phase is related to both the oestrogen and progesterone concentration in the ML phase. However, the associated increase in respiratory rate throughout prolonged exercise in the ML versus EF phase did not increase metabolic demand and therefore could not be expected to exacerbate fatigue. When exercise performance was evaluated by means of a cycling time trial, I found a trend for best performance in the LF phase versus the EF phase (8 of 11 subjects improved by 5.2±2.9%, $p=0.027$), while no differences occurred between other menstrual phases. Metabolic and performance benefits of oestrogen may be concealed in the ML phase by the coincident increase in progesterone in this phase and thus a significant effect is often only evident with a high E/P ratio in the ML phase. The transient LF phase, characterised by the pre-ovulatory surge in oestrogen, reveals the maximum benefits of oestrogen on metabolism and performance during submaximal exercise.

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