



EFFECTS OF ENDOGENOUS AND SYNTHETIC FEMALE SEX STEROIDS ON EXERCISE STATUS IN YOUNG, SEDENTARY WOMEN

**A thesis submitted for the degree of
DOCTOR OF PHILOSOPHY**

by

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ABSTRACT

Endogenous and synthetic female sex steroids, through effects on energy metabolism, thermoregulation, body water and electrolyte homeostasis and respiration, have the potential to affect exercise status. There is no clear consensus in the literature whether exercise status is affected by different hormonal milieu throughout the menstrual cycle or with oral contraceptive pill treatments and earlier studies have highlighted numerous shortcomings in previous research such as differences in the fitness status of subjects, wide inter- and intra-individual variations in hormone levels, menstrual cycle lengths and age from menarche. The aim of this thesis was to address many of the shortcomings evident in earlier works and to examine the impact of fluctuations in endogenous and synthetic female sex steroids on exercise status.

To determine whether fluctuations in endogenous sex steroids might influence exercise status, a single group of young, sedentary women with normal menstrual cycles performed incremental exercise to exhaustion and steady-state submaximal exercise once during the follicular phase and once during the luteal phase (LP) while measurements were made of several metabolic and hormonal variables. It was found that while exercise capacity, as defined by $\dot{V}O_{2peak}$ and the lactate threshold, was unaffected by cycle phase in young, sedentary women, the metabolic responses in the LP during both incremental and steady-state submaximal exercise suggest a greater dependence on fat as an energy source. It was speculated that the change in energy metabolism between the two cycle phases was likely due to progesterone which increased 20-fold in

the LP when carbohydrate metabolism was decreased and lipid metabolism increased.

To test the impact of progestins on exercise status, two-combined monophasic oral contraceptive pills (OCP) were administered to a group of young sedentary women in order to pharmacologically manipulate the circulating concentration of female sex steroids. The women performed incremental exercise to exhaustion, steady-state submaximal exercise and a performance test once during two OCP's where the level of synthetic oestrogen was consistent and the level of the synthetic progestin 2-fold different. The findings showed that exercise capacity ($\dot{V}O_{2peak}$) and lipid metabolism were increased with the OCP containing high progestin and exercise time to exhaustion and total work done were significantly improved during this hormone milieu. Given that the dose of the synthetic oestrogen was constant between the OCP's it was speculated that the increased aerobic power and lipid metabolism was due to a progestin-mediated increase in stroke volume and insulin resistance, respectively.

Given the potential for progestins to alter exercise capacity the final study of this thesis was designed to compare the effects of endogenous (normal menstrual cycle) and synthetic (oral contraceptive pill) female sex steroids and the impact of low and high progestin environments on exercise status in young sedentary women. Incremental and steady state submaximal exercise performed by the OCP users was supported by a higher oxygen uptake and oxygen pulse and lower RER values. Calculations of substrate utilisation indicated that lipid oxidation was higher and carbohydrate oxidation lower in the OCP group compared to the group

with normal menstrual cycles. High levels of circulating progestin during the LP of the menstrual cycle and with an OCP containing high progestin were associated with significant increases in oxygen uptake, oxygen pulse and lipid oxidation and a reduction in the RER and carbohydrate oxidation. Exercise performance in terms of time to exhaustion or peak power output was also increased with high levels of progestins.

In summary this thesis demonstrates that exercise status is influenced by changes in endogenous and synthetic female sex steroid concentrations. This study provides the first evidence that progestins may have a significant affect on peak aerobic capacity and can promote a shift in the principal energy substrate from carbohydrate to lipid. When circulating levels of progestin were high, during the LP of a normal menstrual cycle or during an oral contraceptive pill preparation, aerobic capacity was increased and steady-state submaximal exercise was supported by an increased use of fat as an energy source and improved exercise performance. These findings suggest that the level of circulating progestin could have important implications for active women and that an oral contraceptive pill containing high progestins could result in an improved aerobic power.