CHAPTER 8

SUMMARY AND CONCLUSIONS

SUMMARY

The current series of investigations examined the effect of age on the $\dot{V}O_2$ and mOxy responses during and following moderate-, heavy- and severe-intensity SWT in well-trained cyclists.

Study One: Physiological, histochemical, enzymatic and performance characteristics in well-trained young and middle-aged cyclist.

The purpose of Study One was to examine the effect of age on a range of physiological and performance characteristics of well-trained cyclists. There was no significant effect of age on the VT or $\dot{V}O_2$max in the well-trained cyclists. No significant differences were observed in the muscle fibre composition, fibre CSA or capillarisation of the VL between age groups. Maximal specific activities of both glycolytic (PFK and LDH) and oxidative (CS, β-HAD and 2-OGDH) enzymes in the VL were similar between age groups. Lastly, no significant difference was observed between the two age groups in the mean RPO sustained across a 30TT. In conclusion, the results of the first study support previous reports that physiological and performance characteristics can be maintained into middle-age through continued physical training.

Study Two: On-transient $\dot{V}O_2$ and mOxy kinetics during moderate-, heavy- and severe-intensity exercise in well-trained young and middle-aged cyclists.

The purpose of Study Two was to examine the effect of age on the on-transient $\dot{V}O_2$ and mOxy responses to moderate, heavy and severe-intensity SWT in well-trained cyclists. No significant effect of age was observed in the A_p, TD_p or τ_p of the $\dot{V}O_2$ or mOxy on-transient responses across the three SWT intensities. In the on-transient $\dot{V}O_2$ response, both the A_p and TD_p demonstrated a significant effect of intensity, whereas the $\dot{V}O_2$ τ_p remained stable across the three SWT intensities. Only the mOxy A_p demonstrated a significant effect of intensity in the young and middle-aged cyclists. The speed of the $\dot{V}O_2$ and mOxy on-transient responses was significantly related across the moderate and heavy-intensity SWT in the young cyclists. The speed of the mOxy τ_p and $\dot{V}O_2$ τ_p was significantly ($p<0.05$) related to changes in [BLa^-] and blood pH in the young and middle-aged cyclists, respectively. In the young cyclists, the speed of the moderate and heavy-intensity $\dot{V}O_2$ responses was significantly ($p<0.05$) related to muscle fibre composition and C:F ratio. In the middle-aged cyclists, the moderate and severe-intensity $\dot{V}O_2$ τ_p values were significantly ($p<0.05$) related to muscle fibre composition and capillary contacts per fibre area, respectively.

Study Three: $\dot{V}O_2$ and mOxy slow components determined during heavy- and severe-intensity exercise in well-trained young and middle-aged cyclists.

The third study examined the effect of age on the development of the $\dot{V}O_2$ and mOxy slow components across heavy- and severe-intensity SWT in well-trained cyclists. No significant effects of age were observed in the amplitude or speed of the $\dot{V}O_2$ or mOxy slow components in the well-trained cyclists. A significant effect of intensity was observed in the $\dot{V}O_2$ τ_s in the young cyclists, with the heavy-intensity τ_s being significantly longer than that of the severe-intensity SWT. No significant effect of intensity was observed in any mOxy slow component parameters in either age group. The heavy-intensity $\dot{V}O_2$ slow component was significantly related to maximal CS activity in the young cyclists. No significant relationships were observed between the $\dot{V}O_2$ and mOxy slow components and changes within blood pH, pO_2, [HCO_3^-] or [BLa^-] during the high-intensity SWT. Lastly, non-significant trends across time were observed in both the iEMG and MPF responses of the VL and VM during the heavy and severe-intensity SWT. The available sEMG data suggests that Type II fibre fatigue occurs during high-intensity exercise, which then facilitates an increased recruitment of the number of Type I fibres required to sustain the power output.

Study Four: Off-transient $\dot{V}O_2$ and mOxy kinetics following moderate-, heavy- and severe-intensity exercise in well-trained young and middle-aged cyclists.

Lastly, the fourth and final study examined the effect of age on the off-transient $\dot{V}O_2$ and mOxy responses following moderate-, heavy- and severe-intensity-SWT in well-trained cyclists. No significant ($p>0.05$) effects of age or age x intensity interaction were observed for any off-transient $\dot{V}O_2$ or mOxy parameter between the young and middle-aged cyclists. However, significant increasing effects of intensity were observed for the A_f of both the $\dot{V}O_2$ and mOxy responses. The $\dot{V}O_2$ τ_f was also significantly lengthened following the severe-intensity SWT compared to the moderate and heavy-intensity SWT, but no such observation was observed in the mOxy τ_f response. Following the moderate-intensity SWT, the off-transient $\dot{V}O_2$ τ_f and MRT_f were significantly related to changes in [HCO_3^-] and [BLa^-] in the young cyclists. The off-transient moderate and heavy-intensity $\dot{V}O_2$ response of the middle-aged cyclists was significantly ($p<0.05$) related to changes in [HCO_3^-].

CONCLUSIONS

The current series of studies examined the effect of age on the $\dot{V}O_2$ and mOxy responses during and following bouts of moderate-, heavy- and severe-intensity exercise in well-trained cyclists, matched for physiological and performance capacities. Previous aging research has investigated older sedentary subjects, and as a result, very little data are available on the physiological capacities of well-trained older athletes. Therefore, the present research is original and provides novel insights to the areas of both aging and $\dot{V}O_2$ and mOxy kinetics. The following conclusions can be made from the present series of studies:

1. The physiological capacities (VT and $\dot{V}O_2max$) and peripheral muscle characteristics (fibre composition, fibre CSA, capillarisation and enzyme activities) can be maintained with physical training into middle-age at a level similar to that of a younger cohort of performance-matched cyclists.

2. The on-transient $\dot{V}O_2$ and mOxy responses are not influenced by age across exercise intensities in well-trained middle-aged cyclists. This observation is most likely due to the similarities in the physiological capacities and peripheral muscle characteristics between the two groups. Importantly, the stable $\dot{V}O_2$ and mOxy τ_p across exercise

intensities is suggestive of O_2 utilisation controlling the speed of the on-transient metabolic adaptation.

3. The development of the $\dot{V}O_2$ and mOxy slow components during sustained heavy and severe-intensity exercise was not influenced by age in well-trained middle-aged cyclists. This may be the result of the similar physiological capacities, peripheral muscle characteristics and neuromuscular activity levels across the high-intensity SWT in the two age groups. The observed trends in sEMG analysis suggest an increase in Type I fibre recruitment during the high-intensity exercise SWT in both age groups.

4. The nature of the off-transient $\dot{V}O_2$ and mOxy responses are not influenced by age following moderate, heavy and severe-intensity exercise in well-trained middle-aged cyclists. This similar off-transient response may also be due to the homogenous physiological capacities and peripheral muscle characteristics of the young and middle-aged cyclists. The similar $\dot{V}O_2$ and mOxy τ_f also suggest that O_2 utilisation issues are involved in controlling the speed of the off-transient metabolic response.

FUTURE RESEARCH DIRECTIONS

Based on the results and observations of this thesis, the follow directions of future research are suggested:

1. The current series of investigations should be repeated comparing the responses of the well-trained middle-aged cyclists to sedentary age-matched controls to help identify the influence of training and aerobic capacity on the $\dot{V}O_2$ and mOxy kinetic responses. Originally, this was proposed to be included in the present investigation but was omitted due to ethical concerns by the University Ethics Committee.

2. The current series of investigations should also be repeated utilising older (60+ y) sedentary and well-trained subjects. While the middle-aged cyclists were significantly older than the young in the present study, they are not truly representative of an aging population. This may help to further delineate the effects of concurrent training and aging on the $\dot{V}O_2$ and mOxy kinetic responses.

3. Future research also needs to investigate the relationship between $\dot{V}O_2$ and mOxy kinetics and athletic performance. The use of performance tests such as a prolonged constant-load cycling time trials in order to relate the on- and off-transient $\dot{V}O_2$ and mOxy kinetic responses to an individual's performance capacity is inappropriate and may hide the actual 'real-world' applications of such research.

4. Lastly, future research needs to thoroughly investigate the relationship between $\dot{V}O_2$ and mOxy responses to a range of exercise intensities. The majority of $\dot{V}O_2$ kinetics identifies influential mechanisms which are located within the working muscle, and changes in O_2 utilisation in response to exercise has previously been difficult to quantify and measure. The introduction of NIRS technology has allowed the monitoring of O_2 extraction to be performed non-invasively, and future investigations should aim to incorporate such technology to help identify important O_2 delivery or utilisation limitations.