Determinants of muscle buffer capacity

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Little is known about the stimulus required to increase muscle buffer capacity ($\beta_{in\text{-}vitro}$). It has been hypothesised that it is important that training is: (1) of high intensity; and (2) is performed under conditions of high skeletal muscle hydrogen ion (H^+) accumulation (Weston et al., 1996). We tested this first hypothesis by investigating the effects on $\beta_{in\text{-}vitro}$ of two training protocols of different intensity, but matched for total work. It has previously been shown that increasing the extracellular buffer concentration can reduce the skeletal muscle H^+ accumulation during high-intensity exercise (Costill et al., 1984). We therefore tested the second hypothesis by experimentally manipulating the extracellular buffer concentration during training.

For the first study, 18 untrained females (mean ± SD: age 19 ± 1 y, mass 59.8 ± 5.8 kg) were randomly assigned to high-intensity interval training (INT-5) or moderate intensity continuous (CON-5) training. Training was matched for total work and consisted of 6 - 10 × 2 min intervals (1 min rest) at 130 - 160% of lactate threshold (LT) (INT-5) or 20 - 35 min of continuous cycling at 85 - 95% of LT (CON-5), 3 × per week for 5 weeks. For the second study, 10 untrained females (mean ± SD: age 20 ± 3 y, mass 62.3 ± 10.0 kg) were also randomly assigned to one of two training groups, matched for total work. One group (BIC-8) ingested sodium bicarbonate ($NaHCO_3$, 0.4 $g \cdot kg^{-1}$) while the control group (INT-8) ingested a placebo (NaCl, 0.2 $g \cdot kg^{-1}$) prior to each training session. Training consisted of 6 - 12 × 2 min intervals (1 min rest) at 130 - 180% of LT, 3 × per week for eight weeks. Muscle biopsies (vastus lateralis) were taken at rest to determine muscle lactate ($[La^-]_m$), pH_m and $\beta_{in\text{-}vitro}$.

Training responses are summarised in the table. All training programs resulted in a significant improvement in $O_{2\,peak}$ and LT with no significant difference between groups. However, relative to CON-5, INT-5, INT-8 and BIC-8 had a significantly greater improvement in $\beta_{in\text{-}vitro}$. The pooled data revealed a significant negative correlation between initial $\beta_{in\text{-}vitro}$ and percent change with training ($r=0.58$; $P<0.05$).

Training	Peak O_2		LT		$\beta_{in\text{-}vitro}$	
	Pre	Post	Pre	Post	Pre	Post
CON-5	41.3 ± 7.3	45.6 ± 5.7*	137 ± 33	152 ± 29*	123 ± 32	125 ± 19
INT-5	42.8 ± 6.6	48.1 ± 7.4*	141 ± 27	149 ± 27*	126 ± 15	150 ± 19*
INT-8	40.7 ± 5.6	47.7 ± 6.1*	113 ± 18	130 ± 21*	140 ± 32	161 ± 19*
BIC-8	35.2 ± 7.1	43.0 ± 6.4*	109 ± 21	137 ± 20*	129 ± 32	156 ± 19*

* significantly different to pre-training ($p<0.05$)

Despite similar changes in aerobic fitness, INT-5 had a significantly greater increase in $\beta_{in\text{-}vitro}$ than CON-5. This suggests that it is the intensity of training, not the total work performed, that is the stimulus for change in $\beta_{in\text{-}vitro}$. We have also shown that ingesting $NaHCO_3$ and therefore altering the likely accumulation of H^+ during training, did not affect these adaptations.

Costill, D.L., Verstappen, F., Kuipers, H., Janssen, E. and Fink, W. (1984) *International Journal of Sports medicine* 5, 228-231.

Weston, A.R., Wilson, G.R., Noakes, T.D. and Myburgh, K.H. (1996) *Acta Physiologica Scandinavica* 157, 211-216.