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SHORT REPORT

Contrast water immersion hastens plasma lactate decrease after intense anaerobic exercise

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Summary The benefits of rapid recovery after intense exercise are widely recognised, and lactate elimination is one indicator of recovery rate. This study examined the effect of contrast (alternating hot and cold) water immersion (CWI) on the rate of plasma lactate decrease during recovery after intense anaerobic exercise. Eleven subjects on each of two occasions undertook four successive 30-s Wingate tests separated by 30-s rest periods. On each occasion, plasma lactate concentration during recovery was measured 5 min post-exercise and thereafter at 5 min intervals for 30 min. On one occasion (determined randomly), the subjects recovered passively (PR) on a recovery bed and, on the other, they alternated partial body immersion in hot (36 °C) and cold (12 °C) water baths. Plasma lactate concentrations were analysed by repeated measures analysis of variance and by fitting a linear regression model, allowing for both gender and recovery mode differences. The rate of decrease in plasma lactate concentration over the 30-min recovery period was significantly higher ($p < 0.001$) in CWI; 0.28(±0.02) mmol L^{-1} min^{-1} (CWI) compared to 0.22(±0.02) mmol L^{-1} min^{-1} (PR). These values do not differ significantly between males and females. Contrast water immersion is a valid method of hastening plasma lactate decrease during recovery after intense anaerobic exercise for both males and females. An approximately 1.8 mmol L^{-1} difference between the two conditions may be expected after 30 min. With differences among elite competitors as little as 1—2%, this reduction may be of practical significance.

Introduction

Recovery after strenuous exercise is an important issue for athletes. Any sport that has one or a combination of intense acceleration, power, strength or

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speed repeatability is likely to benefit from strategies that accelerate the recovery process.[1] Very high intensity exercise places a particularly heavy demand on anaerobic glycolysis and muscle lactate levels can increase significantly above resting values, although levels in plasma are lower and lag behind. Intramuscular accumulation of lactate and hydrogen ions have been associated with impaired force production[2] and, whatever mechanism(s) may be at work, the removal of lactate may therefore be beneficial.

One recovery technique being practiced by athletes, contrast (alternating hot and cold) water immersion (CWI), reportedly results in lighter and less tight muscles with a feeling of mental freshness.[1] In a recent review of the technique, Cochrane discusses the mechanisms justifying its merits and concludes that very few scientific studies have focussed on the effectiveness or nature of CWI for post-exercise treatment.[3] Such mechanisms may be metabolically related,[4] neurologically related,[5] thermodynamically related[6] or massage related.[7] A recent study by Coffey et al. found that CWI lowered post-exercise lactate and improved the subjective perception of recovery, suggesting the technique shows promise.[8] The present study was therefore undertaken to assess the nature of post-exercise lactate changes brought about by CWI compared to passive recovery (PR).

Materials and methods

Eleven subjects (6 male, 5 female; age 21.7 ± 1.1 and 20.2 ± 0.8 years; height 1.63 ± 0.11 and 1.78 ± 0.13 cm; mass 84.1 ± 5.2 and 70.5 ± 4.7 kg, respectively) participated in the study. All undertook moderate exercise 3—4 times per week but not regular high intensity (anaerobic) activity. All signed informed consent in accordance with the University Human Ethics Committee and the Declaration of Helsinki.

All subjects attended testing on three occasions. On the first, their age, mass and height were recorded and they performed familiarisation Wingate trials on the ergocycle (Lifecycle, Life Fitness, USA). They also performed trial immersions in the hot (36 °C) and cold (12 °C) water baths, and lay passively on the recovery bed adjacent to the baths.

On each of the next two occasions, after a 5-min warm-up at resistance level 2 (approximately 52 W) and a brief inactive pause, all subjects performed four successive 30-s Wingate tests (resistance levels ranged from 12—20, power range 203—362 W), separated by 30-s relative rest periods cycling at level 2. Subjects were verbally encouraged to produce all-out efforts in all tests. Subjects were instructed to refrain from any moderate or strenuous physical activity and from the ingestion of any caffeine, for 24 h immediately preceding each session. After the first session, subjects were randomly allocated to either passive recovery (PR) or CWI. After the second session they undertook the other recovery protocol. Sessions were separated by at least seven days and took place in the early mornings. Participants were instructed not to consume food or liquid (apart from water) for 10 h prior to testing.

Passive recovery consisted of lying stationary on the recovery bed for 30 min. CWI recovery consisted of alternating immersion of subjects' lower body up to their gluteal fold in the hot and cold baths: hot (9), cold (1), hot (4), cold (1), hot (4), cold (1), hot (4), cold (1), hot (4) and cold (1); time in minutes.

Fingertip blood was sampled 5 min after the end of the fourth Wingate test and thereafter at 5-min intervals for 30 min. Samples were drawn using a sterile lancing device (Softclix Pro) following manufacturer's instructions. Twenty microlitre capillary tube samples were analysed immediately, using a pre-calibrated lactate analyser (YSI 1500, Yellow Springs Inc., USA).

All data were subjected to a three-way repeated measures analysis of variance with interactions (Minitab Inc., State College, PA).

For a short period following a peak occurring about 4—5 min post-exercise, the time (t) course of blood lactate can be approximated by a simple linear regression. This study addresses whether the regression slope is modulated by CWI (and maybe also by gender differences). This is achieved by incorporating dummy variables for both factors.[9] To assess inter-subject differences and characterise the effect of CWI on the nature of the lactate curve during recovery in males and females, simple linear regressions were fitted to individual subject data for each trial and the 22 parameter estimates analysed by two-way repeated measures ANOVA (Minitab Inc.). The significance level was set at 0.05 throughout.

Results

Mean blood lactate concentrations evidence only a significant time trend ($p < 0.001$) and its interaction with recovery mode ($p < 0.001$). Between subject differences are also evident ($p < 0.05$).

The fitted dummy variable regression model including only significant ($p < 0.01$) parameters

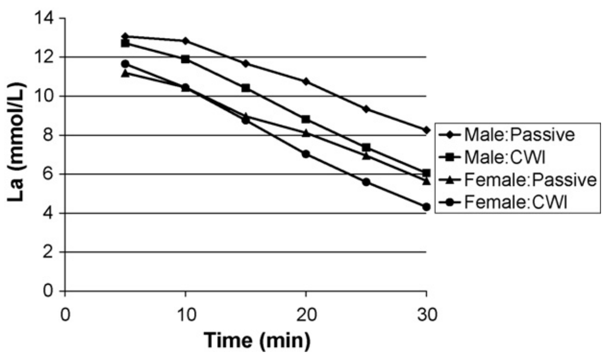

Figure 1 Mean plasma lactate values over time.

(standard errors) was:

$$\mathrm{La}(t) = 14.61(\pm 0.47) - 1.99(\pm 0.38)y - 0.22(\pm 0.02)t - 0.06(\pm 0.02)xt$$

with adjusted $R^2 = 54.7\%$. Substituting for the appropriate dummy variables ($y = 1$ for females and $x = 1$ for CWI) enables simple linear regressions to be estimated for each of the four gender/mode combinations.

The adjusted goodness of fit is not high (54.7%), most likely because of between-subject differences. Fitting simple linear regressions to the data from each subject in each trial confirms this, and that linearity is a good model for these data ($94.9\% < R^2 < 99.4\%$). Analysis of the intercepts and slopes indicates that slopes differ only between recovery modes, and intercepts differ only between males and females. Fig. 1, which plots the mean values for all gender/mode combinations, illustrates these points graphically.

Discussion

The primary finding of this study was that CWI recovery not only resulted in lower blood lactate 30 min post-exercise than with PR, but also more specifically raised its rate of removal above that of PR. These rates were gender-independent. Thus, CWI is a valid and effective means of hastening blood lactate clearance during recovery from high intensity exercise in both males and females.

Blood lactate during active recovery from high intensity exercise is primarily removed via oxidation,[3] and it remains to be established how CWI may facilitate this process. Since CWI required participants to climb in and out of the water baths, it could be said that CWI involved some physical activity over and above the passive recovery condition. Since active recovery *per se* hastens lactate clearance, this may be a confounding factor in explaining the primary finding. The design of this study does not permit a definitive answer to this question, but it is noted that the level of physical activity defining active recovery in other studies[2,8] is far higher than simply climbing in and out of the water baths a few times over a 30-min period. The strength of the findings of this investigation should also be interpreted in light of the following issues: lying supine in the passive recovery condition may limit the muscle pump and hence lactate removal, and the effects of hydrostatic pressure may contribute to the benefits of CWI.

We conclude that contrasting successive hot and cold water immersion and its consequent effect on blood flow and/or temperature may be the likely causal factor in increasing lactate removal rate but that the precise mechanism of this phenomenon remains unclear. Further research is needed to compare CWI with active recovery, and to establish whether a 1.8 mmol L^{-1} reduction is sufficient to benefit subsequent performance.

Practical implications

- Contrast water immersion is a valid and effective means of accelerating recovery from high intensity exercise in both males and females.
- Contrast water immersion hastens blood lactate clearance, results in lighter and less tight muscles with a feeling of mental freshness, and improves the subjective perception of recovery.

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