Time-to-Fatigue and Intramuscular pH Measured via NIRS during Handgrip Exercise in Trained and Sedentary Individuals

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ABSTRACT

Introduction: In exercising muscles, force production and muscular endurance are impaired by a decrease in intramuscular pH. The effects of aerobic training (AT) on preventing acidosis and prolonging exercise time in muscles not specifically targeted by the training are unknown. **Purpose:** To compare interstitial pH, measured non-invasively with near infrared spectroscopy (NIRS), in the flexor digitorum profundus (FDP) during rhythmic handgrip exercise in sedentary subjects and those who participate in AT activities that target the lower body. **Methods:** Maximal isometric force (MIF) was measured on three separate days in AT (n=5) and sedentary (n=8) subjects using a handgrip dynamometer (HGD). Isometric muscular endurance (IME) was measured during five trials, with at least 48 h between trials. For each IME trial subjects rhythmically contracted (4 sec at 40% of MVC) and relaxed (2 sec) to fatigue or failure to reach the target force in three consecutive contractions or four non-consecutive contractions. Interstitial pH was derived from spectra collected using a NIRS sensor adhered to the skin over the FDP. The first four IME trials served to familiarize subjects with the protocol; the fifth trial was used for analysis. NIRS-derived pH was averaged in 30-sec increments. Differences between groups for MIF and exercise time were tested using paired t-tests. A repeated measures ANOVA was used to analyze effects of AT and exercise time on pH. **Results:** MIF was not different between groups (mean±SD: aerobic=415.6±95.4 N vs. sedentary=505.1±107.4 N). Time-to-fatigue was greater in the AT than in the sedentary group (mean±SD: 611±173 sec vs. 377±162 sec, $p<0.05$). pH was not different between groups at any time point. Average pH decreased ($p<0.05$) in both groups from rest (pH=7.4) through 90 sec of exercise (pH=6.9), but did not decrease further throughout the remainder of exercise. **Conclusion:** Although between group differences in pH were not detected, differences in pH during the onset of exercise may exist with a more frequent sampling interval. AT individuals appear to better tolerate decreased interstitial pH and are able to continue submaximal muscular work, possibly due to psychological familiarization with muscular fatigue and/or systemic physiological adaptations.

INTRODUCTION

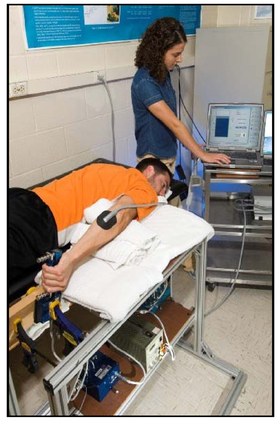
- In exercising muscles, force production and muscular endurance may be impaired by a decrease in muscular pH [3].
- Aerobic training improves endurance performance of the specifically trained muscle as a result of increased blood flow and improved oxidative capacity [4].
  - Elite rock climbers show longer exercise time to fatigue during repeated isometric hand grip contraction compared to sedentary individuals [2].
- The effects of aerobic training on preventing acidosis and prolonging exercise time in muscles not specifically targeted by the training are unknown.

PURPOSE

To compare interstitial pH, measured non-invasively with near-infrared spectroscopy (NIRS), in the flexor digitorum profundus (FDP) during rhythmic handgrip exercise in sedentary subjects and those who participate in aerobic exercise training that targets the lower body.

METHODS

- Subjects (N=13): aerobically trained (n=5) and sedentary (n=8)
  - Sedentary: 5 M, 3 F; Age = 35.6 ± 7.0; Weight = 72.2 ± 9.8 kg
  - Aerobically trained: 2 M, 3 F; Age = 38.6 ± 7.2; Weight = 62.2 ± 13.4 kg
- Maximal isometric force (MIF) using a handgrip dynamometer was measured on three separate days; measurements were at least 48 h apart. The highest of the three trials was used to determine the target load for the endurance trials.
- Isometric muscular endurance was measured on five trials separated by at least 48 h. The fifth trial was used for analysis.
- Each trial consisted of rhythmic handgrip exercise in which subjects contracted (4 sec @ 40% of MIF) and relaxed (2 sec) until failure to achieve 40% of maximal isometric force in three consecutive contractions or four non-consecutive contractions.
- During the endurance trials, interstitial pH was measured continuously using NIRS [5].
- pH measured with NIRS was averaged in 30-sec increments for subsequent analysis.



Statistical Analyses

- Paired t-tests were used to determine differences between the aerobically trained and sedentary groups for MIF and time to endurance task failure.
- A repeated measures ANOVA was used to determine the effects of aerobic training on pH over exercise time.
- Statistical significance was set *a priori* at $P < 0.05$.

RESULTS

	Sedentary	Aerobically Trained
MIF (N)	505.1 ± 107.4	415.6 ± 95.4
Time-to Fatigue (sec) *	377 ± 162	611 ± 173

*Significant difference between aerobically trained and sedentary groups, $p<0.05$.

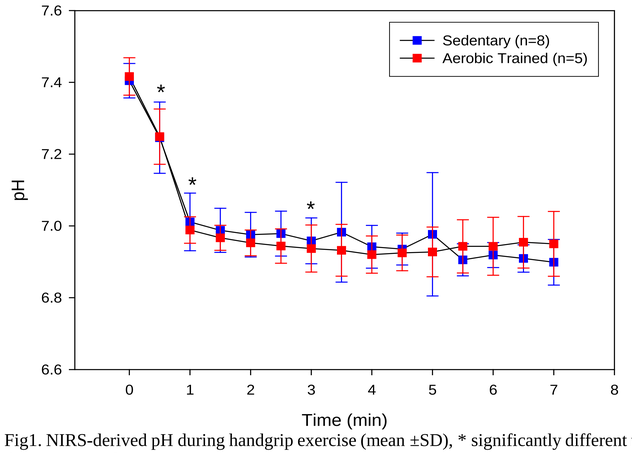


Fig1. NIRS-derived pH during handgrip exercise (mean ±SD), * significantly different than the previous value ($p < 0.05$).

- MIF was not different between the sedentary and aerobic trained groups; however, time to fatigue was longer in the aerobic trained group.
- pH was not different between sedentary and aerobic trained groups at rest or at any time point during exercise.
- All pH values during exercise were different from values measured at rest.

CONCLUSIONS

- Aerobic training does not appear to prevent acidosis during exercise in muscles not specifically targeted by the training.
- Aerobically trained individuals are able to perform exercise using untrained muscle groups for a longer duration than their sedentary counterparts.
- Trained individuals may better tolerate decreased interstitial pH due to psychological familiarization with the muscular “pain” associated with the accumulation of lactic acid.
- Training may alter the sensitivity of the metaboreflex, which could affect muscle blood flow and the clearance of metabolites during exercise that would interfere with muscle contraction [1].

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