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UNDERWATER SWIMMING OF FEMALE RATS: AN EFFECTIVE MODEL OF ANAEROBIC EXERCISE

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ABSTRACT

Anaerobic glycolysis activity in underwater swimming was determined from the effects of exercise intensities on plasma levels of lactic acid and glucose in 36 adult female rats divided equally into the non-swimming, 1, 10, 17, 24 and >24 repetitions of underwater swimming groups. At the conclusion of the group number of underwater swimming repetitions, blood samples were collected by decapitation, and then centrifuged for analysis of the plasma by standard procedures. Mean lactic acid levels in the 1($\bar{x} \pm$ SE: 16.2 ± 0.8 mEq/l), 10(17.9 ± 0.9 mEq/l), 17(17.2 ± 1.6 mEq/l), 24(17.6 ± 1.2 mEq/l) and >24(6.7 ± 0.4 mEq/l) repetitions of underwater swimming groups were significantly ($P<0.05$) higher than levels in the non-swimming (1.9 ± 0.2 mEq/l) group. Mean glucose levels in the 1($\bar{x} \pm$ SE: 147 ± 2 mg%), 10(204 ± 3 mg%), 17(180 ± 7 mg%), 24(179 ± 5 mg%) an >24(36 ± 4 mg%) repetitions of underwater swimming groups were significantly ($P<0.05$) different from values for the non-swimming (126 ± 6 mg%) group. These data indicate that a wide range of underwater swimming intensities elicits uniform anaerobic glycolysis activity.

INTRODUCTION

Elevation in blood levels of lactic acid has been noted to be a significant indicator of exercise models that utilize anaerobic glycolysis for production of energy in muscle contraction (Davis, 1985; Parkhouse and McKenzie, 1984; Skinner and McLellan, 1980). High-intensity bicycling (Eddy et al., 1977; Ready et al., 1981) and running (Brooks et al., 1973; Komi et al., 1977) have been shown to elevate blood levels of lactic acid in female animals and women. Although, Garcy (1985) demonstrated uniform anaerobic glycolysis activity over a wide range of underwater swimming (UWS) intensities in male rats, a similar investigation was not under-

taken in females. Thus, the present study focused on the effects of increasing UWS intensities on plasma levels of lactic acid and glucose in female rats.

MATERIALS AND METHODS

Thirty-six adult female Harlan Sprague Dawley rats, weighing 175-199 g, were maintained in an animal facility with a controlled environment, and supplied with food and water ad libitum. Animals were divided equally into the non-swimming (NS), 1, 10, 17, 24 and >24 repetitions of UWS groups, and swam according to a procedure described in previous studies (Garcy, 1982; Garcy, 1985). At the conclusion of swimming the designated or maximum number of repetitions, blood samples were collected and prepared for analysis by a procedure described in Garcy's (1985) investigation. Plasma concentrations of lactic acid and glucose were determined respectively by the enzymatic methods of Sigma Chemical Co., No. 826-UV and Electro-Nucleonics Inc., Gemstar System.

The data were evaluated by one way analysis of variance. Statistical significance ($P<0.05$) of differences in means was determined by the Student's-Newman-Kuels test.

RESULTS

Mean plasma concentrations of lactic acid and glucose for each group are presented in Figs. 1 and 2. The data in Fig. 1 indicate that plasma levels of lactic acid remained at peak values for the 1 through 24 repetitions of UWS groups, and then decreased, but even the >24 repetitions of UWS group had levels that were higher than in the NS group. Plasma concentrations for the 1($\bar{x} \pm$ SE: 16.2 ± 0.8 mEq/l), 10(17.9 ± 0.9 mEq/l), 17(17.2 ± 1.6 mEq/l), 24(17.6 ± 1.2 mEq/l) and >24(6.7 ± 0.4 mEq/l) repetitions of UWS groups were significantly ($P<0.05$) higher than in the NS(1.9 ± 0.2 mEq/l) group. Furthermore, plasma lactic acid levels for UWS groups 1, 10, 17 and 24 were significantly ($P<0.05$) higher than in the >24 repetitions of UWS group. Moreover, lactic acid levels for the 1, 10, 17 and 24 repetitions of UWS groups were not significantly ($P>0.05$) different from one another.

Mean plasma glucose concentrations as shown in Fig. 2 were elevated for the 1 through 24 repetitions of UWS groups, and then in the >24 repetitions of UWS group fell below the levels of the NS group. Mean plasma glucose levels for the 1($\bar{x} \pm$ SE: 147 ± 2 mg%), 10(204 ± 3 mg%), 17(180 ± 7 mg%) and 24(179 ± 5 mg%) repetitions of UWS groups were significantly ($P<0.05$) higher than in the NS(126 ± 5 mg%) group. Furthermore, glucose levels of UWS groups 10, 17 and 24 were significantly ($P<0.05$) higher than in the 1 bout of UWS group. Moreover, glucose levels for UWS group 10 were significantly ($P<0.05$) greater than in the 1, 17 and 24 repetitions of UWS groups. On the other hand, plasma glucose concentrations in the >24(36 ± 4 mg%) repetitions of UWS group were significantly ($P<0.05$) lower than in the NS group.

DISCUSSION

The elevated plasma levels of lactic acid reported in this study (Fig. 1) have been noted by other investigators (Brooks et al., 1973; Eddy et al., 1977; Roby et al., 1983; Rusko et al., 1980; Schantz and Astrand, 1984; Withers, 1978) in female

animals and women engaged in high-intensity exercises. Furthermore, the lactic acid levels in UWS female rats were uniformly elevated as they were in UWS male rats (Garcy, 1985). On the other hand, peak levels of lactic acid in UWS females were lower than in UWS males, suggesting reduced anaerobic glycolysis activity. An implication is that lower levels of world record athletic performances in women when compared to men, may be attributed to reduced anaerobic glycolysis activity in combination with smaller muscle area and mass (Costill et al., 1976; Drinkwater, 1984; Pauhl et al., 1982; Wilmore, 1979).

Demonstration of elevated plasma concentrations of glucose in UWS female rats (Fig. 2) was also shown in UWS male rats (Garcy, 1985). On the other hand, peak glucose concentrations in UWS females were lower than in UWS males. Moreover, glucose concentrations in females exercising at the highest level of UWS intensity were lower than in NS females, whereas glucose concentrations in males exercising at the same level of UWS intensity were above control values. These observations indicate that the proposed lower anaerobic glycolysis activity in female rats may be associated with smaller supplies of glucose.

In conclusion, the results from this study indicate that a wide range of UWS intensities elicits uniform anaerobic glycolysis activity in female rats. Thus, UWS of female rats is an effective model of anaerobic exercise.

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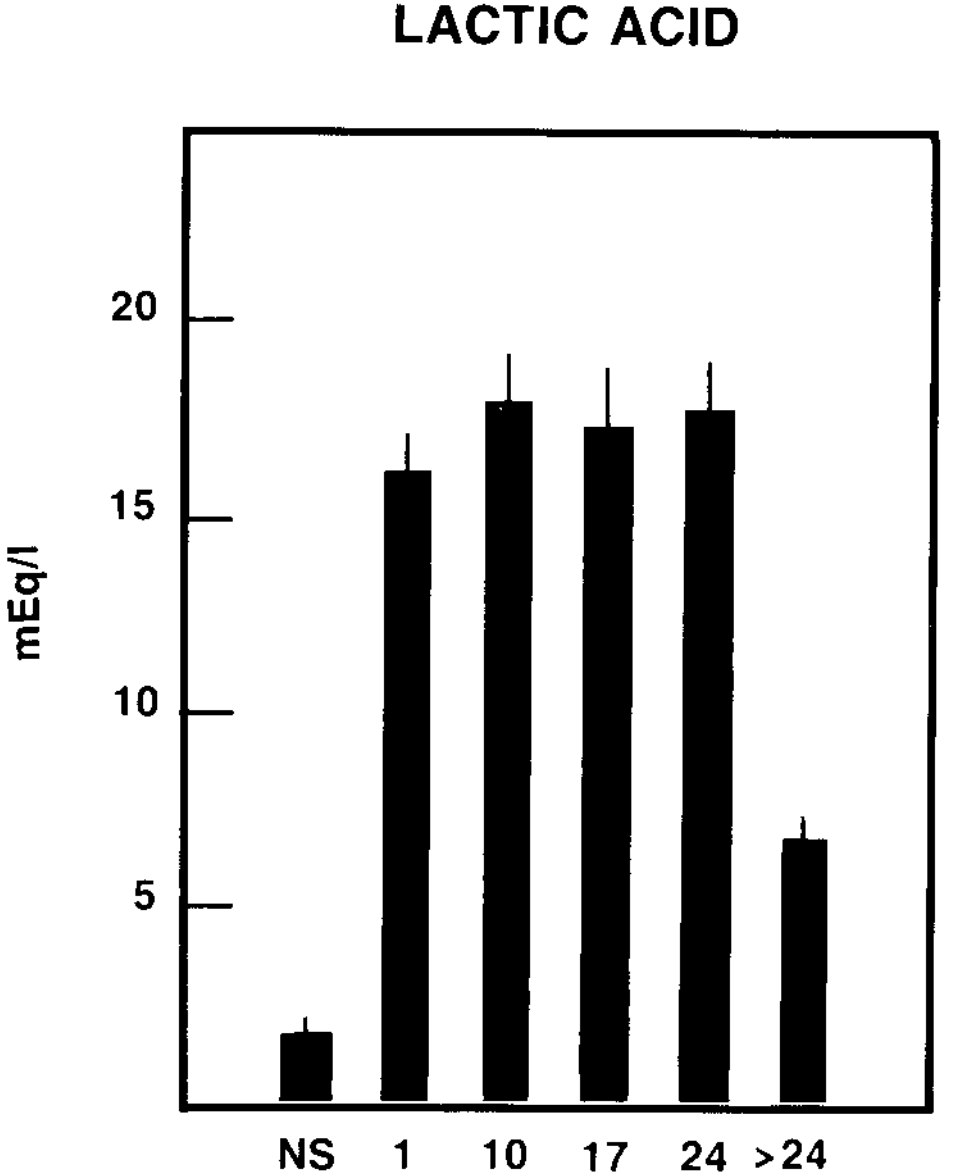

Fig. 1 Plasma lactic acid concentrations (mEq/l) for the non-swimming (NS), 1, 10, 17, 24 and >24 repetitions of underwater swimming groups. Bars with vertical lines indicate the means ± standard errors.

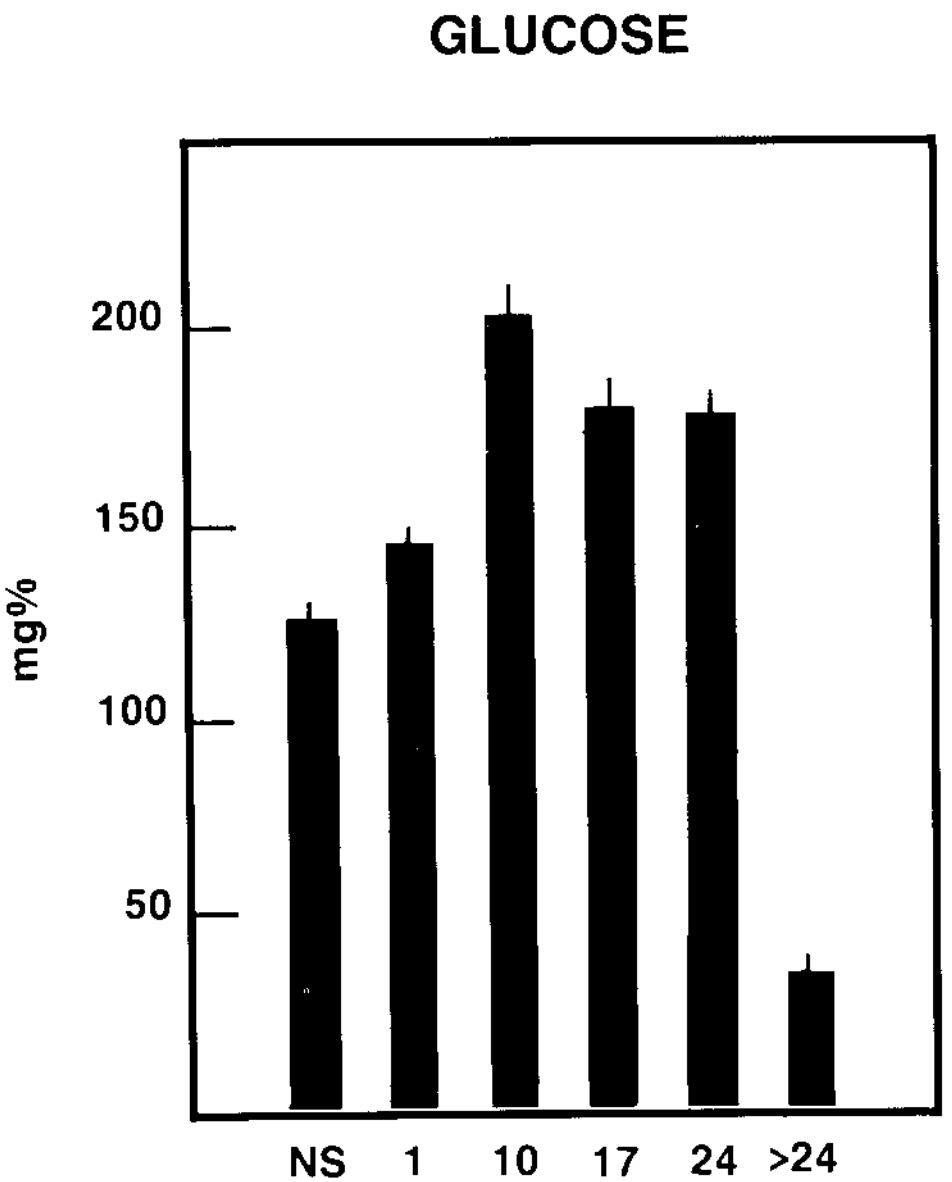

Fig. 2 Plasma glucose concentrations (mg%) for the non-swimming (NS), 1, 10, 17, 24 and >24 repetitions of underwater swimming groups. Bars with vertical lines indicate the means ± standard errors.