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EFFECTS OF INCREASING ACUTE UNDERWATER SWIMMING LOAD ON ADRENOCORTICAL ACTIVITY, TISSUE ENZYMES AND SERUM LEVELS OF LIPIDS IN MALE RATS

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ABSTRACT

The effects of increasing acute underwater load on serum levels of corticosterone, creatine kinase, lactate dehydrogenase, alkaline phosphatase, triglycerides, total cholesterol and high-density lipoprotein cholesterol were determined in 36 adult male rats that were separated 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 serum by radioimmunoassay and enzymatic procedures. Mean serum levels of corticosterone in the 1 ($\bar{x} \pm SE$: 645 ± 80 ng/ml), 10 (638 ± 94 ng/ml), 17, (532 ± 19 ng/ml), 24 (648 ± 47 ng/ml) and >24 (519 ± 66 ng/ml) repetitions of UWS groups were significantly ($P<0.05$) greater than in non-swimming (193 ± 70 ng/ml) group. Mean serum levels of creatine kinase in the >24 (4414 ± 270 U/l) repetitions of underwater swimming group were significantly ($P<0.05$) higher than in the non-swimming (3568 ± 229 U/l), 1 (3564 ± 473 U/l), 10 (2665/236) U/l), 17 (2520 ± 227 U/l) and 24 (2479 ± 379 U/l) repetitions of underwater swimming groups. Mean serum levels of lactate dehydrogenase in the >24 (1631 ± 452 U/l) repetitions of underwater swimming group were significantly ($P<0.05$) elevated above the non-swimming (702 ± 143 U/l), 1 (685 ± 137 U/l), 10 (609 ± 129 U/l), 17 (483 ± 142 U/l) and 24 (673 ± 50 U/l) repetitions of underwater swimming groups. On the other hand, underwater swimming had minimal effect

on serum levels of alkaline phosphatase, triglycerides, total cholesterol and high-density lipoprotein cholesterol. These data indicate that one session of underwater swimming may illicit adaptive and maladaptive responses.

INTRODUCTION

Investigators (Atha, 1982; Clarke, 1974; Hakkinen, 1985; Hoeger et al., 1987) have demonstrated that performance of vigorous movements may be improved by resistance training; however, the mechanisms of adaptation and maladaptation to intense exercise stress are not clearly understood. On the other hand, studies (Brooks, 1985; Costill et al., 1983; Davis, 1985; Gollnick et al., 1986; Jones and Ehrsam, 1983; Pimental et al., 1984) have shown that high intensity exercise stimulates anaerobic glycolysis production of lactic acid in skeletal muscle. Garcy (1985) reported that mean plasma levels of lactic acid were elevated in adult male rats engaged in single bouts through exhaustive repetitons of underwater swimming (UWS); however, the knowledge gained from the study provides a narrow scope of understanding UWS stress. Therefore, the present investigation was undertaken in order to determine the effects of increasing acute UWS load on serum levels of corticosterone, creatine kinase (CK), lactate dehydrogenase (LDH), alkaline phosphatase, triglycerides (Tg), total cholesterol (T-C) and high-density lipoprotein cholesterol (HDL-C).

MATERIALS AND METHODS

Thirty-six adult male Harlan Sprague Dawley rats, Indianapolis, Indiana, weighing 175-199 g, were housed in a controlled environment animal facility at 22 ± 1 °C, with 12 h of light and 12 h of darkness, and supplied with Certified Purina Rodent Chow and water ad libitum. The animals were separated equally into the non-swimming (NS), 1, 10, 17, 24 and >24 repetitions of UWS groups. The UWS protocol and procedure for collection of blood samples were described in previous studies (Garcy, 1982; Garcy, 1985). Serum samples (1-2 ml) were stabilized by freezing (-20°C) or refrigeration (2-8°C), and assayed within 48 h for tissue enzymes and lipids. Serum Levels of corticosterone were determined by the radioimmunoassay procedure of Radioassay Systems Laboratories, Inc., Carson, California. Tissue enzymes and lipids were assayed according to the enzymatic methods of Gemstar, Electro-Nucleonics, Inc., Fairfield, New Jersey.

The data were evaluated by one way analysis of variance. Statistical significance ($P<0.05$) of differences in means was determined by the protected t-test.

RESULTS

Mean serum levels of corticosterone, CK, LDH, alkaline phosphatase, Tg, T-C and HDL-C are presented in Figs. 1, 2 and 3. Data in Fig. 1 indicate that serum levels of corticosterone in the 1 ($\bar{x} \pm$ SE: 645 ± 80 ng/ml), 10 (638 ± 94 ng/ml), 17 (532 ± 19 ng/ml), 24 (648 ± 47 ng/ml) and >24 (519 ± 66 ng/ml) repetitions of UWS groups were significantly ($P<0.05$) higher than in the NS (193 ± 70 ng/ml) group. Furthermore, the corticosterone levels in the UWS groups were not significantly ($P>0.05$) different.

Fig. 2 shows that mean serum levels of CK, LDH and alkaline phosphatase remained unchanged or decreased in the 1, 10, 17 and 24 repetitions of UWS groups, whereas enzyme levels remained unchanged or increased in the >24 repetitions of UWS group. Mean serum levels of CK in the >24 ($\bar{x} \pm SE$: 4414 ± 270 U/l) repetitions of UWS group were significantly ($P<0.05$) higher than in the NS (3568 ± 229 U/l), 1 (3564 ± 473 U/l), 10 (2665 ± 236 U/l), 17 (2520 ± 227 U/l) and 24 (2479 ± 379 U/l) repetitions of UWS groups. On the other hand, serum levels of CK in the 10, 17 and 24 repetitions of UWS groups were significantly ($P<0.05$) lower than in the NS and 24 repetitions of UWS groups, whereas CK levels in the NS and 24 repetitions of UWS groups were not significantly ($P<0.05$) different.

Fig. 2 shows that mean serum levels of LDH in the >24 ($\bar{x} \pm SE$: 1631 ± 452 U/l) repetitions of UWS group were significantly ($P<0.05$) higher than in the NS (702 ± 143 U/l), 1 (685 ± 137 U/l), 10 (609 ± 129 U/l), 17 (483 + 142 U/l) and 24 (673 ± 50 U/l)repetitions of UWS groups. Furthermore, serum levels of LDH in the 1, 10, 17 and 24 repetitions of UWS groups were not significantly ($P>0.05$) different from the NS group. Moreover, alkaline phosphatase levels in the NS (339 ± 44 U/l), 1 (360 ± 42 U/l), 10 (350 ± 54 U/l), 17 (387 ± 39 U/l), 24 (386 ± 75 U/l) and >24 (390 ± 54 U/l) repetitions of UWS groups were not significantly ($P>0.05$) different.

Mean serum levels of Tg, T-C and HDL-C as demonstrated in Fig. 3 remained similar to those in the NS group. Serum levels of Tg in the NS ($\bar{x} \pm SE$: 53 ± 10 mg/dl), 1 (74 ± 10 mg/dl), 10 (61 ± 7 mg/dl), 17 (56 ± 10 mg/dl), 24 (60 ± 8 mg/dl) and >24 (66 ± 21 mg/dl) repetitions of UWS groups were not significantly ($P>0.05$) different. Furthermore, serum levels of T-C were not significantly ($P>0.05$) different in the NS (79 ± 4 mg/dl), 1 (82 ± 4 mg/dl), 10 (74 ± 5 mg/dl), 17 (77 ± 12 mg/dl), 24 (80 ± 7 mg/dl) and >24 (86 ± 13 mg/dl) repetitions of UWS groups. Moreover, serum levels of HDL-C were not significantly ($P>0.05$) different in the NS (43 ± 13 mg/dl), 1 (40 ± 6 mg/dl), 10 (40 ± 8 mg/dl), 17 (44 ± 7 mg/dl), 24 (48 ± 11 mg/dl) and >24 (54 ± 16 mg/dl) repetitions of UWS groups.

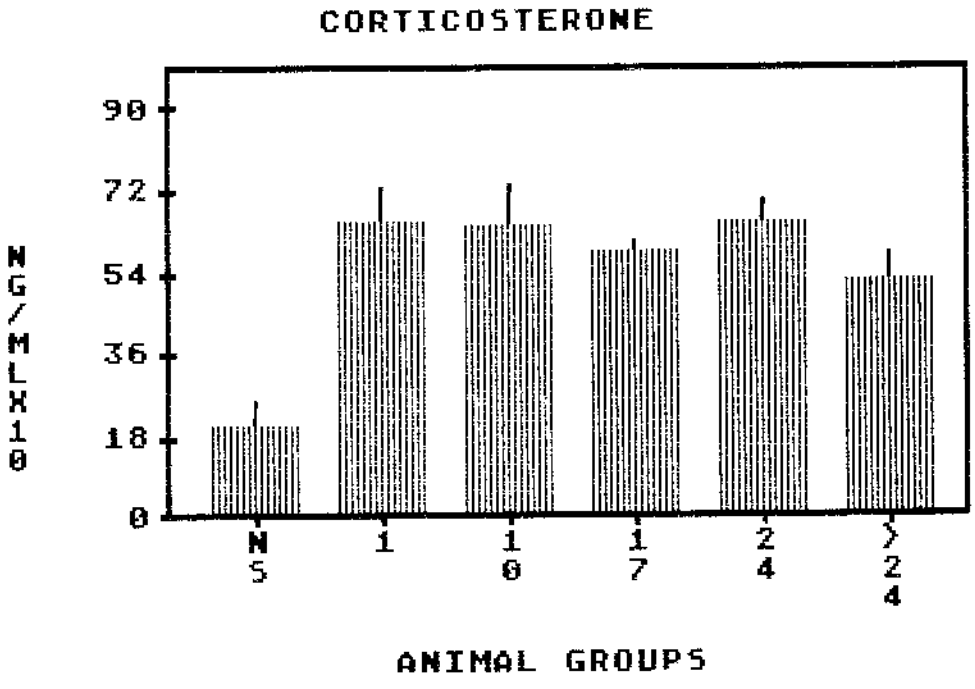

Fig. 1. Mean serum levels of corticosterone (ng/ml) in the non-swimming (NS), 1, 10, 17, 24 and >24 repetitions of underwater swimming groups. Bars with vertical lines indicate the means ± standard errors.

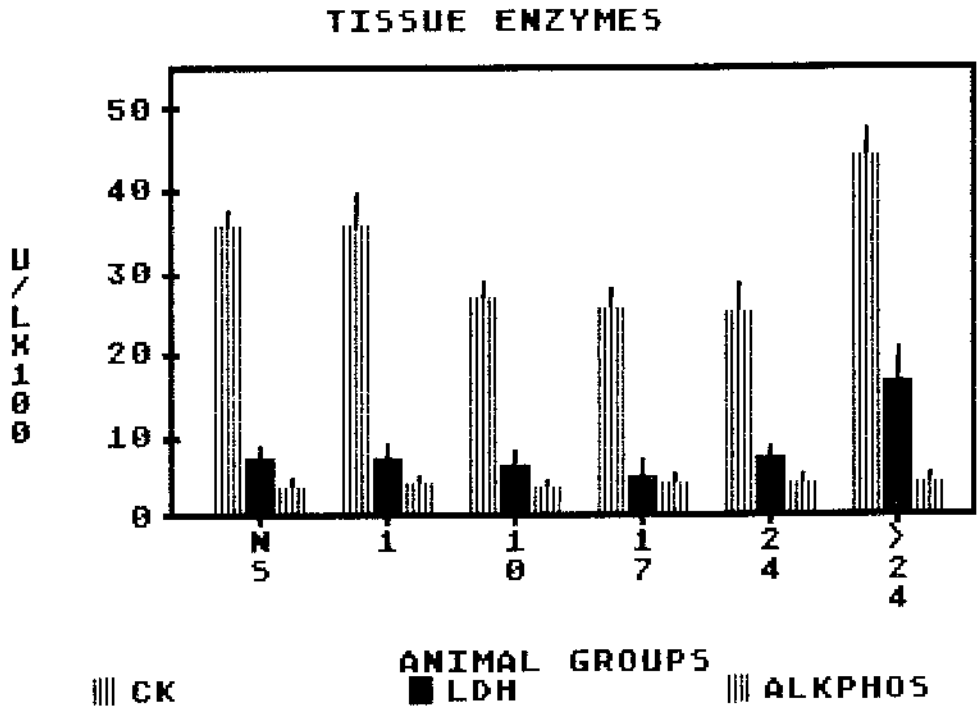

Fig. 2. Mean serum levels of creatine kinase (CK), lactate dehydrogenase (LDH) and alkaline phosphatase (ALKPHOS) (U/l) in the non-swimming (NS), 1, 10, 17, 24 and >24 repetitions of under swimming groups. Bars with vertical lines indicate the means ± standard errors.

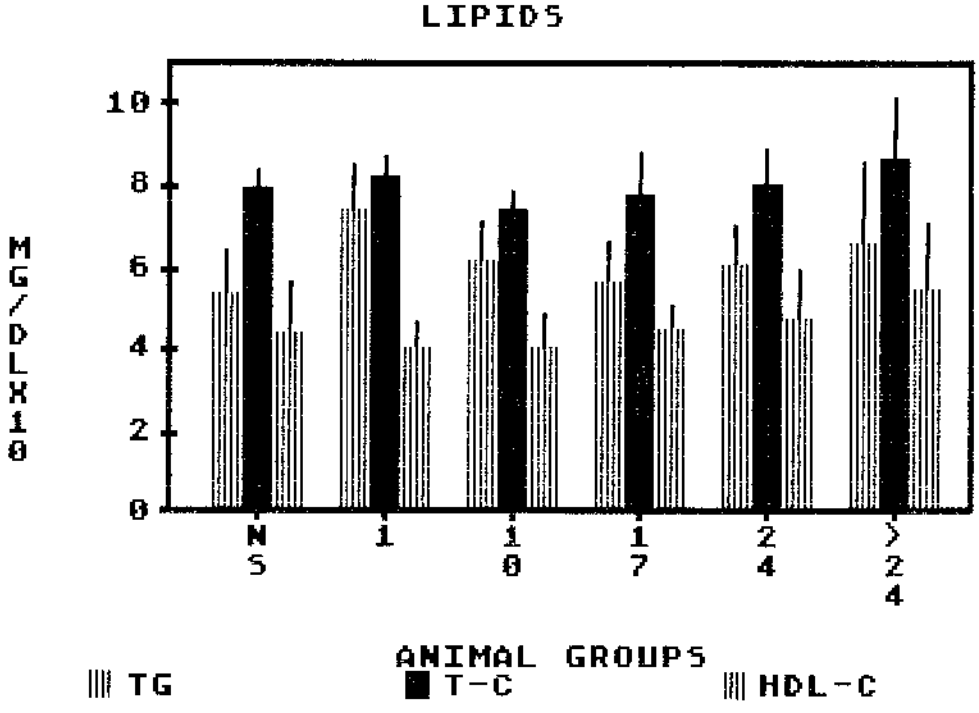

Fig. 3. Mean serum levels of triglycerides (Tg), total cholesterol (T-C) and high density lipoprotein cholesterol (HDL-C) (mg/dl) in the non-swimming (NS), 1, 10, 17, 24 and >24 repetitions of underwater swimming groups. Bars with vertical lines indicate the means ± standard errors.

DISCUSSION

The elevated serum levels of corticosterone reported herein (Fig. 1) are in accordance with adrenocorticoid values published elsewhere for animals and humans performing high intensity and long-term exercise (Davies and Few, 1973; O'Connor and Corrigan, 1987; Ronkainen et al., 1986; Terjung, 1980; Tharp and Buuck, 1974). Moreover, the uniform elevation of corticoid in the single bout through exhaustive repetitions of UWS groups (Fig. 1) indicates that the exercise stimulates high level adrenocortical activity. Although, reduced blood glucose is known to increase corticosterone levels, Garcy (1985) reported stable to elevated plasma glucose in UWS male rats, suggesting that underwater contraction of muscle is a potent stressor of the adrenal cortex. The adaptive significance of corticosterone in UWS may be in maintaining an adequate supply of substrate for repeated muscle contractions.

The increased serum levels of CK and LDH noted in exhaustive UWS (Fig. 2) have been demonstrated in animals and humans undergoing irreversible tissue maladaptation incurred by performing alternative forms of severe exercise (Deldar et al., 1982; Holly et al., 1986; Rogers et al., 1985). Furthermore, the increased values of CK and LDH in contrast to stable values of alkaline phosphatase suggest maladaptation to severe UWS stress in tissues such as skeletal and cardiac muscles. On the other hand, the stabilized or reduced levels of CK, LDH and alkaline phosphatase in single bouts and repetitions of UWS indicates that the anaerobic exercise stress does not induce irreversible tissue maladaptation.

Long-term vigorous exercise has been shown to alter blood levels of Tg, T-C and HDL-C (Blessing et al., 1987; Durstine et al., 1985; Haskell, 1985; Johnson et al., 1982; Leeds et al., 1986; Naveri et al., 1985; Savage et al., 1986; Tran et al., 1983). On the other hand, serum levels of lipids in the UWS and NS groups were similar (Fig. 3), suggesting that stability of lipids may be associated with anaerobic exercise utilization of glucose (Gollnick and Hermansen, 1973; Gollnick, 1982; Sjodin and Svedenhas, 1985) or insufficient duration of exercise to compromise steady state lipid metabolism.

In conclusion, the results from this study indicate that increments in acute UWS load illicits responses of metabolic adaptation, whereas exhaustive UWS imposes maladaptive stress on tissues.

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