Transactions of Illinois Academy of Sciences
(1982), Volume 75, 3 and 4, pp. 233-237

THE EFFECTS OF REDUCED PLASMA ANDROGEN LEVELS ON THE WEIGHTS OF VARIOUS TISSUES FROM MALE RATS PERFORMING PROLONGED ANAEROBIC SWIMMING

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ABSTRACT

The objective of this study was to determine the effects of reduced plasma androgen levels on the weights of various tissues from male rats performing anaerobic swims five days per week for eight weeks. At the conclusion of the anaerobic swim program bodyweights, hematocrits, hemoglobins, red blood cell counts, red blood cell volumes and tissue to bodyweight ratios were recorded for animals from the intact nonswim, castrated nonswim, intact swim and castrated swim groups. Decreased seminal vesicles and kidney weight ratios indicated that prolonged anaerobic swimming did not alter the effects of reduced plasma androgen levels on these tissues as reported in earlier studies. On the other hand, increased liver weight ratios suggested that the exercise program stimulated weight gains in this tissue.

INTRODUCTION

Adaptation to prolonged anaerobic exercise includes the modification of structures and functions in various tissues such as hypertrophy and improved force of contraction in skeletal (Morpurgo, 1897; Edgerton, 1970) and cardiac muscles (Morganroth et al., 1975; Zeldis et al., 1978). Although the enhanced anaerobic work capacity of skeletal muscle has been shown to include increases in the numbers of myofibrils (Gollnick et al., 1973) and total posphogen stores (Hickson et al., 1975), the physiological control mechanisms for these and other adaptations to anaerobic training are unclear. Masculinization of the male by testicular hormones has prompted physiologists to investigate a potential relationship between plasma levels of androgens and the degree of adaptation to anaerobic exercise training. Some investigators have demonstrated increases in plasma levels of testosterone following short intense exercise (Sutton et al., 1973; Dessypiris et al., 1976), whereas other scientists have reported a decrease in the plasma androgen levels

after less intense but prolonged exercise (Galbo et al., 1977; Morville et al., 1979).

Since physiologists have shown that plasma levels of testosterone vary with changes in exercise conditions, this study was undertaken in order to determine the effects of reduced plasma androgen levels on the process of adaptation to anaerobic training by changes in tissue to bodyweight ratios from rats performing prolonged anaerobic swimming.

MATERIALS AND METHODS

Thirty-two young male Sprague-Dawley rats, weighing 175 to 200 g, were maintained in separate cages in a controlled temperature room at 23°C with a 12 light and 12 dark lighting schedule and fed Purina Rat Chow and water *ad libitum*. Sixteen animals were divided equally into the intact nonswim and intact swim groups. The remaining sixteen animals were castrated and then allowed to recover for one week. These animals were divided equally into the castrated nonswim and castrated swim groups after which the animals were swam anaerobically. The animals from the swim groups were placed into a velcrow harness and then attached to a polyvinyl line that ran through two eyelets along the bottom and at the opposite ends of a swim tank. The line was pulled posteriorly in order to lower the animals 5-10 cm beneath the surface of the water and maintain them in this position for anaerobic swims lasting twenty seconds. These animals were swam five days per week for eight weeks at two to five repetitions per swim period. At the conclusion of the anaerobic swim program the animals were weighed on a Fisher digital scale and then sacrificed for collection of blood samples and excision of tissues. Hematocrits, hemoglobins, red blood cell counts and red blood cell volumes were determined by a Hycell counter. The brains, hearts, bones (tibia-fibula), muscles (gastronemius), seminal vesicles, left kidneys and livers were weighed on a Torball balance.

Values for bodyweights, hematocrits, hemoglobins, red blood cell counts, red blood cell volumes and tissue to bodyweight ratios were evaluated by analysis of variance and the Student-Newman-Kuels test. Statistical significance was determined when $P < 0.05$.

RESULTS

The results on hematocrits, hemoglobins, red blood cell counts, red blood cell volumes and the tissue weight ratios for the bones, hearts, and muscles were not significantly ($P < 0.05$) different for the four groups of animals. On the other hand, bodyweights and the tissue weight ratios for the seminal vesicles, left kidneys and livers were significantly ($P < 0.05$) different among the four animal groups.

Bodyweights (fig. 1) for the castrated nonswim, intact swim and castrated swim groups were significantly ($P < 0.05$) lighter than the bodyweights for the intact nonswim group, whereas the bodyweights for the castrated nonswim, intact swim and castrated swim groups were not significantly ($P < 0.05$) different.

The seminal vesicles weight ratios as shown in fig. 2 for the castrated nonswim, intact swim and castrated swim groups were significantly ($P < 0.05$) smaller than the ratios for the intact nonswim group. On the other hand, the seminal vesicles weight ratios for the intact swim group were significantly ($P < 0.05$) larger than the weight ratios for the castrated nonswim and castrated swim groups. Furthermore, the seminal vesicles weight ratios for the castrated nonswim and castrated swim groups were not significantly ($P < 0.05$) different.

The left kidney weight ratios as shown in fig. 3 were significantly ($P < 0.05$) less for the castrated nonswin and castrated swim groups than the ratios for the intact nonswim and intact swim groups. Moreover, the left kidney weight ratios for the castrated nonswim and castrated swim groups were not significantly ($P < 0.05$) different.

The liver weight ratios in fig. 4 for the castrated nonswim and castrated swim groups were significantly ($P < 0.05$) less than the ratios for the intact swim group, whereas the liver weight ratios of the intact swim group were significantly ($P < 0.05$) greater than the liver weight ratios for the intact nonswim, castrated nonswim and castrated swim groups. Moreover, the liver weight ratios for the castrated swim group were not significantly ($P < 0.05$) different from the liver weight ratios of the intact nonswim group, whereas the liver weight ratios for the castrated swim group were significantly ($P < 0.05$) greater than the ratios for the castrated nonswim group.

DISCUSSION

The reduction in the levels of plasma androgens following castration and/or prolonged anaerobic swimming were noted to affect the gains in bodyweights and the weights of various tissues. Retardation of bodyweight gains from reduced plasma androgen levels supported an earlier study by Leatham, 1948. Sandberg et al., 1939 demonstrated a reduced positive nitrogen balance in castrated rats. The deficiency in plasma androgens may have compromised the synthesis of proteins (Thomas and Mawhinney, 1973) with a concomitant retardation in bodyweight gains. On the other hand, the reduction in bodyweight gains of intact animals performing prolonged anaerobic swimming may have been attributed to decreased food intakes. Oscai et al., 1971 showed that male rats performing prolonged aerobic swimming had poor appetites and reduced bodyweights. Furthermore, the combination of reduced appetites and decreased protein synthesis may not have been sufficient to synergize additional decreases in bodyweights of castrated animals performing prolonged anaerobic swimming.

There was a confirmation of earlier studies that castrated male rats have reduced weight gains in the seminal vesicles (Korenchevsky, 1925), kidneys (Basinger and Gittes, 1974) and livers (Kochakian et al., 1956). On the other hand, prolonged anaerobic swimming restored the reduced liver weights of castrated rats to intact animal values. A well known activity of the liver is to supply glucose via glycogen for the performance of exercise. In addition, exercise has been shown to stimulate the synthesis of liver glycogen (Hultman and Nilsson, 1971). Prolonged anaerobic swimming may have stimulated the restoration of the liver weights in the castrated swim group through the deposition of glycogen.

The performance of prolonged anaerobic swimming by the intact animals stimulated weight gains in the kidneys and livers, whereas the exercise program inhibited weight gains in the seminal vesicles. These tissues in intact nonswim rats are known to be responsive to androgens as indicated by activation and induction of various enzymes (Kochakian, 1959). In addition, the directions of the responses may be determined by the metabolic states of the tissues (Pratt and Aronow, 1966). Prolonged anaerobic swimming may have modified the directions of androgen actions by altering the metabolic states of the tissues, thus there were increases in weight gains of the livers and kidneys, whereas there were a decreases in the weight gains of the seminal vesicles.

In conclusion, the results from this study indicate that prolonged anaerobic

swimming modifies the direction of tissue response to the androgens. This shift may be attributed to a metabolic reaction to an overload imposed by prolonged anaerobic exercise.

ACKNOWLEDGMENTS

Support for this study was through a grant awarded by the Chicago State University Foundation. Special consideration is given to the contributions by Thomas Hagler and Alberto Mariano, students from the Department of Biological Sciences, Chicago State University. In addition, special thanks are given to Joan Oksas, Department of Library Science and Communications Media, Chicago State University, for the production of the graphic presentations in this study.

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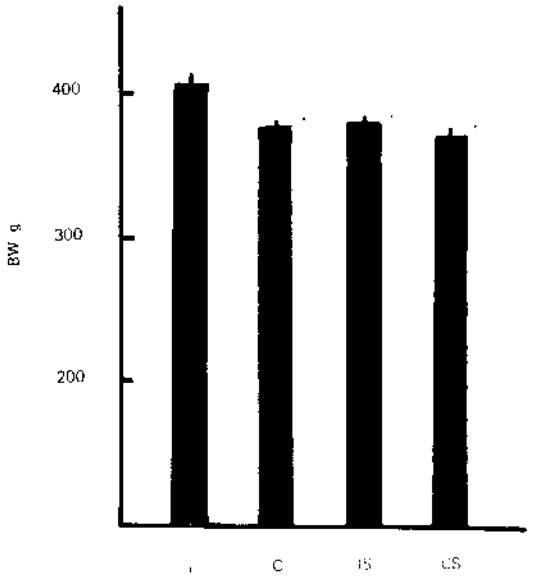

Fig. 1. Bodyweights for I = Intact Nonswim, C = Castrated Nonswim, IS = Intact Swim and CS = Castrated Swim groups at the end of eight weeks. Bar with vertical line indicates the mean ± standard error. *denotes $P < 0.05$ from the Intact Nonswim group.

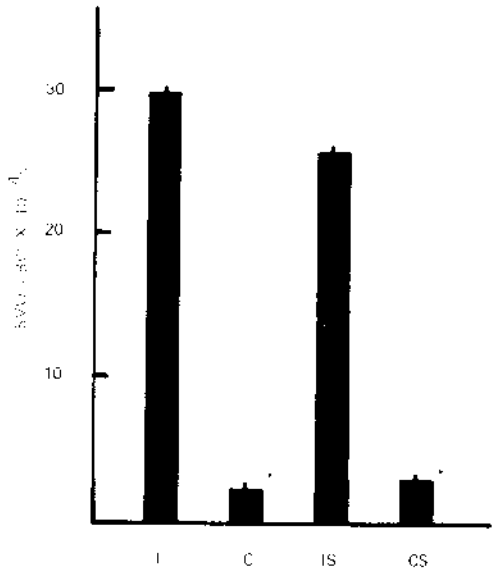

Fig. 2. Seminal vesicles weights to bodyweights for I = Intact Nonswim, C = Castrated Nonswim, IS = Intact Swim and CS = Castrated Swim groups at the end of eight weeks. Bar with vertical line indicates the mean ± standard error. *denotes $P < 0.05$ from the Intact Nonswim group.

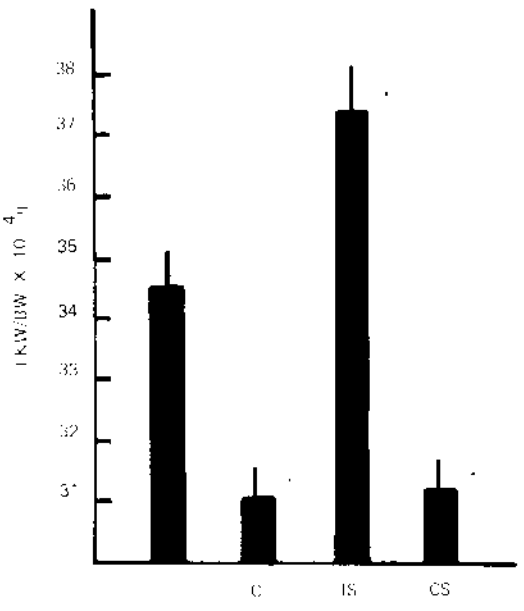

Fig. 3. Left kidney weights to bodyweights for I = Intact Nonswim, C = Castrated Nonswim, IS = Intact Swim and CS = Castrated Swim groups at the end of eight weeks. Bar with vertical line indicates the mean ± standard error. *denotes $P < 0.05$ from the Intact Nonswim group.

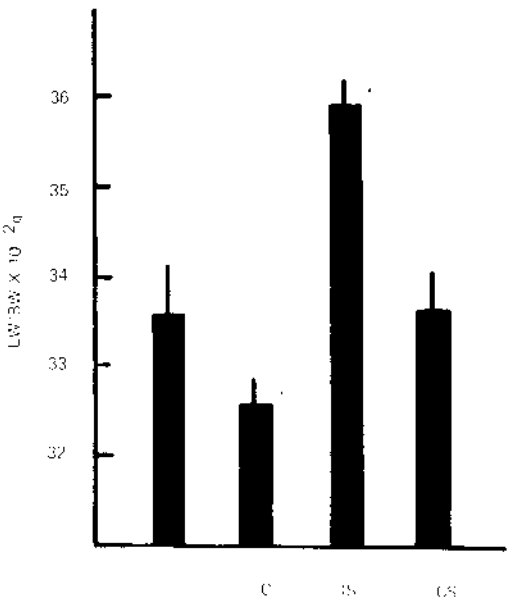

Fig. 4. Liver weights to bodyweights for I = Intact Nonswim, C = Castrated Nonswim, IS = Intact Swim and CS = Castrated Swim groups at the end of eight weeks. Bar with vertical line indicates the mean ± standard error. *denotes $P < 0.05$ from the Intact Nonswim group.