EXERCISE UPON THE FOOD CONSUMPTION AND BODY WEIGHTS OF YOUNG MALE ALBINO RATS

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ABSTRACT

THE EFFECTS OF VARIOUS LEVELS OF EXERCISE UPON THE FOOD CONSUMPTION AND BODY WEIGHTS OF YOUNG MALE ALBINO RATS

by Gundars Strautnieks

The purpose of this experiment was to determine the effects of various levels of exercise upon the food consumption and body weights of young male albino rats. The experiment was divided into two major parts. The first part consisted of thirty-five days and will be referred to as the treatment phase. The second part consisted of one hundred and five days and will be referred to as the post-treatment phase. The experiment ran one hundred forty consecutive days.

Thirty rats of the Sprague-Dawley strain were used for the entire experiment. Animals were divided into three groups, each group consisting of ten rats. The Sedentary Group was allowed sedentary activity for the treatment phase but spontaneous activity for the post-treatment phase. The rats in the Spontaneous Group served as controls and were allowed spontaneous activity for the entire experiment.

Individual rat body weight was determined daily for the first seventy days, and every third day for the last

seventy days. Animal food consumption was measured for each individual rat throughout the entire experiment. The spontaneous activity was measured daily for each individual rat by means of revolution counters that were attached to their cages. These data were recorded daily.

Rotation order was developed so that each rat would be in the microswitch-equipped caged once for a 24-hour period every five days. This was done because of another study that was run concurrently.

The results indicate that when young male albino rats are forced to exercise at young age they do not gain as much weight as those animals that are restricted from activity or allowed to exercise at their own desire in the spontaneous activity wheels. Even though the activity was different for each group of animals, there were no significant differences between the group totals in their food consumption. Finally, the rats that were forced to exercise by swimming at an early age ran a significantly greater number of revolutions than either the post-sedentary or general group rats.

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By

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I wish to express my sincere gratitude to Dr. Wayne Van Huss for his generous assistance and supervision during the course of this study. I am also indebted to Dale L. Hansen for his assistance in preparing and carrying out this experiment.

DEDICATION

This thesis is dedicated to my wife, Astrida, for her love and patience during this period of study and research.

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CHAPTER I

THE PROBLEM

Introduction

Overweight is associated with definite health hazards in terms of an increased incidence of serious disease and impaired life expectancy. When all facts are considered, it is apparent that overweight is a major health problem of our day. Although the evidence is incomplete in some respects, it seems quite clear that substantial health gains would result if overweight could be either prevented or remedied in an appreciable segment of our population.

Desirable weight is an individual thing. It may be described as the weight at which a person both looks and feels his best. A person's age, sex, height, bone structure, and muscular development all affect his weight.

Life is much easier in many ways for persons who are not too fat. They usually feel and look better. They are likely to live longer. They are less likely to suffer from backaches, foot troubles, fatigue, and other discomforts. Normal weight is worth any effort it takes to reach and keep it--worth in the terms of everyday comfort and of a healthier, longer life.

This study is not expected to solve any weight control problems or affect the general health of humans directly, it may, nevertheless, shed some light upon the problem that through further research may finally give some real beneficial results.

Statement of the Problem

To study the effects of various levels of exercise upon the food consumption and body weight of young male albino rats.

Justification of the Study

We are starting to realize today that the lean people of the past were so, not because they didn't have the food, but simply because they led a more active life. The increasing overweight problems and the complications that come along with obesity are certainly on an upswing in the United States.

Even though the methods of controlling obesity are crude and not universally effective under practical conditions, progress can be made. Research planned or in progress should do much to improve our understanding of the role of exercise on weight control as well as the basic nature and causes of overweight and hence develop better methods of prevention, diagnosis, and control.

Limitations of the Study

1. This is an animal study and therefore, whatever results should be obtained, the application to humans will always be complicated.

2. Some single animal may affect the whole group average as far as the body weight or food consumption is concerned.

3. The study was conducted using young male albino rats.

4. The minimal amounts of food lost through collecting and measuring methods.

5. The room temperature variations may have affected the food intake.

CHAPTER II

LITERATURE REVIEW

Introduction

In recent years tremendous advances have been made towards a better understanding of the effects of exercise. In spite of this advancement in many exercise areas, considerably little has been done to understand the effects of physical work on the food intake and body weights.

Various investigators have studied the influences of certain diets and how they affect the body weights and general food consumption. Others have investigated the effects of spontaneous activity and handling upon growth of animals.

The Effects of Spontaneous Activity on Food Intake and Growth

Slonaker (40) suggested that the fluctuation in spontaneous activity of the albino rat appear to be of normal occurrence and that therefore must be considered in experiments dealing with activity. In his animal work he found that the female albino rat not only exhibits variations in daily activity, known as the oestrual rhythm, but also shows gradual fluctuation in average daily activity which extend over long periods of time. Slonaker also found that fluctuations in average daily activity are common to both sexes, He further states that the lack of synchronism of these fluctuations in a group of animals indicates that changes in environment such as moisture, temperature or barometric pressure, are not the cause. Nevertheless, that a greater tendency toward synchronous fluctuation existed in the males than in the females.

Hetherington and Ranson (24) investigated spontaneous running activity both before and after operation of 10 rats with hypothalamic lesions frequently causing adiposity and of 6 normal litter-mate controls. It was observed that the animals having bilateral lesions in the hypothalamus tended to indulge in much less spontaneous running than did the majority of normal controls. The food consumption of the obese operated animals greatly exceeded the intake of normal controls or did not exceed at all, depending upon the nature of the food supplied. A soft palatable diet encouraged maximum consumption, whereas the hard dry pellet diet apparently discouraged higher intake.

Shirley (37) Slonaker (41) and Slonaker (42) after conducting extensive experiments on the activity of rats throughout the major part of the life period, showed that young and very old animals are quite inactive, but that there is little change in activity level from puberty to the age of one hundred days. They also demonstrated that the activity of each animal tends to a relatively constant value during the major part of the life cycle, with the female rats being much more active than the male. In addition, Slonaker showed that during the prime of life the activity is confined principally to night, and rest to day time. Of the whole amount of work done during the life time, almost three-fourths is done before reaching middle age. The males far surpassed the females in weight. The control males not only reached their maximum weight at an earlier age than the exercised males, but also greatly excelled them. The exercised rats were more active, more alert and brighter in appearance than the non-exercised ones, nevertheless, the control rats lived longer than the exercised rats.

Brody (9) did a study on the effects of selective breeding on activity and found that selective breeding had no effect upon increasing the mean activity or reducing the variability within the active strain of the albino rat.

Browman (10) controlled temperature and observed the effects upon the spontaneous activity rhythms of the albino rat. He succeeded in modifying the daily spontaneous activity rhythm and onset of oestrous of normal animals by daily variation of light and dark regardless of environmental temperature and by daily variation in temperature keeping the light conditions constant. And Brobeck (2) observed, that when temperature was low the average activity was high, but when the temperature was female rats being much more active than the male. In addition, Slonaker showed that during the prime of life the activity is confined principally to night, and rest to day time. Of the whole amount of work done during the life time, almost three-fourths is done before reaching middle age. The males far surpassed the females in weight. The control males not only reached their maximum weight at an earlier age than the exercised males, but also greatly excelled them. The exercised rats were more active, more alert and brighter in appearance than the non-exercised ones, nevertheless, the control rats lived longer than the exercised rats.

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The Effects of Animal Handling on Growth

McClelland (33) and Weininger (47) and others, in their animal work, support the theory that tactile stimulation during handling in the form of gentling enhances the vitality of the albino rat in the following specific ways: a) increasing body weight and skeletal length under ad libitum feeding conditions, b) increasing ambulatory activity and thereby decreasing emotionality, and c) decreasing organic damage under severe stress in the form of immobilization and food and water deprivation.

Greenman and Duhring (18) observed that handling of animals reduces emotionality and that the animals become tame and respond to the experimental procedures instead of "freezing." Gertz, (16) on the other hand, showed that there was no significant differences in emotionality from formal handling between the groups when tested as adults. Gertz concluded that there was no evidence for a "critical age" at which handling is effective in terms of later behavior.

Hall (22) from studying the relationships between external stimulation, food deprivation, and activity concludes that increased environmental stimulation results in an increase in activity, and the addition of the food-deprived state increases it still more.

The Effects of Exercise on Growth

There appears to be some controversy about the effects of exercise on growth. Donaldson (15) states that "exercise improves growth" when allowed as voluntary exercise, but that the over-exercising of rats at young age will retard growth. Price and Jones (35) report the effects of forced exercise on the growth of young rats exercised daily in drums turned by a motor. No special diet was administered. In results they found clear variation of growth between the resting rats and the exercised. The resting group showed greater rate of growth when expressed in the average percentage weights--whereas the exercised rats lagged behind. Measurements of body weights, body length, weight of humerus, length of humerus, weight of femur, and length of femur were given for 6 animals from controls (resting) and exercised animals--on every single count the controls were larger, longer and heavier. "All the weights and measurements of the exercised rats are less than the corresponding weights and measurements of the control rats." Price and Jones concluded that exercise retards the increase in weight and length of the body and of the skeleton.

Kimeldorf and Baum (27) report on alternations in organ and body weight of rats following daily exhaustive exercise, and exposure to x-rays. In their experiment they observed that body weight and weight of the gluteus maximus, kidney, and thymus were reduced while adrenal weight was increased in animals subjected to daily exhaustive exercise or exposed to x-rays. Spleen and heart were enlarged on particular days of sacrifice following exercise, whereas they were reduced with most doses of x-ray. Testis and pituitary weights were decreased by irradiation but not by exhaustive exercise.

The Effects of Diet on Activity and Growth

There appears to be a lot of experimental work done on various kinds of diets and how they affect the general health and well-being of laboratory animals. The references selected here were just the ones dealing with growth and exercise and how they are affected by diet, vitamin content in diet, and the denial of food or water.

Deuel and others (14) found that ad libitum feeding to rats of diets varying in fat content from 5 to 50 per cent resulted in better growth, greater physical capacity, and better reproductive and lactation performance. Optimum growth was observed on diets containing 20 to 40 per cent fat. Carpenter and Mayer (12) observed that the yellow mice gained the most weight on high fat diets, but if the animals were given a possibility to exercise in activity cages, they lost weight.

Slonaker (39) studied the effects of vegetable diet on the spontaneous activity, rate of growth, and longevity of albino rats. The rats fed on vegetable diet plus animal food were much more active and did more work in spontaneous activity cages than the vegetarians during their lifetime. He further observed that the vegetarian rats aged much earlier in life, and that their total growth was greatly retarded.

Mann and others (28) related their experimental findings to the development of obesity. Their study showed that the doubling of the caloric supply of young men did not increase the serum lipoproteins and cholesterol levels so long as the surplus energy was expended as heat and muscular energy. These findings probably reflect the benefits of physical activity.

Smith and Conger (43) suggested that differences in spontaneous activity of albino rats are due to dietary differences. In their experiment they fed one group a diet high in fat, the other group high in protein, and the third group a well-balanced diet. All the animals used in the study were litter-mates. The results showed that as much as 56 per cent of calorific value of the food may come from fat, and spontaneous activity be maintained at a normal level, but if the diet is 72 per cent of fat calories it depresses the activity a little. However, if the diet is 50 per cent animal protein, it induces a marked increase in activity.

Slanetz (38) evaluated diets for laboratory animals in respect to protein, fat, certain minerals, vitamin A and a number of the vitamin B fractions. He found variations between manufacturer's claims and his findings on vitamin A content in diets. He states that the diets investigated are apparently adequate in respect to vitamin B fractions, but feels that rat diets may be somewhat low in fat and too low in vitamin A for good liver storage of that vitamin.

Keith and Mitchell (26) tried the effects of muscular work with rats on vitamin requirements. The results indicated that the amount of exercise did not uniformly affect the well-being of the rats on complete rations or of those on rations lacking in vitamin B. They indicated that exercise did distinctly hasten the appearance of the symptoms of vitamin A deficiency, and hasten the death of young animals receiving insufficient amount of this vitamin. This study indicates a rather clear evidence that muscular exercise increases the demand for vitamin A.

Guerrant and others (20) using young rats showed that less food was consumed, smaller increases in body weight were made, and less severe symptoms of vitamin A deficiency developed when the animals were forced to exercise in a rotating wheel, than when permitted to exercise voluntarily, or when confined in the usual type of cage. This study showed that animals which were forced to exercise exhibited the greatest efficiency of food utilization, they voided the greatest number of fecal pellets, indicating a beneficial effect of exercise on intestinal mobility. Furthermore, it was shown that animals, which were exercised voluntarily, and which received daily allotments of vitamin A, were more active physically than were the litter-mates which did not receive the vitamin supplement.

Beznak and others (7) and Beznak (6) in their studies on growth and food consumption of albino rats exercised in revolving drums found that the growth of inactive rats on a low vitamin B_1 diet was proportional to the amount of fat in the diet. When the latter was reduced to 3 per cent, the growth becomes stunted. Forced exercise caused resumption of growth in the low fat diet group and slowing of growth in the high fat diet groups. On return to inactive life growth in all groups quickened. It was also observed in this study that water consumption during exercise period was inversely proportional to the fat content in diet and that it increased in later stages of exercise.

Guerrant and Dutcher (19) in their conducted experiments with carefully selected groups of young rats, yielded data which demonstrate that vitamin B_1 requirement of these animals, as indicated by the time required for the cessation of growth and for the development of paralytic symtoms, is increased by physical exercise. In the animals receiving no vitamin B_1, increased exercise resulted in less food consumption, less growth, early development of paralytic symptoms, and the elimination of a greater number of fecal particles. During the first 4 weeks of the test period, those animals which were permitted to exercise voluntarily were more active physically while not receiving vitamin B_1 than were the animals receiving the vitamin B_1. However, the physical activity declined during the latter stages of vitamin B_1 depletion.

Sheer and others (36) studied the physical capacity of rats in relation to energy and fat content of the diet. In their work they describe methods for the determination of body specific gravity, and capacity for exhaustive work in rats. The specific gravity determination was based upon determination of body volume by displacement. They determined the physical capacity by measuring the duration of a swim to exhaustion with regularly increased work load. No significant correlation between specific gravity and fat content from 0 to 40 per cent were fed ad libitum, physical capacity of the animals increased. When caloric intake was severely restricted, physical capacity decreased markedly.

The Effects of Exercise Upon the Food Intake

This has been the most controversial issue in the past, and for that matter, still is. The general belief is that exercise directly affects the food consumption. Most research and experimental work show just the opposite, simply, that there is no direct relationship between increase in food intake and mild activity.

Thomas and Miller (44) studied the influence of treadmill running on food intake, body weight and spontaneous activity in male albino rats. The initial response to gradually increasing exercise load was a decrease infood intake and body weight on exercise days, with compensatory increase in both factors on week-ends (rest days). By the time the exercise was increased to one mile per day, food intake on exercise days had returned to normal or slightly above, and food intake on rest days was significantly elevated. During the recovery period following the exercise, food intake remained elevated despite the absence of a significant weight deficit. Overnight spontaneous activity was strikingly reduced in exercised rats, with only partial restoration on rest days, and with gradual return to normal during the post-exercise recovery period.

Andik and others (3) studied the effects of exercise on food consumption and selection. Animals were offered free choice of 3 foods containing 1/3 standard mixture and 2/3 starch, casein and lard, respectively. The rats ran from 8 to 9 hours daily at 750 meters per hour and it was observed that the consumption of the starch food diminished, intake of fat rich, and especially of the casein rich food, increased markedly. The bulk of the food consumed remained practically unchanged, the change over from starch to fat furnishing the surplus calories. The termination of exercise was followed by return to pre-exercise levels of intake of all 3 foods.

Mayer and others (31) observed, that when mature rats accustomed to a sedentary existence were exercised in a treadmill for increasing daily periods, no increase in food intake was noted for low duration of exercise, 20 minutes to 1 hour, but the food intake actually decreased slightly but significantly, as did body weight also. With longer durations of exercise (1 to 6 hours) food intake increased linearlly and weight was maintained. For very long duration, animals lost weight, food intake decreased and the animals' appearance deteriorated.

Tribe (45) maintained 3 groups of 8 hooded Lister rats on a self-selection system of feeding and each group was submitted to 3 different levels of exercise. It was observed that at no time did the voluntary caloric intake vary with the amount of exercise undergone. Instead, the rate of body-weight increase slowed down as the amount of exercise increased.

Mayer and others (32) extended their experimental studies on work and food intake relationships to man. They established relation between caloric intake, body weight, and physical work in a group of 213 mill workers in West Bengal, India. The workers fit into a wide range of physical activity, from sedentary to very hard work. It was found that caloric intake increases with activity only within a certain zone. Below that range, a decrease in activity is not followed by a decrease in food intake, but rather by an increase. Body weight is also increased in that range. The picture presented here on humans is similar to that found in experimental animals.

The Role of Exercise in Weight Control

Mayer and others (31) in order to gain better insight on the effects of exercise on body weight studied non-obese and genetically obese mice. When the sedentary animals were exercised on a treadmill for 1 hour a day, the exercise did not affect the weight of the normal mice but considerably decreased the weight gain of the obese mice, even though the latter responded to exercise with increased food intake. The importance of considering exercise, as well as food intake, in the weight control, is well illustrated by these results.

Johnson and others (25) compared two groups of high school girls, 28 obese subjects and 28 non-obese individuals of similar age, grade and height in regard to maturation, food intake and activity. The groups differed in maturation the obese girls showing advanced development, that is, earlier deceleration of growth in height. Both groups were found to be relatively inactive, but the obese girls being significantly more so. When caloric intakes and activity indices were compared to determine the energy factors in the development and maintenance of obesity, on statistical basis, it was observed, inactivity was much more important than "overeating". In fact, the caloric intake of the obese group was significantly lower than that of the non-obese girls, with the relatively greater energy balance being consequently supplied by inactivity.

Passmore (34) theorizes, that "there is no doubt that in physically active persons appetite balances with remarkable precision, the energy values of the food eaten and the work performed." He performed a study of food intake on a dog. This animal within a short period of exercise did not increase the appetite above the sedentary level, but some slight loss of weight occurred.

The results are thus in line with a number of other studies and support their suggestion that a certain minimal level of physical activity is necessary for the appetite to function with precision and to adjust food intake to the requirements.

"I am convinced that inactivity is the most important factor explaining the frequency of 'creeping' overweight in modern western societies." These words belong to Jean Mayer, who has done considerable experimental work to support his statement. Mayer (29) studied in detail the food intake and the daily schedule of overweight children. He found that they differed from the normal, not in that they ate more but that they were extraordinary inactive. It was noted that the obese children just sat all their waking time. The role of physical inactivity in the development of the overweight was indicated by the fact that the overweight children who attended camps, where physical exercise was compulsory, lost weight during their summers. Mayer concludes that "the lack of physical activity is a major factor in the development of obesity in the adult as well as in the field--moderate exercise does not increase food intake, but does reduce body weight." Green (17) also traced the cause of obesity in human adults to a sudden decrease in activity.

Cecil and Loeb (13) have this to say about overweight problems, "weight reduction through caloric restriction alone is rarely successful, additional measures such as psychotherapy as well as physiological therapy are needed." Guyton (21) states that forced exercise is often an essential part of the treatment of obesity. Along with the previous thoughts Bard (4) suggests that emphasis should be placed on both exercise and diet--"the store of body fat can be increased or decreased only if the energy intake is greater or less respectively, than the energy expenditure. The fact that food intake is not the only factor involved in overweight is indicated by Beaudoin and Mayer (5) in their work, where they found that the average caloric intake of obese women does not contain significantly higher proportion of either carbohydrate or fat than does that of their normal weight controls.

Whalley and others (48) in their experiments forced animals to swim with additional weights amounting to 2.5 per cent, at other times forced them to swim without the weights. This study shows that rats offered a diet of fixed composition ingested less food and water during periods of enforced daily exercise than during periods of relative rest. It was conducted that physical stress (such as employed in this study) depressed in rats the desire to eat and drink.

Brobeck's (8) experimental work suggests that food intake, activity and temperature regulation in the rat are in a certain sense independent variables upon which weight gain depends. Brobeck further theorizes that since the regulation of body temperature, of activity, and of food intake is disturbed in animals with hypothalamic lesions, the hypothalamus may be the level of the central nervous system responsible for the control of every exchange.

Concerning the origin and mechanism of obesity in contrast to the over-simplified overeating theory, Mayer (30) theorizes that a number of different genes, probably working by different mechanisms, lead to obesity, that hormonal factors are implicated, and that exercise plays a role of different importance in different obesity syndromes.

Finally, the role of exercise in the control of body weight should not be overlooked. The teachers of physical education should constantly keep the importance of their job in this area in their minds. The possibility that the importance of physical activity has not been stressed enough in the past will always exist. Burt and Blyth (11) state 3 implications on weight control:

1. Body weight can be maintained or reduced by a considerable reduction in caloric intake.

2. Body weight can be maintained or reduced by vigorous daily exercise, with no reduction in caloric intake.

3. Body weight can be maintained or reduced by only a small reduction in caloric intake and a corresponding amount of daily exercise.

Thus, while diet may do the job temporarily, a more satisfactory way of weight control is through regular activity combined with sensible eating habits.

CHAPTER III

METHODS OF PROCEDURE

Introduction

The present study was undertaken to determine the effects of forced exercise, spontaneous activity, and sedentary activity upon the food intake and body weights of young male albino rats. More specifically, this experiment was undertaken to determine 3 things:

1. The effects of forced exercise, spontaneous activity and sedentary activity on food consumption and body weights of young male albino rats.

2. The effects of spontaneous activity on food consumption and body weight of young male albino rats following a period of forced exercise and sedentary activity.

3. To relate individual rat's spontaneous activity level with its food consumption and body weight following a period of forced exercise and sedentary activity.

It is necessary to state here that these same animals were used for another study that was being run concurrently. Therefore, a lot of information reported here will also reflect on the other study, nevertheless, it is felt that in order to present the picture in the clearest possible way, it is necessary to bring out that information. The other experiment was concerned about the effects of forced exercise upon the spontaneous activity. The length of this study was 140 days. The first 35 days will be referred to as the Treatment Phase while the remaining 105 days as Post-Treatment Phase.

The animals assigned to Group I were sedentary for the first 35 days but were allowed spontaneous activity for the remaining 105 days. Those animals which were assigned to Group II were allowed spontaneous activity during the entire experiment. The animals assigned to Group III in addition to spontaneous activity were forced to swim daily with the overload method for the first 35 days, for the final 105 days these animals were allowed spontaneous activity only. The animals from Group II were kept as Controls, whereas the animals from Groups I and III were held as Experimental Groups.

The food consumption was measured for each animal for the entire experiment. The average daily food consumption per animals per group was determined 11 times through the Treatment Phase and 24 times throughout the Post-Treatment Phase.

Subjects and Equipment

Thirty young male albino rats of the Sprague-Dawley strain were used for the study. These animals were 29 days old when they were received in the laboratory, 33 days old at the start of the experiment, 68 days old at the end of the Treatment Phase (first 35 days) and 173 days old at the termination of the experiment. These animals were all born on the same day but were not litter-mates.

The animals were assigned to groups by means of random selection. Fifty-four animals were received and were placed in individual sedentary cages. Each cage was numbered. Using a random number table, selection into groups of 10 rats each was made, and the animals were placed into the proper cage for their respective group. Each cage was numbered for the group and the individual. The animals assigned to Group I were housed in individual rectangular cages that measured approximately 10 inches long, 8 inches wide, and 7 inces high. Those animals which were assigned to Groups II and III were placed into individual spontaneous activity cages. These cages consisted of a 4 x 4 hardware cloth rectangular enclosement that was approximately 12 inches long, 5 1/2 inches wide, and 5 inches high. These cages were attached to a partition wall that measured 18 inches high and 18 inches wide with a 1/16 of one inch thickness. On the reverse side of the partition was a spontaneous wheel that measured approximately 45 inches in circumference and was 5 inches wide. An animal would have to run 1408 revolutions to cover a mile. The ~~outer~~ surface of this wheel was made of plexiglass while the running surface was made of 4 x 4 hardware cloth. The spontaneous wheel was connected to the partition wall by means of a bicycle axle which was free wheeling. A hole that measured 3-3/4 inches x 3-1/4 inches was cut in the partition wall between the rectangular cage and the wheel giving the animal free access to either portion of the cage.

Animals housed in the spontaneous activity cages entered the spontaneous wheel at will and made it turn by running. Many of the animals jumped high on the wheel to start it in motion and then they ran on it much like running on a tread mill. The wheels were designed so that the animal could run in either direction with the same effort and the revolution counters that were attached to each cage counted each complete revolution. A mechanical revolution counter was mounted on the rectangular cage side of the partition and its arm operated from an extension rod which attaches to a circular disc that was screwed onto the bicycle axle. This counter was calibrated to measure each revolution that the wheel makes and works equally well in either direction.

Water was supplied to the animals in all three groups by means of an inverted bottle which was fastened to the outside of the rectangular cage. A metal tube extended from the bottle into the cage and the animals received water by placing their mouth on the end of the tube.

A marking code was designed for the identification of individual rats. The code consisted of various patterns of circular and triangular holes made in the ears of the rats. The circles were made with a punch and the triangles with scissors. There was very little bleeding and no infection from this marking.

The temperature in the laboratory was not controlled, but was recorded daily with a Daystrom-Weston temperature recorder. The relative humidity was kept low by the use of a dehumidifier.

Small plastic containers were used for collection and transfer of food. The containers were specially marked for each animal. All food was weighed by the use of the Cent O Gram Triple Beam Balance. Fine screen plates were used to collect all the food that fell out of the spontaneous wheel or from the rectangular cage. These screen plates were placed over the trays containing the woodshavings and allowed all the urine and water to be absorbed by the woodshavings but leaving the food on top of the plate covering the tray.

All animals were fed Wayne Lab Blox for Rats, manufactured by the Allied Mills of Chicago and were allowed to consume all the food they desired.

Training Program

The entire experiment took 140 consecutive days. These 140 days were divided into two parts, the Treatment

Phase (first 35 days) and the Post-Treatment Phase (last 105 days). Within the Treatment Phase the individual daily average food consumption was determined 11 times. During the Post-Treatment Phase of the experiment the food intake of each animal was obtained 24 times. During the third and fourth phases, 8 times. Throughout the Treatment Phase, the animals from Group I were kept in individual sedentary cages while the animals from Group II and III were kept in spontaneous activity cages. The animals from Group III were forced to swim for 30 minutes daily using the overload method. Two per cent of the animal's weight was applied to his tail by water-proof adhesive tape. These animals swam in a sink which was lined with plexiglass. The water used for swimming was kept between 35 and 37 degrees Centigrade.

Since only six of the spontaneous exercise cages contained microswitches to measure the intensity of spontaneous activity for the other study, a rotation order was developed whereby each rat from the control group and forced exercise group was placed in these cages for 24 hours every 5 days. At the end of the 24 hour period, the rats were removed from these cages and were placed in the cage of the rat which was to take his place in the microswitch-equipped spontaneous activity cage. Prior to this move, all of the food was removed from the cages of the animals involved and each animal from all three groups was weighed. The animal's water bottle was moved with him as was his identification tag that was taped to the outside of his cage. This moving procedure shuffled the rats about the room so that they would be exposed to the varying environments in all of the locations within the room. The sedentary cages were shuffled around every second day so that the animals would not be on the same shelf for three days in a row.

During the Post-Treatment Phase of the experiment, all animals from each group were housed in the spontaneous activity cages. The ten sedentary animals were marked for identification purposes. A new rotation order was established to use the spontaneous activity cages equipped with the microswitches. Each animal was placed in one of these special spontaneous exercise intensity cages for 24 hours every five days. The total spontaneous wheel revolutions were recorded each day.

Testing Techniques

Each day starting at 2 p.m. all the animals were weighed. The food was then collected from the animal's cages that were scheduled to be tested for that day. Actually, the food was picked up from the six spontaneous activity cages equipped with microswitches as well as from the cages from which the animals were transferred to these specially equipped cages. Since there were three cages used for both, the spontaneous activity group and the forced exercise group, to measure the intensity of the running, the food was measured for six animals from each group. The food was collected in small plastic containers marked for each animal. The same procedure in the food collection was followed with the Sedentary Group animals.

The new food was weighed and prepared so that it could be placed in the cages right after the animals were rotated according to their rotation order for that day. Each animal was given from 30 to 40 grams extra food to avoid any possible shortages.

Specially built fine, screen plates were placed over the trays containing the woodshavings so that no food would be lost. Each smallest piece of leftover food was always collected from the animal's cage and the screen plates.

The weighing of the animals, collecting the food from the cages, weighing the collected food, weighing the new food, placing the new food in the cages and filling the water bottles took approximately from 2-1/4 to 2-3/4 hours. All this was done in one block of time. On the days when the waste trays were cleaned, it took an additional hour of time.

The same procedures were followed for the Post-Treatment Phase of the experiment. Instead of weighing the food for 18 animals each day as in the first half, now the food was handled only for 12 animals daily.

CHAPTER IV

RESULTS

This experiment was undertaken to determine the effects of various levels of exercise upon the food consumption and body weight of young male albino rats. The experiment consisted of two parts, a treatment phase (35 days in length) and a post-treatment phase (105 days in length). The various treatments applied to each group were described earlier. Individual rat number nine of the control group was eliminated because of extreme deviate activity and a large daily food consumption in the post-treatment phase. This animal's activity accounted for almost 50 per cent of the total spontaneous activity revolutions of the control group. This animal was also considerably lighter than any other animal in that group.

Food Consumption

Figure 1 shows the animal daily average food consumption. The sedentary and the forced exercise rats at the start of the experiment averaged approximately the same amount of food per day. The Controls were slightly below the other two groups in their food intake per day. The average daily food intake for the

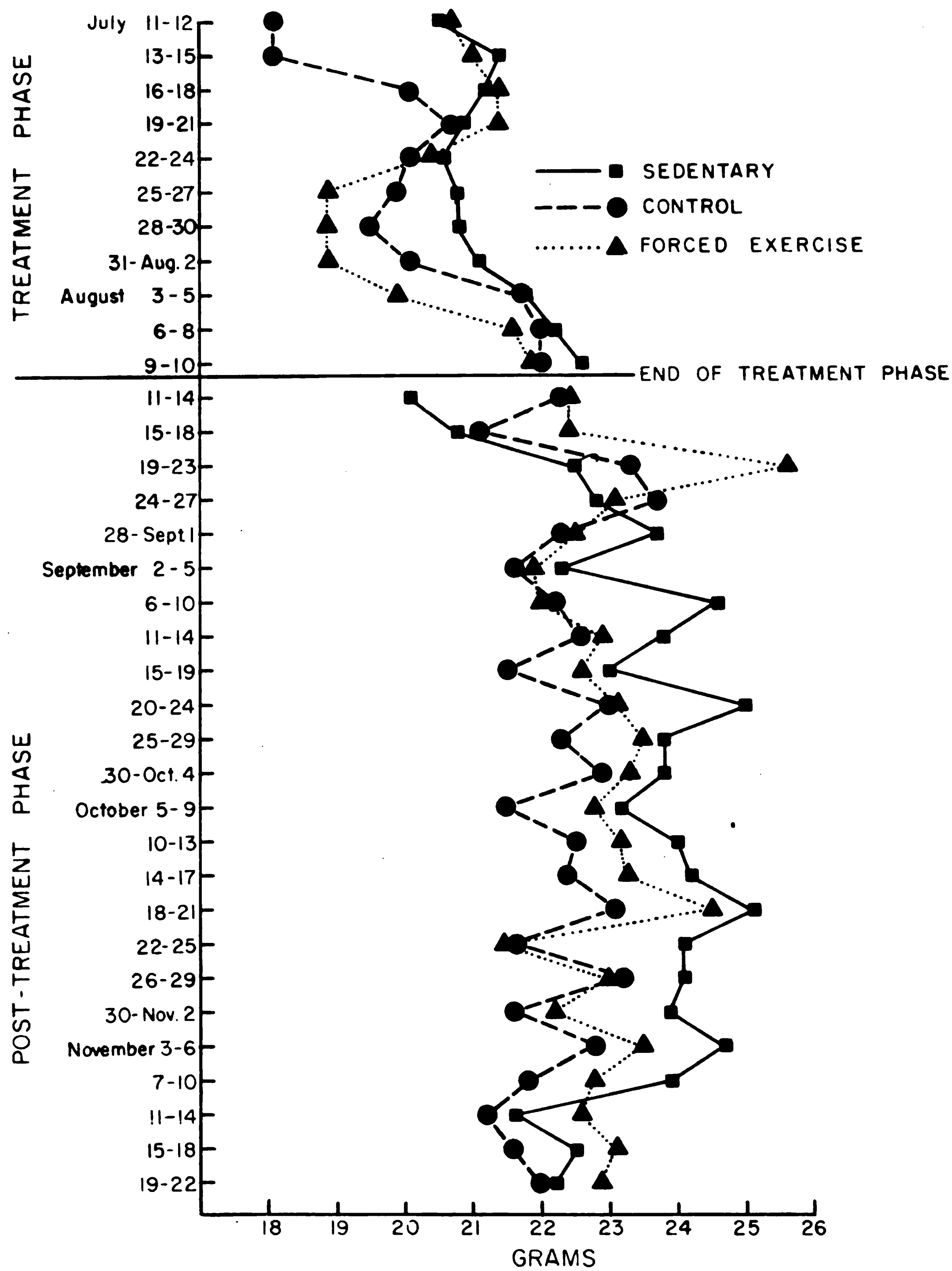

Figure 1. Average Food Consumption Per Group Per Test Period

treatment phase came out about equal for all three groups. The Sedentary Group averaged daily 21.290 grams per rat, the Controls 20.202 grams, and the Forced Exercise Group 20.466 grams per rat.

Statistically there were not any significant differences between the groups in animal food consumption for the Treatment Phase. Based on twenty-nine rats and three treatments, the allocation of degree of freedom were the following for food consumption during the treatment phase: Total--28, Treatments--2, and Error--26. The variance due to treatments was not significant at the 5 per cent level (F = 1.59). The results of the analysis of variance are shown in Table I.

TABLE I

ANALYSIS OF VARIANCE OF DATA FOR FOOD CONSUMPTION DURING THE TREATMENT PHASE

Source of Variation	D.F.	Sums of Squares	Mean Square	F	F.05
Total	28	57.236			
Treatments	2	6.227	3.1135	1.59	3.39
Error	26	51.009	1.9619		

The daily average food consumption for the post-treatment phase for the three groups came out as follows: Sedentary Group 23.321 grams per rat, Controls 22.934

grams per rat, and Forced Exercise 22.934 grams per rat. When the daily averages of the post-treatment phase are compared with those of the treatment phase, the daily food consumption per rat has increased by all three groups.

Statistically there were not any significant differences between the groups in animal food consumption during the post-treatment phase. Based on twenty-nine rats and three treatments, the allocation of degrees of freedom were the following for the food consumption for the post-treatment phase: Total--28, Treatments--2, and Error--26. The variance due to treatments was not significant at the 5 per cent level (F = 0.70). The results of the analysis of variance are shown in Table II. The means of the three groups were tested at the 5 per cent level through the use of the Duncan Test for Mean Values.

TABLE II

ANALYSIS OF VARIANCE OF DATA FOR FOOD CONSUMPTION DURING THE POST-TREATMENT PHASE

Source of Variation	D.F.	Sum of Squares	Mean Square	F	F.05
Total	28	108.207			
Treatments	2	5.584	2.782	0.70	3.39
Error	26	102.623	3.9470		

Animal Weights

At the start of the experiment the Sedentary and the Control Groups were averaging 107 grams per rat. The Forced Exercise Group averaged 105 grams per rat. Figure 2 shows the weight gain patterns for the entire experiment.

At the end of the Treatment Phase the Sedentary Group averaged 320 grams per rat, the Control Group 296 grams, and the Forced Exercise Group 280 grams per rat. From this it can be seen that the Sedentary Group gained approximately 213 grams per rat in the 35 days of sedentary activity. The Control Group gained approximately 189 grams per rat while running at their own desire in the spontaneous activity wheel for 35 days. The Forced Exercise Group, while swimming daily for 30 minutes with the overload method in addition to the running in the spontaneous activity wheels, gained 174 grams per rat for the same 35 days.

Statistically, there was a significant difference between the groups in the animal weights at the termination point of the Treatment Phase. Based on twenty-nine rats and three treatments, the allocation of degrees of freedom were the following for the animal weights for the Treatment Phase: Total--28, Treatments--2, and Error--26. The variance due to treatments was found to be significant both, at the 5 per cent level ($F_{.05} = 3.37$) and at the 1 per cent level ($F_{.01} = 5.53$). The results of the analysis of variance are shown in Table III.

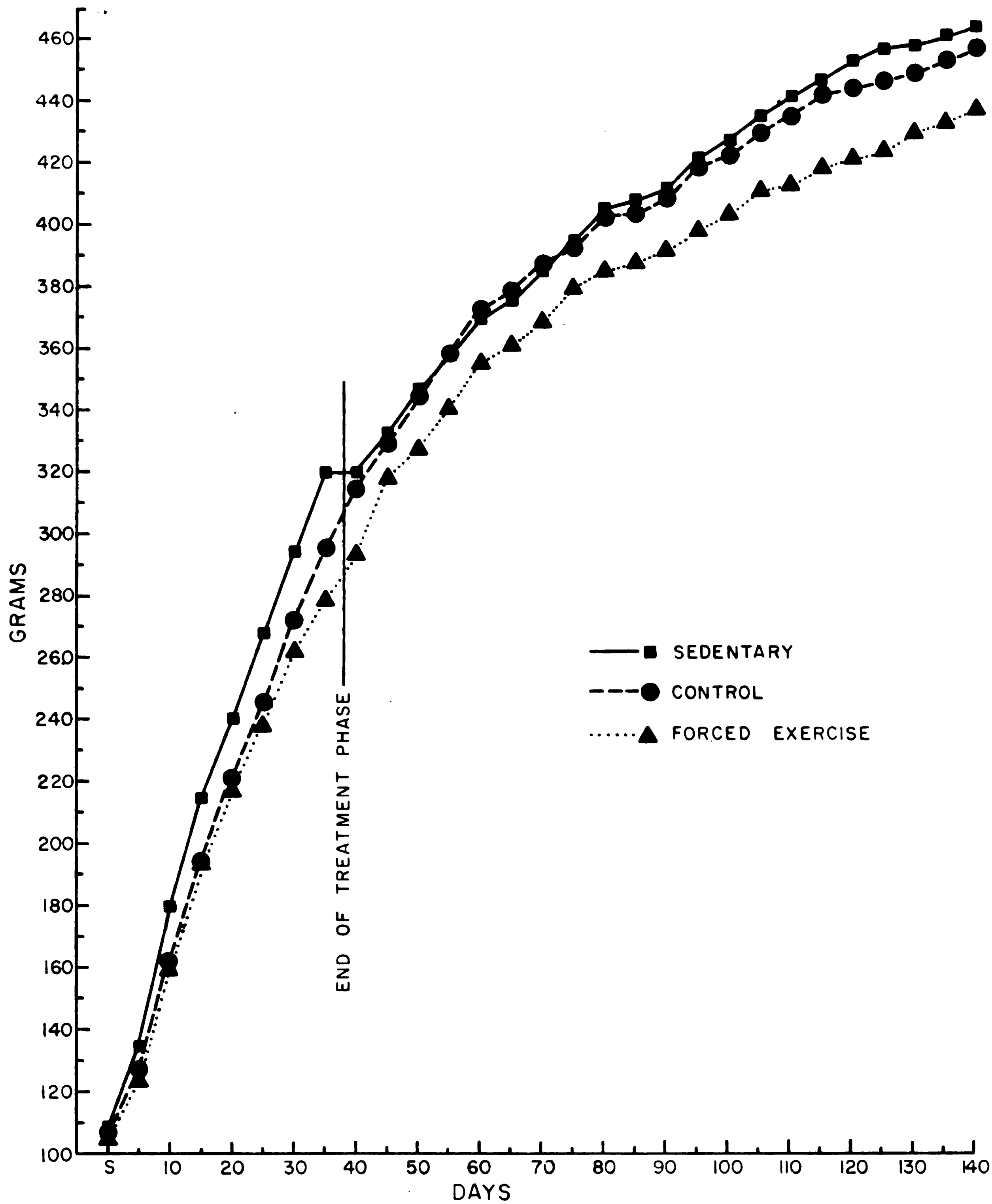

Figure 2. Rat Body Weight Per Group

TABLE III

ANALYSIS OF VARIANCE OF DATA FOR THE ANIMAL WEIGHTS DURING THE TREATMENT PHASE

Source of Variation	D.F.	Sum of Squares	Mean Squares	F	F.05	F.01
Total	28	16,217.95				
Treatments	2	7,563.99	3782.00	11.36	3.37	5.53
Error	26	8,653.96	332.84			

To Test Group Means at the 5 Per Cent Level:

174.30 Forced Exercise Group	188.80 Control Group	212.80 Sedentary Group

Using Range Table with 26 D.F.

2 2.91 (2) 17.07	3 3.06 (3) 17.95	$S_{\bar{t}} = \sqrt{\frac{332.84}{3}\left(\frac{1}{10} + \frac{1}{9} + \frac{1}{10}\right)}$

To Compare Sedentary Group with the other two groups:

$$\begin{array}{r} 212.80 \\ -17.95 \\ \hline 194.85 \end{array}$$

194.85 is greater than 188.80 so, therefore, the sedentary group mean is significantly greater than the other two groups at the 5 per cent level.

To Compare the Control Group with the Forced Exercise Group:

$$\begin{array}{r} 188.80 \\ -17.07 \\ \hline 171.73 \end{array}$$

171.73 is less than 174.30 so, therefore, the Control Group mean is not significantly greater than the Forced Exercise Group.

At the termination of the experiment (140 days) the Sedentary Group was averaging 465 grams per rat, the Control Group 458 grams per rat. Thus, since the end of the

Treatment Phase the Sedentary Group had gained about 145 grams per rat, the Controls 162 grams per rat, and the Forced Exercise Group about 159 grams per rat.

Statistically there were not any significant differences in animal weights between the groups from the end of the treatment phase to the end of the post-treatment phase. Based on twenty-nine rats and three treatments, the allocation of degrees of freedom were the following for animal weights during the post-treatment phase: Total--28, Treatments--2, and Error--26. The variance due to treatments was not found to be significant at the 5 per cent level (F = .92). The results of the analysis of variance are shown in Table IV.

TABLE IV

ANALYSIS OF VARIANCE OF ANIMAL WEIGHT DIFFERENCES FROM THE END OF TREATMENT PHASE TO THE END OF THE EXPERIMENT

Source of Variation	D.F.	Sum of Squares	Mean Square	F	F.05
Total	28	24,842.98			
Treatments	2	1,642.52	821.26	.92	3.37
Error	26	23,200.46	892.32		

Over the entire experiment (140 days) the Sedentary Group gained 357 grams per rat, the Control Group gained 351 grams per rat, and the Forced Exercise Group gained 334 grams per rat.

Statistically there were not any significant differences between the groups on the total weights gained for the entire experiment. Based on twenty-nine rats and three treatments, the allocation of degrees of freedom were the following for the animal weights for the entire experiment: Total--28, Treatments--2, Error--26. The variance due to treatments was not found to be significant at the 5 per cent level (F = 1.04). The results of the analysis of variance are shown in Table V.

TABLE V

ANALYSIS OF VARIANCE OF DATA FOR ANIMAL WEIGHT DIFFERENCES FOR THE ENTIRE EXPERIMENT

Source of Variance	D.F.	Sum of Squares	Mean Square	F	F.05
Total	28	41,113.55			
Treatments	2	3,032.97	1516.49	1.04	3.37
Error	26	38,080.58	1464.64		

<u>Spontaneous Activity</u>

Along with this experiment, the amount and intensity of spontaneous activity of the same rats was tested through another study by Dale L. Hanson. (23) Spontaneous activity was measured by the total number of wheel revolutions made by the individual rats. The mean values for spontaneous wheel revolutions are given in Figure 3.

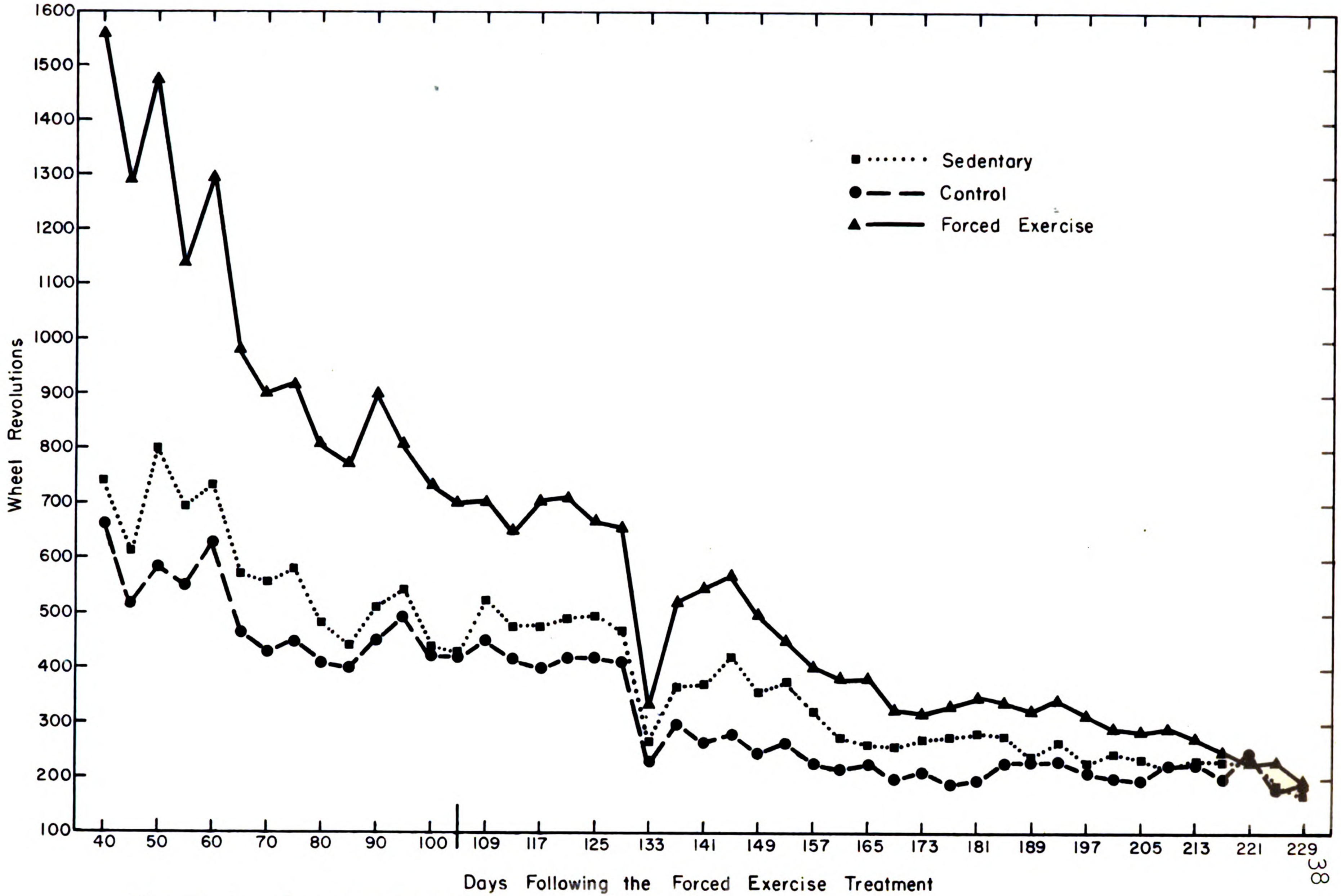

Figure 3. Average Spontaneous Wheel Revolutions Per Group

The results showed that rats which were forced to exercise by swimming with the overload method, increased their total spontaneous activity significantly as measured by wheel revolutions during the post-treatment phase but not during the treatment phase. The post-sedentary rats had comparable total spontaneous activity with that of control rats, but the total spontaneous activity of both of these two groups was significantly less than that of the forced exercise rats.

Discussion

The evidence presented indicated that in rats, under the conditions of this experiment, the voluntary food intake was not affected by forced exercise, nor was it decreased when the forced exercise treatment was terminated. Altogether, there were no significant differences between the groups in the average food consumption throughout the entire experiment. Nevertheless, the mean food consumption of the sedentary rats was slightly higher than that of the forced exercise rats during the treatment phase and also during the post-treatment phase. The food consumption of the control group was less than that of any of the other two groups.

The obvious drop in food consumption in the forced exercise group as well as in the control group during the treatment phase could probably be due to an increase in room temperature. It is very interesting to note, however, that if the temperature really was the deciding factor here, it affected the food intake of the sedentary rats very little.

The daily food consumption of the sedentary rats fell off quite considerably during the first stages of the post-treatment phase when these animals were placed on spontaneous activity for the first time. This sudden drop was probably due to the opportunity to exercise and also due to the new environmental conditions. Thus, it could be assumed that the opportunity to run in the spontaneous activity wheel, along with the new environment, temporarily depressed the rat's desire for the food offered. This also was the only time in the entire experiment when the sedentary rats did not gain any weight for five consecutive days, and even when they started to gain again, the rate of weight gained per day was not as great as previously during the treatment phase. The forced exercise group and the control group were averaging approximately the same weight until the twentieth day of the experiment. From then on the rate of the daily weight gain of the forced exercise rats started to decrease and continued so to the end of the treatment phase. During the first part of the post-treatment phase the rate of the daily weight gain of the forced exercise rats was slightly increased, but then, as these rats started to increase their spontaneous activity, the rate of the weight gain became slower again. Nevertheless, the rate of the weight gain during the post-treatment phase was slightly higher in the control and forced exercise groups than in the sedentary group. In the case of the forced exercise rats, this could be an attempt to restore the body weight deficit incurred during the forced swimming period, why this is so with the controls, remains to be investigated.

The fact that spontaneous activity was depressed in the forced exercise rats during the treatment phase, but was greatly elevated following the termination of the treatment phase, indicates that forced exercise at early age does affect the degree of spontaneous activity in adult male albino rats.

Finally, considering voluntary food consumption a measure of desire for food, it can be concluded that the levels of exercise designed for this experiment did not affect the rats food intake. The exercise did, however, affect the rats body weight.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

The purpose of this experiment was to determine the effects of various levels of exercise upon the food consumption and body weights of young male albino rats. The experiment was divided into two major parts. The first part consisted of thirty-five days and will be referred to as the treatment phase. The second part consisted of one hundred and five days and will be referred to as the post-treatment phase. The experiment ran one hundred forty consecutive days.

Thirty rats of the Sprague-Dawley strain were used for the entire experiment. Animals were divided into three groups, each group consisting of ten rats. The Sedentary Group was allowed sedentary activity for the treatment phase but spontaneous activity for the post-treatment phase. The rats in the Spontaneous Group served as controls and were allowed spontaneous activity throughout the entire experiment. The Forced Exercise Group was forced to swim with the overload method for the treatment phase and were allowed spontaneous activity for the entire experiment.

Individual rat body weight was determined daily for the first seventy days, and every third day for the last seventy days. Animal food consumption was measured for each individual rat throughout the entire experiment. The spontaneous activity was measured daily for each individual rat by means of revolution counters that were attached to their cages. These data were recorded daily.

Rotation order was developed so that each rat would be in the microswitch-equipped cage once for a 24-hour period every five days. This was done because of another study that was run concurrently.

The results indicate that when young male albino rats are forced to exercise at young age they do not gain as much weight as those animals that are restricted from activity or allowed to exercise at their own desire in the spontaneous activity wheels. Even though the activity was different for each group of animals, there were no significant differences between the groups total in their food consumption. Finally, the rats that were forced to exercise by swimming at an early age ran a significantly greater number of revolutions than either the post-sedentary or control group rats.

Conclusions

1. Exercise does significantly affect body weight.
2. Mild exercise does not increase food intake.

3. Forced exercise rats participate significantly more in spontaneous running.

4. Independent from the group, those animals which do the least work gain the most weight and also on the average eat more.

5. Independent from the group, those animals which do the most work gain the least weight and also on the average eat less.

Recommendations

1. A similar study should be done over a longer period of time to determine whether the animal weights for all three groups would ever come together.

2. A similar study should be done over a longer period of time to determine whether the spontaneous activity level of the forced exercise rats would ever drop below that of the other two groups.

3. A similar study should be done with an additional treatment phase in later stages of life to determine the effects upon food consumption, body weight, and spontaneous activity.

4. A study should be done varying the overload weights to determine the effects upon food consumption, body weight, and spontaneous activity during the treatment phase and during the post-treatment phase.

5. A similar study should be done on a carefully selected active strain of rats.

BIBLIOGRAPHY

1. American Public Health Association, Inc. Care of Laboratory Animals. New York: American Public Health Association, Inc., 1954.

2. Anand, Bal K., and John R. Brobeck. "Food Intake and Spontaneous Activity of Rats with Lesions in the Amygdaloid Nuclei," Journal of Neurophysiology, 15:421-430, September, 1952.

3. Andik, I., J. Bank, I. Moring, and Gy Szegvari. "The Effect of Exercise on Food Intake and Selection," Acta Physiologica Academiae Scientiarum Hungaricae, 5:457-461, 1954.

4. Bard, Philip. Medical Physiology. St. Louis: C. V. Mosby Company, 1956.

5. Beaudoin, R., and J. Mayer. "Food Intakes of Obese and Non-obese Women," Journal of American Dietetic Association, 29:29-33, January, 1953.

6. Beznak, A. B. L. "Dietary Fat, Work, and Growth," Experientia, pp. 236-238, 1953.

7. Beznak, A. B. L., M. Beznak, and J. Hajdu. "The Growth and the Food and Water-Consumption of the Testing or Exercising Albino Rat on Diets Containing Various Amounts of Fat and Reduced Quantity of Vitamin B_1," Hungarica Acta Physiologica et Biologica, 1 (2/3):35, 1947.

8. Brobeck, John R. "Effects of Variations in Activity, Food Intake and Environmental Temperature on Weight Gain in the Albino Rat," The American Journal of Physiology, 143:1-5, January, 1945.

9. Brody, Elizabeth Graves. Genetic Basis of Spontaneous Activity in the Albino Rat. Baltimore, Maryland: The Williams & Wilkins Company, 1942.

10. Browman, Ludvig G. "Effects of Controlled Temperature Upon the Spontaneous Activity Rhythms of the Albino Rat," Journal of Experimental Zoology, 94:477-489, December, 1943.

11. Burt, J. J., and C. S. Blyth. "Role of Exercise in Weight Control," Journal of Health, Physical Education, and Recreation, 32:23-24, January, 1961.

12. Carpenter, K. J., and Jean Mayer. "Physiologic Observations on Yellow Obesity in the Mouse," American Journal of Physiology, 193:499-504, June, 1958.

13. Cecil, Russell L., and Robert F. Loeb. A Textbook of Medicine. Philadelphia: W. B. Saunders Company, 1955.

14. Deuel, Harry J., Emily R. Merserve, Evelyn Straub, Cornelia Hendrick, and Bradley T. Scheer. "The Effect of Fat Level of the Diet on General Nutrition," Journal of Nutrition, 33:569-582, May, 1947.

15. Donaldson, H. H. The Rat--Data and Reference Tables, 2nd ed., p. 179, 1924.

16. Gertz, Boris. "The Effect of Handling at Various Age Levels on Emotional Behavior of Adult Rats," Journal of Comparative Physiological Psychology, 50:613-616, December, 1957.

17. Greene, James A. "Clinical Study of the Etiology of Obesity,: Annals of Internal Medicine, 12:1797-1803, May, 1939.

18. Greenman, M. J., and F. L. Duhring. Breeding and Care of the Albino Rat For Research Purposes, 2nd ed. Philadelphia: The Wistar Institute of Anatomy and Biology, 1931.

19. Guerrant, N. B., and R. A. Dutcher. "The Influence of Exercise on the Growing Rat in the Presence and Absence of Vitamin B_1," Journal of Nutrition, 20:589-598, December, 1940.

20. Guerrant, N.B., R. A. Dutcher, and F. Chornock. "The Influence of Exercise on the Growing Rat in the Presence and Absence of Vitamin A," Journal of Nutrition, 17:473-484, May, 1939.

21. Guyton, Arthur C. Textbook of Medical Physiology. Philadelphia: W. B. Saunders Company, 1956.

11. Burt, J. J., and C. S. Blyth. "Role of Exercise in Weight Control," Journal of Health, Physical Education, and Recreation, 32:23-24, January, 1961.

12. Carpenter, K. J., and Jean Mayer. "Physiologic Observations on Yellow Obesity in the Mouse," American Journal of Physiology, 193:499-504, June, 1958.

13. Cecil, Russell L., and Robert F. Loeb. A Textbook of Medicine. Philadelphia: W. B. Saunders Company, 1955.

14. Deuel, Harry J., Emily R. Merserve, Evelyn Straub, Cornelia Hendrick, and Bradley T. Scheer. "The Effect of Fat Level of the Diet on General Nutrition," Journal of Nutrition, 33:569-582, May, 1947.

15. Donaldson, H. H. The Rat--Data and Reference Tables, 2nd ed., p. 179, 1924.

16. Gertz, Boris. "The Effect of Handling at Various Age Levels on Emotional Behavior of Adult Rats," Journal of Comparative Physiological Psychology, 50:613-616, December, 1957.

17. Greene, James A. "Clinical Study of the Etiology of Obesity,: Annals of Internal Medicine, 12:1797-1803, May, 1939.

18. Greenman, M. J., and F. L. Duhring. Breeding and Care of the Albino Rat For Research Purposes, 2nd ed. Philadelphia: The Wistar Institute of Anatomy and Biology, 1931.

19. Guerrant, N. B., and R. A. Dutcher. "The Influence of Exercise on the Growing Rat in the Presence and Absence of Vitamin B_1," Journal of Nutrition, 20:589-598, December, 1940.

20. Guerrant, N.B., R. A. Dutcher, and F. Chornock. "The Influence of Exercise on the Growing Rat in the Presence and Absence of Vitamin A," Journal of Nutrition, 17:473-484, May, 1939.

21. Guyton, Arthur C. Textbook of Medical Physiology. Philadelphia: W. B. Saunders Company, 1956.

22. Hall, John F. "The Relationship Between External Stimulation, Food Deprivation, and Activity," Journal of Comparative and Physiological Psychology, 49:339-341, March, 1955.

23. Hanson, Dale L. "The Effects of Forced Exercise Upon the Amount and Intensity of Spontaneous Activity of Young Male Albino Rats." Unpublished Ph. D. Thesis, Michigan State University, East Lansing, 1962.

24. Hetherington, A. W., and S. W. Ranson. "The Spontaneous Activity and Food Intake of Rats with Hypothalamic Lesions," American Journal of Physiology, 136:609-617, March, 1942.

25. Johnson, Mary Louise, Bertha S. Bruke, and Jean Mayer. "Relative Importance of Inactivity and Overeating in the Energy Balance of Obese High School Girls," American Journal of Clinical Nutrition, 4:37-44, January-February, 1956.

26. Keith, M. H., and H. H. Mitchell. "The Effect of Exercise on Vitamin Requirement," American Journal of Physiology, 65:128-138, June, 1923.

27. Kimeldorf, D. J., and S. J. Baum. "Alternations in Organ and Body Growth of Rats Following Daily Exhaustive Exercise, X-Irradiation, and Post-Irradiation Exercise," Growth, 18:79-96, May, 1954.

28. Mann, George V., Katherine Teel, Olive Hayes, Ann McNally, and Dorothy Bruno. "Exercise in the Disposition of Dietary Calories," The New England Journal of Medicine, 253:349-355, September, 1955.

29. Mayer, Jean. "Exercise Can Keep Us Fit," Journal of Health, Physical Education & Recreation, 27:12+, September, 1956.

30. Mayer, Jean. "An Experimentalist's Approach to the Problem of Obesity," Journal of American Dietetic Association, 31:230-235, March, 1955.

31. Mayer, Jean, M. Marshall, J. J. Vitale, J. Christensen, M. Mashayekli, and F. J. Stare. "Exercise, Food Intake and Body Weight, in Normal Rats and Genetically Obese Adult Mice," American Journal of Physiology, 177:544-548, June, 1954.

32. Mayer, Jean, P. Roy, and K. P. Mitra. "Relation Between Caloric Intake, Body Weight and Physical Work in an Industrial Male Population in West Bengel," American Journal of Clinical Nutrition, 4:169-175, March-April, 1956.

33. McClelland, W. J. "Differential Handling and Weight Gain in the Albino Rat," Canadian Journal of Psychology, 10:19-22, March, 1956.

34. Passmore, R. "A Note on the Relation of Appetite to Exercise," Lancet, 1:29, January, 1958.

35. Price-Jones, Cecil. "The Effect of Exercise on the Growth of White Rats," Quarterly Journal of Experimental Physiology, 16:61-67, 1927.

36. Sheer, B. T., S. Dorst, J. F. Codie, and D. F. Soule. "Physical Capacity of Rats in Relation to Energy and Fat Content of the diet," American Journal of Physiology, 149:194-203, April, 1947.

37. Shirley, M. "Studies of Activity. I. Consistency of the Revolving Drum Method of Measuring the Activity of the Rat," Journal of Comparative Psychology, 8:23-38, February, 1928.

38. Slanetz, Charles A. "The Adequacy of Improved Stock Diets for Laboratory Animals," American Journal of Veterinary Research, 4:182-189, April, 1943.

39. Slonaker, James Rollin. "The Effect of a Strictly Vegetable Diet on the Spontaneous Activity, the Rate of Growth, and Longevity of the Albino Rat," Leland Stanford Jr. University Publications, pp. 1-52, April 2, 1912.

40. Slonaker, James Rollin. "Long Fluctuations in Voluntary Activity of the Albino Rat," The American Journal of Physiology, 77:503-508, August, 1926.

41. Slonaker, James Rollin. "The Normal Activity of the Albino Rat from Birth to Natural Death, Its Rate of Growth, and Duration of Life," Journal of Animal Behavior, 2:20-42, February, 1912.

42. Slonaker, James Rollin. "The Normal Activity of the White Rat at Different Ages," Journal of Comparative Neurology and Psychology, 17:342-359, July, 1907.

43. Smith, Erna A., and R. M. Conger. "Spontaneous Activity in Relation to Diet in the Albino Rat," The American Journal of Physiology, 142:663-665, December, 1944.

44. Thomas, Barbara M., and A. T. Miller, Jr. "Adaptation to Forced Exercise in the Rat," The American Journal of Physiology, 193:350-354, May, 1958.

45. Tribe, D. E. "The Influence of Exercise on the Selection of Food by Rats," British Journal of Animal Behavior, 2:140-143, 1954.

46. Weininger, O. "The Effects of Early Experience on Behavior and Growth Characteristics," Journal of Comparative and Physiological Psychology, 49:1-9, October, 1956.

47. Weininger, O., W. J. McClelland, and R. K. Arima. "Gentling and Weight Gain in the Albino Rat," Canadian Journal of Psychology, 14:219-224, September, 1954.

48. Whalley, J., J. Howden, and F. R. Goetzl. "On the Influence of Enforced Exercise Upon Voluntary Food Intake of Rats," Permanente Foundation Medical Bulletin, 9:114-118, October, 1951.

APPENDICES

APPENDIX A

SEDENTARY GROUP FOOD CONSUMPTION IN GRAMS FOR TREATMENT PHASE

Testing Dates		Animals 1	2	3	4	5	6	7	8	9	10	Gr. Aver. Per Test Period
July	11-12	21.5	21.0	18.9	21.9	18.4	19.8	20.5	19.8	21.2	22.4	20.54
	13-15	22.7	21.2	19.3	23.1	19.4	20.8	22.6	20.6	22.1	22.4	21.42
	16-18	22.2	20.8	19.1	22.8	19.7	20.3	22.3	20.2	21.4	23.3	21.21
	19-21	22.9	21.5	19.5	22.7	17.8	21.2	21.6	19.4	20.4	22.1	20.91
	22-24	22.5	21.9	19.5	23.0	16.5	21.7	21.2	17.2	20.8	22.0	20.63
	25-27	22.7	22.4	21.3	21.9	18.3	21.3	20.6	17.8	20.3	21.8	20.84
	28-30	23.9	23.3	22.6	21.5	19.1	20.6	18.8	17.4	20.6	20.5	20.83
	31-Aug.2	25.2	24.3	23.2	20.5	20.1	20.8	18.0	17.9	21.3	20.4	21.17
August	3-5	25.7	25.0	23.7	22.9	19.7	21.7	19.7	18.6	22.7	18.2	21.79
	6-8	24.8	24.7	24.6	22.6	21.2	22.8	20.7	19.7	21.8	19.5	22.24
	9-10	26.3	25.7	23.8	22.1	20.6	24.3	21.1	19.6	21.5	21.2	22.62
Indiv. Rat Averages		23.672	22.890	21.409	22.272	19.163	21.390	20.645	18.927	21.281	21.254	
Total Gr. Average:		21.290										

APPENDIX B

CONTROL GROUP FOOD CONSUMPTION IN GRAMS FOR TREATMENT PHASE

Testing Dates		Animals 1	2	3	4	5	6	7	8	9	10	Gr. Aver. Per Test Period
July	11-12	17.5	17.8	18.3	19.7	19.4	17.3	17.0	17.9		17.9	18.08
	13-15	19.5	22.1	16.3	20.3	17.7	15.1	16.4	18.6		16.5	18.05
	16-18	22.6	23.9	21.6	23.2	18.1	15.5	17.1	20.2		18.9	20.12
	19-21	23.8	21.3	20.3	21.2	20.1	15.2	20.4	23.2		20.9	20.71
	22-24	22.8	16.3	22.0	21.9	17.2	18.2	21.2	22.9		18.6	20.12
	25-27	20.9	17.1	18.9	23.7	19.1	18.8	23.3	20.3		16.9	19.88
	28-30	21.0	18.9	19.2	22.4	18.5	18.1	17.7	17.5		21.8	19.45
	31-Aug. 2	21.4	20.8	20.7	21.4	17.9	19.2	20.0	19.5		19.6	20.05
August	3-5	23.8	22.2	22.4	23.1	18.6	21.5	22.4	19.4		22.1	21.72
	6-8	24.4	21.6	21.9	24.2	21.1	22.9	20.7	21.6		19.3	21.96
	9-10	22.9	21.8	24.4	26.1	19.6	19.6	20.8	23.5		19.7	22.04
Indiv. Rat Averages		21.87[illegible]	20.345	20.545	22.472	18.845	18.309	19.727	20.418		19.290	
Total Gr. Average:		20.195										

APPENDIX C

FORCED EXERCISE GROUP FOOD CONSUMPTION IN GRAMS FOR TREATMENT PHASE

Testing Dates		Animals 1	2	3	4	5	6	7	8	9	10	Gr. Aver. Per Test Period
July	11-12	20.7	21.9	22.3	22.1	20.2	20.2	19.3	17.6	20.3	22.8	20.74
	13-15	21.6	22.1	21.8	21.6	21.3	21.3	18.6	18.4	20.7	22.2	20.96
	16-18	23.7	22.5	22.8	22.5	20.3	21.1	18.9	17.7	21.6	22.4	21.35
	19-21	21.2	22.9	22.6	22.7	21.9	21.4	17.6	20.2	19.9	23.9	21.43
	22-24	17.2	16.7	23.8	23.5	19.4	20.3	20.3	16.5	22.9	23.7	20.43
	25-27	16.8	18.3	17.9	21.5	16.9	25.0	21.3	13.3	21.1	17.2	18.93
	28-30	15.6	20.4	16.7	21.1	21.9	22.1	19.7	14.1	18.6	18.9	18.91
	31-Aug. 2	19.2	18.6	16.9	20.5	18.9	22.4	20.3	17.1	19.1	16.5	18.95
August	3-5	19.1	20.2	18.0	20.6	18.4	24.7	19.0	20.8	20.1	18.4	19.93
	6-8	20.5	21.3	20.0	23.8	24.0	26.9	20.1	17.6	21.2	21.1	21.65
	9-10	21.9	20.2	18.3	24.4	23.2	26.2	22.4	23.4	18.9	19.9	21.86
Indiv. Rat Averages		19.772	20.445	20.100	22.209	20.581	22.872	19.772	17.881	20.400	20.636	

Total Gr. Average: 20.467

APPENDIX D

SEDENTARY GROUP FOOD CONSUMPTION FOR POST-TREATMENT PHASE (IN GRAMS)

Testing Dates		Animals 1	2	3	4	5	6	7	8	9	10	Gr. Aver. Per Test Period
August	11-14	18.5	20.3	19.2	18.4	17.3	16.8	17.0	21.9	21.1	30.7	20.12
	15-18	20.6	20.7	13.9	19.0	19.5	24.9	17.6	17.7	25.3	29.2	20.84
	19-23	28.7	27.6	21.8	19.3	19.1	20.4	19.4	20.4	27.5	20.8	22.50
	24-27	25.3	25.4	25.4	25.8	14.7	21.6	21.9	23.9	21.1	22.5	22.76
	28-Sep. 1	23.7	25.1	25.6	20.8	22.9	24.1	23.5	22.6	23.5	25.1	23.69
September	2-5	29.4	25.9	23.3	20.4	17.2	19.0	16.5	21.5	25.9	23.6	22.27
	6-10	25.3	27.6	25.3	25.2	28.7	22.5	22.5	19.7	24.4	24.4	24.56
	11-14	27.1	25.1	25.2	24.3	21.7	21.5	25.3	21.0	20.2	26.6	23.80
	15-19	26.8	26.3	22.6	23.2	19.3	20.8	24.1	20.6	21.6	24.9	23.02
	20-24	27.7	27.5	28.6	25.6	20.7	22.6	25.3	21.5	22.5	28.4	25.04
	25-29	25.2	27.4	24.0	25.0	19.6	21.9	20.8	21.4	24.1	28.8	23.82
	30-Oct. 4	25.4	24.1	26.2	24.5	20.1	21.3	23.4	22.0	24.1	26.7	23.78
October	5-9	25.1	25.0	26.5	21.6	20.8	21.7	22.3	22.1	20.2	26.3	23.16
	10-13	25.6	25.2	25.5	23.3	20.8	22.0	23.8	22.3	25.0	26.6	24.01
	14-17	25.0	26.2	25.8	21.3	22.9	22.8	23.0	21.9	25.6	27.1	24.16
	18-21	27.8	26.5	27.6	26.2	21.8	21.8	23.4	21.5	27.0	27.8	25.14
	22-25	26.4	25.1	22.1	26.2	21.7	22.2	21.1	20.5	26.6	28.8	24.07
	26-29	26.4	26.5	23.7	24.8	20.3	23.3	23.9	21.7	25.8	24.2	24.06
	30-Nov. 2	26.8	26.0	24.0	25.8	21.3	20.6	23.1	20.8	25.9	24.4	23.87
November	3-6	29.3	27.4	25.0	27.3	20.4	22.4	20.7	21.7	25.3	27.9	24.74
	7-10	25.5	26.6	24.8	25.8	20.3	22.1	22.5	20.8	24.0	27.0	23.94
	11-14	23.5	24.5	22.3	20.6	16.4	20.9	20.6	18.6	21.1	27.6	21.61
	15-18	23.2	24.6	23.8	24.5	18.3	21.3	20.0	19.1	24.1	26.5	22.54
	19-22	23.4	23.7	24.4	21.4	18.5	21.5	22.2	19.1	23.9	24.1	22.22
Indiv. Rat Averages		25.487	25.429	24.024	23.345	20.179	21.666	21.828	21.012	23.991	26.249	

Total Gr. Average: 23.321

APPENDIX E

CONTROL GROUP FOOD CONSUMPTION FOR POST-TREATMENT PHASE (IN GRAMS)

Testing Dates		Animals 1	2	3	4	5	6	7	8	9	10	Gr. Aver. Per Test Period
August	11-14	25.0	24.4	19.6	22.7	23.5	20.6	21.1	25.5		18.7	22.34
	15-18	25.1	22.4	20.9	15.9	19.9	17.3	26.6	19.1		22.4	21.06
	19-23	28.9	24.6	20.4	19.9	22.2	25.2	22.2	27.9		18.0	23.25
	24-27	26.1	22.8	24.8	32.7	17.5	20.8	18.7	32.3		17.2	23.65
	28-Sep. 1	25.3	22.2	21.4	13.9	23.1	27.8	21.1	26.4		19.5	22.30
September	2-5	26.0	22.3	21.9	23.1	21.5	14.4	21.0	23.5		20.5	21.57
	6-10	20.8	23.6	21.4	23.3	21.3	23.0	21.7	23.9		20.8	22.20
	11-14	23.5	21.3	22.2	21.7	21.3	23.1	22.1	24.4		23.7	22.58
	15-19	23.2	20.8	19.9	22.2	20.4	23.0	20.0	25.2		18.6	21.47
	20-24	24.2	23.9	20.2	26.1	21.1	23.5	21.6	25.8		20.9	23.03
	25-29	26.7	22.1	19.6	22.4	21.4	19.1	22.4	27.4		19.7	22.31
	30-Oct. 4	24.8	21.4	19.9	22.9	21.1	25.7	21.8	26.9		21.3	22.86
October	5-9	20.6	20.5	21.4	25.0	21.1	22.8	20.6	21.9		20.0	21.54
	10-13	24.0	22.4	21.9	24.6	20.9	22.3	20.3	24.7		21.2	22.47
	14-17	24.5	21.9	20.3	23.2	21.7	22.0	20.6	25.4		22.0	22.40
	18-21	24.6	23.9	21.2	24.8	21.9	23.0	20.5	25.8		21.9	23.06
	22-25	23.1	21.1	19.3	23.6	22.0	21.1	19.5	25.1		19.3	21.56
	26-29	25.1	23.8	19.8	26.2	21.9	23.0	21.3	26.2		21.1	23.15
	30-Nov. 2	23.9	21.2	21.3	23.2	20.1	19.6	20.6	25.6		18.8	21.58
November	3-6	23.5	21.5	22.1	25.0	22.4	21.8	21.7	26.2		21.2	22.82
	7-10	22.4	20.8	19.8	22.7	20.9	22.5	22.4	25.1		19.2	21.75
	11-14	21.9	21.4	17.3	24.3	20.1	20.4	19.7	25.9		20.1	21.23
	15-18	23.4	20.1	18.2	25.2	20.6	22.2	20.4	23.4		21.1	21.62
	19-22	24.7	21.9	18.5	24.8	20.3	22.3	20.7	24.3		20.3	21.97
Indiv. Rat Averages		24.220	22.179	20.554	23.308	21.174	21.937	21.191	25.329		20.312	

Total Gr. Average: 22.245

APPENDIX F

FORCED EXERCISE GROUP FOOD CONSUMPTION FOR POST-TREATMENT PHASE (IN GRAMS)

Testing Dates		Animals 1	2	3	4	5	6	7	8	9	10	Gr. Aver. Per Test Period
August	11-14	23.3	21.6	21.1	20.2	26.4	29.5	19.8	18.9	21.2	21.9	22.39
	15-18	23.0	22.8	23.2	26.3	25.1	21.1	19.7	15.7	23.2	23.9	22.40
	19-23	24.7	22.6	24.3	31.1	29.3	28.8	22.0	24.6	22.9	26.1	25.64
	24-27	22.1	21.3	25.2	27.6	19.8	13.8	28.1	23.2	24.8	24.7	23.06
	28-Sep. 1	16.5	22.7	21.7	27.6	23.1	30.5	21.0	18.5	22.1	21.3	22.50
September	2-5	16.5	24.8	21.3	25.9	21.1	20.6	19.8	20.6	24.8	23.1	21.85
	6-10	21.2	17.9	20.5	25.3	23.1	29.8	19.0	19.6	23.2	20.7	22.03
	11-14	21.2	22.9	23.4	26.5	22.8	28.2	16.8	22.9	21.7	22.8	22.92
	15-19	23.0	22.5	21.2	25.5	22.5	23.8	22.5	22.1	22.4	20.0	22.55
	20-24	24.8	23.0	21.1	24.1	21.6	27.0	23.5	22.1	22.2	21.8	23.12
	25-29	21.8	22.6	21.5	24.5	24.9	26.2	23.5	24.0	23.6	21.9	23.45
	30-Oct. 4	23.7	22.0	20.9	26.1	22.7	24.8	22.9	23.5	23.3	22.7	23.26
October	5-9	21.7	24.0	21.2	25.5	25.5	23.4	22.2	20.4	22.3	21.5	22.77
	10-13	22.3	23.3	21.2	26.4	25.1	25.3	23.7	20.6	22.0	21.6	23.15
	14-17	25.5	23.6	21.4	25.3	24.5	24.8	21.6	20.9	22.4	22.8	23.28
	18-21	24.6	23.5	24.5	27.0	26.9	26.9	23.2	22.7	22.0	23.6	24.49
	22-25	20.7	19.5	21.3	25.2	21.0	23.9	21.1	21.3	20.8	20.2	21.50
	26-29	22.7	22.3	22.2	24.4	23.0	26.6	21.8	22.8	21.8	22.7	23.03
	30-Nov. 2	23.5	20.0	21.3	24.5	20.8	24.9	21.8	22.0	21.6	21.4	22.18
November	3-6	23.2	22.2	22.0	25.3	23.5	25.6	22.8	23.1	24.1	23.0	23.48
	7-10	23.7	21.5	22.4	23.8	23.3	24.4	20.5	23.6	22.7	22.0	22.79
	11-14	22.3	22.1	20.3	23.3	22.0	25.9	23.7	21.5	22.1	23.0	22.62
	15-18	24.1	22.2	22.3	22.5	22.0	26.2	23.8	21.7	23.6	22.4	23.08
	19-22	23.6	21.4	23.4	23.8	21.0	25.8	22.7	21.5	22.8	23.0	22.90
Indiv. Rat Averages		22.487	22.179	22.037	25.320	23.374	25.324	21.979	21.574	22.649	22.420	

Total Gr. Average: 22.934

APPENDIX G

AVERAGE COUNTER REVOLUTIONS PER GROUP PER TEST PERIOD

Test Periods	Sedentary	Spontaneous	Forced Exercise
Treatment Phase			
1		1124	1705
2		863	1182
3		713	726
4		614	520
5		702	391
6		849	462
7		826	468
Post Treatment Phase			
8	360	580	785
9	483	619	801
10	524	498	1005
11	648	542	1371
12	699	476	1202
13	747	543	1423
14	787	551	1430
15	830	664	1775
16	675	517	1558
17	922	584	1685
18	851	551	1266
19	964	631	1467
20	655	466	1153
21	640	430	1181
22	718	447	1155
23	603	409	1060
24	489	397	1031
25	568	452	1131
26	614	495	906
27	524	419	842
28	484	420	780

ANIMAL BODY WEIGHTS

Group		Treatment Phase								Post-Treatment						
	Group	July 6	July 11	July 16	July 21	July 26	July 31	Aug. 5	Aug. 10	Aug. 15	Aug. 20	Aug. 25	Aug. 30	Sept. 4	Sept. 9	Sept. 14
I. Sedentary Group	1	110.3	130.5	175.1	214.6	248.2	285.3	321.3	353.5	338.8	342.6	363.5	372.0	382.5	395.0	400.4
	2	109.0	135.4	175.0	213.2	240.3	274.6	308.5	335.0	335.0	344.2	364.0	377.0	391.6	395.7	408.2
	3	108.2	135.5	177.6	203.2	237.1	272.0	303.2	331.5	325.5	337.3	346.7	358.8	372.8	381.0	388.1
	4	110.1	143.4	186.2	220.3	245.5	276.5	297.5	326.0	320.3	337.1	343.6	353.0	360.7	388.5	401.6
	5	103.4	127.6	171.0	202.5	224.0	247.5	282.5	310.3	308.6	322.2	328.3	340.7	355.2	350.0	361.8
	6	103.7	126.2	174.7	215.0	237.6	261.5	297.1	323.2	325.7	337.1	353.6	364.0	379.4	366.3	375.5
	7	108.5	134.9	180.8	216.4	242.5	266.0	276.0	297.4	296.7	307.6	319.9	330.5	324.4	333.3	351.5
	8	106.4	133.4	174.2	216.0	224.6	252.7	273.4	296.0	307.0	321.0	335.8	348.0	361.5	359.4	370.4
	9	109.3	143.7	192.2	226.0	253.2	274.0	303.1	325.8	334.0	348.2	363.5	371.9	385.4	398.1	399.8
	10	109.7	140.4	190.0	229.5	256.0	276.3	290.2	305.1	317.8	332.1	354.0	368.5	386.2	398.0	408.1
	Avg.	107.9	135.1	179.7	215.7	240.9	268.6	295.3	320.4	320.9	332.9	347.3	358.4	370.0	376.5	386.5
II. Control Group	1	109.2	124.0	168.5	197.8	235.3	258.5	287.0	306.6	323.8	346.4	363.3	372.4	385.4	392.5	398.0
	2	106.2	125.1	162.0	187.2	193.5	217.0	247.0	271.3	297.3	319.4	333.5	342.3	360.6	374.8	383.2
	3	108.5	127.3	166.0	201.0	219.0	240.5	269.2	286.5	308.8	322.7	333.4	349.0	359.4	361.0	368.8
	4	109.7	134.1	174.6	209.0	252.0	274.5	298.3	316.2	328.3	343.2	360.9	363.5	379.0	384.2	396.0
	5	104.6	134.1	166.0	204.9	225.4	246.1	272.0	298.2	315.2	331.6	343.8	361.6	386.0	391.7	398.8
	6	110.2	133.5	147.8	181.0	210.0	236.0	270.0	306.4	317.0	327.4	345.2	360.4	366.6	373.6	367.5
	7	105.2	121.2	174.0	203.4	232.6	258.4	285.4	293.0	316.5	330.0	340.8	355.2	361.4	360.0	373.4
	8	106.2	129.4	146.1	195.0	214.3	239.5	257.0	293.5	314.8	337.8	355.4	378.5	398.5	402.2	421.7
	9	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	10	105.2	120.8	156.1	180.6	211.6	245.7	279.0	292.1	311.2	320.5	328.5	350.6	367.1	366.6	378.4
	Avg.	107.2	127.7	162.3	195.5	221.5	246.2	273.9	296.0	314.8	331.0	345.0	359.3	373.8	378.5	387.3
III. Forced Exercise Group	1	108.3	138.6	173.5	202.3	218.2	244.5	258.5	279.8	298.1	308.5	321.0	330.2	342.6	348.6	349.2
	2	99.3	105.7	149.1	185.0	212.5	231.5	257.4	271.5	289.0	311.7	318.2	332.4	343.6	353.0	361.8
	3	96.7	101.1	137.6	181.7	211.0	227.2	252.0	261.3	278.3	303.5	309.9	321.6	338.0	335.0	341.4
	4	109.4	141.5	183.5	215.8	243.5	265.2	290.0	309.2	330.0	357.6	367.1	382.4	395.0	404.9	417.1
	5	103.7	114.1	148.6	177.3	198.2	227.9	248.0	277.4	298.4	325.5	334.3	354.0	368.0	376.0	385.2
	6	106.7	124.8	169.9	216.3	238.9	269.2	298.2	330.8	351.0	367.1	376.6	389.0	403.8	412.7	422.6
	7	107.3	132.2	148.0	191.5	222.5	240.4	267.5	276.0	280.5	306.5	311.7	316.8	328.6	330.0	336.4
	8	106.1	118.8	150.1	179.9	184.4	203.9	228.5	243.5	255.2	279.1	289.2	301.0	320.8	320.2	328.3
	9	104.9	122.5	159.9	187.5	212.1	234.9	259.4	267.7	268.8	302.2	320.0	338.5	353.5	366.0	373.3
	10	110.4	143.0	184.0	217.5	230.6	240.0	260.0	278.2	288.8	319.8	333.8	348.4	362.7	369.2	373.6
	Avg.	105.3	124.2	160.4	195.5	217.2	238.5	262.0	279.5	293.8	318.2	328.2	341.4	355.7	361.6	368.9

ANIMAL BODY WEIGHTS (Continued)

Group		Post-Treatment													
		Sept. 19	Sept. 24	Sept. 29	Oct. 4	Oct. 9	Oct. 14	Oct. 19	Oct. 24	Oct. 29	Nov. 3	Nov. 8	Nov. 13	Nov. 18	Nov. 23
I. Sedentary Group	1	410.4	418.4	415.2	414.8	426.4	421.3	435.6	443.6	453.6	470.2	471.6	468.5	472.0	479.2
	2	416.6	432.4	437.5	443.6	456.6	469.0	473.6	480.3	491.4	503.0	510.6	511.6	518.2	520.2
	3	399.9	410.5	409.4	421.5	433.4	443.3	453.0	456.0	460.2	467.5	473.0	471.6	479.5	487.0
	4	399.5	410.0	417.8	417.4	418.5	416.0	427.3	437.5	449.4	455.4	462.5	462.0	469.0	470.8
	5	372.1	380.0	376.3	387.0	396.7	403.4	410.0	416.6	419.7	418.3	419.0	418.3	417.6	416.4
	6	375.8	390.3	398.0	404.4	411.7	419.7	422.2	430.8	433.2	433.6	437.2	447.4	443.5	448.0
	7	364.5	372.6	366.3	377.5	376.3	383.0	397.1	397.7	409.3	413.0	411.0	404.0	404.8	406.3
	8	380.8	390.3	396.0	400.2	416.0	418.0	420.0	425.2	430.5	435.7	436.4	436.5	432.4	433.4
	9	412.6	426.3	425.0	419.7	433.8	446.4	451.8	462.0	471.0	476.6	478.0	473.5	481.0	487.6
	10	419.7	427.0	439.6	440.8	450.2	464.2	470.3	471.4	460.0	470.8	487.0	497.4	497.6	504.0
	Avg.	395.2	405.8	408.1	412.7	422.0	428.4	436.1	442.1	447.8	454.4	458.6	459.1	461.6	465.3
II. Control Group	1	410.2	419.0	428.2	429.6	437.8	448.0	460.0	462.5	470.6	470.2	472.0	476.0	477.2	483.3
	2	390.9	399.7	398.4	406.4	412.5	418.6	427.2	430.0	434.0	436.4	438.2	438.3	444.4	446.6
	3	365.7	375.5	371.5	370.6	383.4	384.7	388.5	402.3	405.5	418.0	412.0	409.6	412.0	411.0
	4	402.7	418.5	419.0	417.6	438.0	435.4	443.4	450.5	466.2	455.0	464.0	473.3	472.5	486.7
	5	405.0	413.6	422.5	418.4	434.8	436.4	438.0	449.0	450.3	452.3	458.2	458.4	466.0	463.5
	6	381.8	399.4	371.6	389.5	407.4	406.2	413.6	418.3	416.4	421.0	423.2	421.6	433.7	431.3
	7	378.3	384.4	386.0	395.2	402.6	397.3	400.8	403.3	413.0	410.2	416.7	419.8	416.2	429.4
	8	424.4	437.5	443.3	450.1	460.4	467.0	476.8	481.2	499.0	504.6	509.5	521.0	527.3	520.2
	9	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	10	384.0	393.2	395.1	404.2	410.4	420.9	426.0	427.8	432.2	433.0	431.2	432.7	440.5	450.0
	Avg.	393.7	404.5	404.0	409.1	420.8	423.8	430.5	436.1	443.0	444.5	447.2	450.1	454.4	458.0
III. Forced Exercise Group	1	365.0	377.3	377.2	387.4	397.4	397.0	408.4	399.2	406.0	411.0	413.4	417.7	425.7	429.2
	2	377.3	377.0	384.3	388.0	399.4	405.7	408.7	406.0	405.5	411.5	410.0	420.7	422.2	424.5
	3	353.0	350.6	349.5	355.4	362.0	363.0	370.2	370.0	372.0	374.5	379.3	381.0	383.5	383.2
	4	430.9	428.4	423.0	427.0	438.5	450.4	456.1	468.0	477.6	482.4	474.8	480.8	483.0	491.3
	5	396.4	404.0	406.6	407.6	426.6	436.2	445.0	444.8	451.5	447.6	453.7	458.0	460.2	461.8
	6	431.9	446.2	448.8	453.1	458.6	461.5	471.9	476.8	490.8	493.7	493.6	501.6	502.2	521.2
	7	339.0	346.6	351.5	351.2	357.9	360.0	363.5	366.4	362.3	364.3	365.5	377.0	379.7	386.8
	8	341.5	345.3	352.4	358.0	351.7	353.4	361.6	369.0	378.7	385.7	393.0	396.2	401.3	396.2
	9	384.8	389.8	400.8	402.2	406.6	415.3	417.0	418.2	418.7	423.0	431.2	436.7	440.4	444.6
	10	380.4	385.4	389.3	391.0	394.3	404.6	418.9	413.3	429.5	436.0	433.6	441.4	446.0	449.2
	Avg.	380.0	385.1	388.3	392.1	399.3	404.7	412.1	413.2	419.3	423.0	424.8	431.1	434.4	438.8