THE EFFECTS OF PRETREATMENT WITH EXERCISE ON ADULT MALE ALBINO RATS IN ACQUIRING CROSS-RESISTANCE TO COLD WATER IMMERSION

Thesis for the Degree of M. A.
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Donald Peter Frank

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THE EFFECTS OF PRETREATMENT WITH EXERCISE ON ADULT MALE ALBINO RATS IN ACQUIRING CROSS-RESISTANCE TO COLD WATER IMMERSION

By

Donald Peter Frank

AN ABSTRACT OF A THESIS

Submitted to
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1963

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ABSTRACT

THE EFFECTS OF PRETREATMENT WITH EXERCISE ON ADULT MALE ALBINO RATS IN ACQUIRING CROSS-RESISTANCE TO COLD WATER IMMERSION

by Donald Peter Frank

The purpose of the problem was to determine whether adult male albino rats can acquire cross-resistance to cold water immersion by pretreatment with exercise.

Thirty-three adult male albino rats of the Carlworth Farm's CFE strain of specific pathogen-free rats were used in this experiment. The animals in group I B were forced to swim daily carrying an additional five per cent of their weight attached to their tails until they reached the crucial point. The animals in group I A were forced to swim carrying a weight that would permit them to swim for a half hour. Group V and the control group were forced to swim only during the all out swims.

To determine whether the exercised animals had acquired cross-resistance to cold water the following procedure was used. All animals were loosely taped around the thorax, and a wire inserted into the tape. The wire was used to adjust the animal's depth in the water during the cold water immersion test. Survival time was recorded from the time the animal was placed in the water until drowning occurred.

Donald Peter Frank

The results indicate that adult male albino rats pre-treated with exercise did not survive significantly longer, during the cold water immersion test, than the control animals. The weight of the control animals was significantly higher than the animals that were exercised to the crucial point daily. A correlation between body weight and survival time was .339, which is statistically significant at the .05 level. This indicates the heavier animals survived longer than the lighter animals.

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Dedication is made to my wife, Marilyn, whose patience and love has given me added purpose and encouragement to complete the task.

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The author wishes to acknowledge Wayne Van Huss whose professional assistance has given me confidence in the undertaking and completion of this task. Acknowledgment is also made to Wynn Updyke for his assistance while doing my research.

D.P.F.

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CHAPTER I

THE PROBLEM

Introduction

The problem of stress, since its formal presentation by Hans Selye (12) in 1936, has been an interesting and thought provoking area of experimentation. This can readily be confirmed by the numerous articles written on the subject of stress.

We, in physical education in general, have failed to realize the real implications of the stress theory in the area of physical education, since strenuous exercise is a stressor which produces physiological changes. We, in physical education, state that exercise is good for the normal individual, implying that the physiological changes are beneficial. Many authors (4, 8, 9, 10, 13) have stated the benefits of exercise upon animals or humans. However, few studies have shown whether pretreating an organism with a stressor will increase the organism's resistance to another stressor.

The experimental animals in this study were stressed using exercise. When the treatment phases were completed the experimental animals, along with the controls, were exposed to the cold water immersion. The data obtained determined whether pre-treating the adult male albino rats with exercise had elicited cross-resistance to cold water immersion.

Statement of the Problem

The purpose of the problem was to determine whether adult male albino rats can acquire cross-resistance to cold water immersion by means of pretreatment with exercise.

Importance of the Study

If it could be proven that exercised animals are able to withstand the stressor cold water significantly better than sedentary animals, then further research, using exercise as the means of adaptation to other stressors, might be performed. If animals which have been pre-treated with exercise are able to acquire cross-resistance to the effects of cold water immersion then one should consider the implications of exercise as a means of withstanding other stresses in humans.

Limitations of the Study

1. No attempt was made to control the amount of food or water consumed by the animals.

2. No attempt was made to control the humidity in the test rooms.

3. The exercise level might not be effective to bring about cross-resistance to cold water in the experimental animals.

4. The results of animals studied are not directly applicable to humans.

Definition of Terms

Cross-resistance. Cross-resistance is increased tolerance to a stressor other than that to which the body has adapted.

Stress. Stress is the state manifested by the specific syndrome which consists of all the non-specifically induced changes within a biological system.

Stressor. A stressor is that which produces stress.

Control group. Control group is used to denote that group of animals whose activity was confined to cages, except for the all out swims in phase three (see Appendix for all out swim time).

Crucial point. The crucial point is that time during the animal's swim when drowning will take place, according to the observer, if the animal is not rescued.

CHAPTER II

REVIEW OF THE LITERATURE

Selye (12) has stated that bodily changes take place as an organism reacts to stress. "Stress causes certain changes in the structure and chemical composition of the body. Some of these changes are merely signs of damage. Others are manifestations of the body's adaptive reactions, its mechanism of defense against stress."(12) The general adaptation syndrome is the total of all the changes that take place as an organism faces stress. This general adaptation syndrome has three stages: (1) the alarm reaction, (2) the stage of resistance, and (3) the stage of exhaustion.

When the alarm reaction stage is entered the organism's level of resistance is lowered, due to the effect of the stressor. This stage is manifested by enlarged adrenals, loss of weight, shrinkage of the thymus, stomach ulcers, and changes in the body's chemistry. During this stage one of two alternatives may happen. Either the organism adapts to the stressor and enters the stage of resistance or the stress is so intense that the organism dies.

The manifestations of the stage of resistance are quite different from, and in many instances the exact opposite, of those that characterized the alarm reaction stage. The organism's adaptation to the stress during the second stage raises its resistance above normal. Although the organism can live in the stage of resistance, in time, the acquired resistance is lost and the organism enters the stage of exhaustion.

The symptoms of the stage of exhaustion are similar to those of the alarm reaction stage. During the alarm reaction stage the organism is able to adapt to the stress and lives. In contrast in the stage of exhaustion the organism can not adapt to the stress and dies.

Such stressors as cold, exercise, irradiation, and drugs can produce the general adaptation syndrome with its three stages. Selye (12) states that any one agent is a stressor in proportion to the degree of its ability to produce stress. In this experiment the stress was produced by the exercise.

Numerous articles have been written stating the effects of stress on animals and humans. The review of literature in this study was limited to those articles which dealt with the effects of cross-resistance.

According to the definition of cross-resistance it is feasible for an organism to increase its tolerance to stress by pre-treatment with any stressor.

The review of the literature dealt with the following: (1) pre-treatment with stressors other than exercise, and (2) pre-treatment with exercise.

Pre-treatment with Stressors Other than Exercise

Heroux and Hart (5) have demonstrated that adaptation to the stressor cold provided a degree of resistance to restraint hypothermia.

Bajusz and Selye (2) found that cardiac necrosis produced under experimental conditions can be prevented by pre-treatment with cold bath, noradrenaline, and restraint.

Egolinskii and Bogorad (15) established that training animals by regular cooling of the body increases the resistance of rats to hypoxia and irradiation.

Korobkov, Golavacheva, and Shkurdoda (7) state that increased resistance to irradiation can be acquired by injections of "dibazol."

Most studies found that cross-resistance can be acquired by pre-treating the animals with stressors other than exercise, however, some authors found that pre-treating animals with certain stressors would not produce cross-resistance.

Egolinskii and Bogorad (15) stated that cooling did not increase rats' cross-resistance to heat.

Selye (11) found that pre-treatment of animals with corn oil prevented the cardiotoxic action of subsequent treatment with the same substance, but pre-treatment with corn oil did not prevent other stressors from eliciting cardiac necrosis.

Pre-treatment with Exercise

Bartlett,(3) using a group of twenty control animals and a group of twenty forced exercised animals, found there was a highly significant difference in the response of the two groups disclosing that the daily exercise produced a degree of inhibition to restraint hypothermia.

Bajusz and Selye (2) found that animals which were gradually pre-treated with exercise had developed cross-resistance to cardiac necrosis when exposed to the full pathogenic dose of other stressors.

Korobkov, Golovacheva, and Shkurdoda (7) state that rats trained to climb a pole 1.5 cm. in diameter, in which small circular steps were cut every 5 cm., exhibited a greater tolerance to hypoxaemia at a height of 13,000 meters than control animals.

Zimnitskay (15) found that rats trained by swimming are more capable of withstanding the effects of cooling and heating than control animals.

Zimkin and Korobkov (15) found that rats' resistance to the action of trichlorethylamine was increased by muscular training. Eighty-six per cent of fifteen trained rats survived the poison, whereas only fifty-eight per cent of the twelve untrained rats survived. They further state that of the animals which died the trained animals survived longer.

Shernyakov,(15) studying whether the body can increase its resistance to certain infective illness through exercise, found that medical assistance was sought by fifty-eight per cent of individuals not doing any exercise, thirty-eight per cent by individuals who did exercise irregularly, and twenty-one per cent by individuals doing regular exercise.

Trifonov (15), experimenting with rats, indicates that moderate physical impositions (swimming or maintaining position on a pole for 50-60 minutes daily over a period of six to eight weeks), increased cross-resistance to subsequent irradiation much more than an increase of three hours daily swimming.

Kimeldorf and Jones (6) found that exercised animals did not survive any longer than controls animals when faced with the stressor, irradiation.

Kudryashov and Nikolayeva (15) found no difference between trained and untrained animals when faced with the stressors strychnine and carbon monoxide. The same authors found that trained rats were less resistant to cyanide poisoning than untrained animals.

CHAPTER III

EXPERIMENTAL METHOD

The purpose of this experiment was to determine whether forced exercise could produce cross-resistance to cold water immersion in adult male albino rats.

Subjects

The thirty-three animals in this experiment were part of a group of 120 male albino rats which were used in another study. The Carlworth Farm's CFE strain of specific pathogen-free rats were used in this experiment. All animals were born on October 24, 1961. These animals were 59 days old when they were received in the laboratory, 61 days old at the beginning of phase one, 67 days old at the beginning of phase two, 151 days old at the beginning of phase three, and 227 days old when thirty-three of the animals were used in the cold water immersion test.

The thirty-three animals used in the cold water immersion test were previously treated according to the treatment of animal data sheets (see Appendix). After the treatment phase the animals used in the cold water immersion test were 227 days old. The animals used in the cold water immersion test were loosely taped around the thorax and a wire was inserted in the tape. The wire was used to adjust the animals' depth in the cold water and to prevent the animal from submerging. Survival time was recorded from the time the animals were placed into the water until drowning occurred.

Treatment of Animals

The diet of the animals consisted of Dietrich and Gambrill pathogen-free rat and mouse biscuits which were manufactured by Dietrich and Gambrill, Inc., Frederick, Maryland. Food was placed on the bottom of the animal's cage. Water was supplied to the animals by means of an inverted bottle which was fastened to the outside of the cage. A metal tube extended from the bottle into the cage from which the animals received water by placing their mouths at the end of the tube. Food and water were permitted ad libitum.

The animals were housed in individual rectangular cages which measured ten inches long, eight inches wide, and seven inches high. These cages were made of four by four hardware cloth and were fitted into a large mobile rack which provided housing for sixty animals.

Because the animals were used in another study the experimenter feels that an understanding of the animals' treatment prior to their cold water immersion test is imperative. The treatment the animals received was divided into three phases. Each phase is summarized on the animal data sheets (see Appendix). Along with the summary there is a statement of the objectives of each phase.

The rats which were forced to exercise were swum according to the exercise schedule (see Appendix). When the animals were forced to exercise a weight was attached to their tails by means of waterproof tape. The weight consisted of lead sinkers attached to wires. The dates when the animals were forced to swim are listed in the treatment of animal data sheets (see Appendix).

The rats swam in a galvanized tank that measured three feet wide, eight feet long, and thirty inches deep. Inside the tank were twenty-four plastic swimming sections each twelve inches wide, twelve inches long, and thirty inches deep. These sections prevented the animals from interfering with one another while swimming. The water temperature was kept between 35 and 37 degrees centigrade.

After completing the forced exercise the animals were placed in various cages to dry. The twenty-four drying cages were placed thirty inches beneath four 250 watt Ken-Rad infra-red heat lamps. The animals, after thirty minutes in the drying cages, were placed into their regular cages.

Cold Water Immersion Procedures

On June fifth, when the animals were 227 days old, the cold water immersion experiment was conducted. Group IA, IB, V, and a random selection of ten control animals were used. At this time there were six animals in group IA, nine animals in group IB, and eight animals in group V.

The experimental procedures were conducted in the following way: A wooden frame was hung from the ceiling, thirty inches above the eight by four foot immersion tank. After weighing an animal a ten by two inch strip of waterproof adhesive tape was loosely placed under the animal and brought up on both sides of the thorax to the nap of the animal's neck (see Appendix for weight of animals). The two inches of excess tape were taped together above the animal's neck.

The ends of a ten inch piece of wire were bent into the shape of hooks. One hook was inserted into the excess tape of the animal. The other hook was attached to the hardware cloth. The hardware cloth was connected to a wire which was suspended from the wooden frame. The animal's depth in cold water was adjusted by placing the wire at different positions on the hardware cloth.

The animals were attached to wires and then placed in water which was kept between fourteen and sixteen degrees centigrade. (See Appendix, Figure 1, for the cold water temperature chart.) In order to keep the animal's body below the surface of the cold water a twenty-eight gram weight was attached to the animal's tail. After placing an animal in the cold water the wire was adjusted periodically so that the animal's head was kept above the cold water. No animal had to swim to keep its head above the cold water; however, every animal swam quite rapidly for about twenty minutes after being placed in the water.

While the animals had control of their physiological functions they could keep their heads out of the water. When the animals began to lose control of these functions, because of the anesthetic effect of the cold water, their noses would drop into the water. The animal's nose dipped into the water five to seven times before the rat could no longer lift its nose out of the water for the purpose of breathing. When an animal's nose would dip into the water, the time was recorded. If the animal's nose remained below the surface of the water for five minutes the animal was considered unable to withstand the stressor cold water.

The survival time was measured from the time the rat was placed into the cold water until the animal could no longer raise its head to inhale. The survival time is recorded in minutes (see Appendix). It should be noted that the length of the animal's survival time was related to its ability to withstand the cold water stressor; however, actual death occurred because of drowning.

CHAPTER IV

RESULTS

The following groups were used in this experiment to determine whether pre-treatment with exercise will elicit cross-resistance to the stressor cold water immersion: Group IA, six animals; Group IB, nine animals; Group V, eight animals; and ten control animals.

Survival Time

Survival time was measured according to the procedure discussed earlier. The null hypothesis was tested on the basis that no difference existed between the groups. The variance, due to the treatment, was not significant at the five per cent level (F=2.20), therefore, the null hypothesis was accepted. Data are presented in Figure 1, and the analysis of variance in Table I.

Weight of Animals

All animals were weighed, on June sixth, prior to the cold water immersion test (see Appendix). The null hypothesis was tested on the basis that no difference exists between groups. The variance due to the treatment was highly significant at the .001 level (F-7.64), therefore, the null hypothesis was rejected. The data is presented in Figure 2, and the analysis of variance in Table II. These results

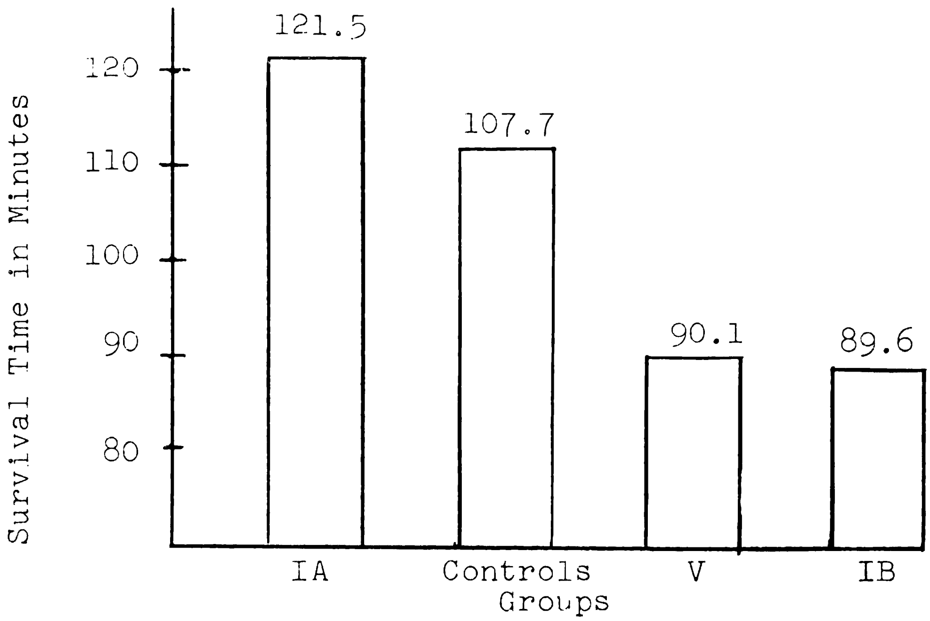

Fig. 1. Mean survival time per group during cold water immersion.

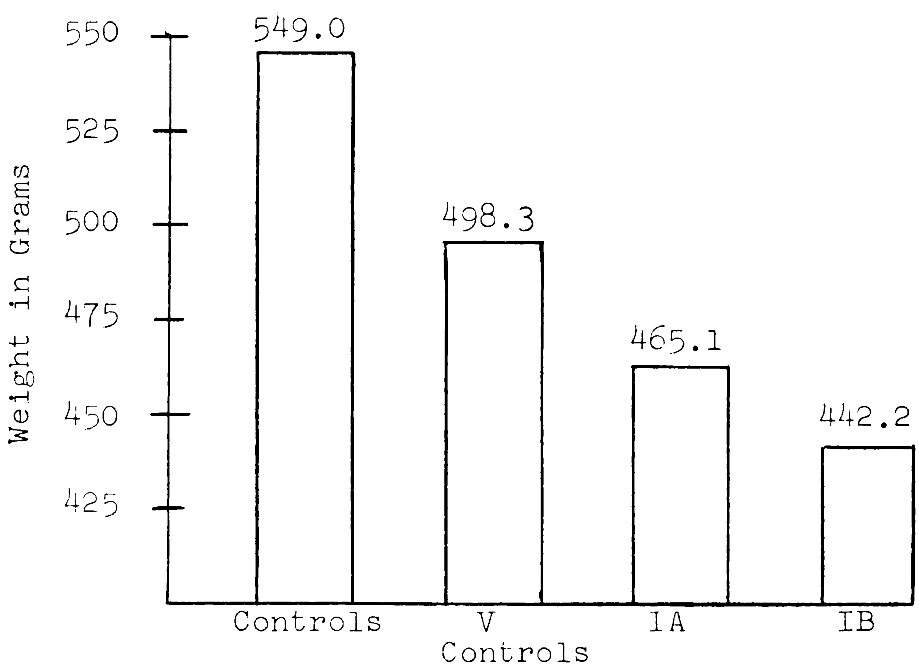

Fig. 2. Mean body weight per group prior to cold water immersion test.

confirm previous work indicating the greater the exercise stress the lower the weight of the animal.

TABLE I

ANALYSIS OF VARIANCE DATA FOR SURVIVAL TIME DURING THE COLD WATER IMMERSION TEST

Source of Variance	Sum of Squares	Degree of Freedom	Variance Estimate	F	F.05
Total	27382.	32			
Between Means	5072.49	3	1690.83		
Within Groups	22311.	29	769.3	2.20	2.93

TABLE II

ANALYSIS OF VARIANCE DATA FOR WEIGHT OF ANIMALS

Source of Variance	Sum of Squares	Degree of Freedom	Variance Estimate	F	F.001
Total	134,598	32			
Between Means	59,419	3	19,806.33	7.64	7.12
Within Groups	75,179	29	2,592.37		

Survival Time and Body Weight

In order to determine if a correlation between survival time and body weight exists the Pearson "r" statistical method was used. The correlation between body weight and survival time was .339, which is statistically significant at the .05 level. The heavier animals survived longer than the lighter animals.

Discussion

The results indicate that no difference exists between pre-treated exercised rats and control adult male albino rats in their ability to withstand the effects of cold water immersion.

At the time of the cold water immersion test the control rats were significantly heavier than the experimental rats which were trained to the crucial point daily. Their weight was not significantly different from the other groups.

When the weights and immersion test survival times for the animals in all groups were pooled, a significant relationship was found between weight and survival time. Considering the insulating properties of fat this was an expected finding.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

The purpose of this experiment was to determine whether exercised adult male albino rats can acquire cross-resistance to cold water immersion. The animals used in this experiment were the Carlworth Farm's CFE strain of specific pathogen-free rats. The animals were treated in another study prior to the cold water immersion test. The rats in Group IA were forced to swim for thirty minutes, carrying an overload which was gradually increased daily. The rats in Group IB were forced to swim, carrying an additional five per cent of their body weight, until they reached the crucial point. The rats in Group V were exercised during phase two, but during phase three their activity was confined to cages except for the three all out swim tests. The rats in the control group were confined to cages during phase two and three except for the three all out swim tests.

The cold water immersion test was conducted on June sixth using thirty-three adult male albino rats. The groups used in the cold water immersion test were: group IA, six animals; group IB, nine animals; group V, eight animals; and ten control animals.

In conducting the experiment a wooden frame was hung from the ceiling, thirty inches above the immersion tank. Wires were suspended from the wooden frame. At the end of each wire was a strip of hardware cloth enabling the experimenter to adjust the animals' depth in the water.

Each rat was weighed prior to the cold water immersion test. After weighing the animals, a ten inch strip of waterproof tape was placed around the rats' bodies to the nape of their necks. A wire was hooked through the excess tape, the opposite end of the wire being hooked to the hardware cloth. The wire was adjusted periodically so that the animals' bodies were submerged except for their heads. The animals had a twenty-eight gram lead sinker attached to their tails to keep their bodies from floating. The water temperature was kept between fourteen and sixteen degrees centigrade.

The survival time was measured from the time the rat was placed into the cold water, until the rat could no longer raise its head to inhale.

The results indicate that no significant difference exists between exercised rats and sedentary control rats in their ability to survive during cold water immersion.

Conclusion

Adult male albino rats pre-treated with the stressor exercise did not survive significantly longer during the cold water immersion test than control animals.

Recommendations

Research should be done to find out if there is an optimum exercise level which will produce cross-resistance in adult male albino rats.

Research should be done to determine whether other forms of exercise will bring about cross-resistance in adult male albino rats.

Research should be done using larger numbers of animals in each group when using swimming as a means of exercise.

Animal studies should be conducted in sanitary areas where heat and humidity can be controlled.

Visitors must be prohibited in animals' quarters while an experiment is being conducted.

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APPENDIX A

DATA SHEETS--TREATMENT OF ANIMALS

DATA SHEET--TREATMENT OF ANIMALS[1]

Summary of Phase I

Date	All Animals N-120
12/23/61	Handled
12/24/61	Handled
12/25/61	No Treatment
12/26/61	Five minute swim
12/27/61	Ten minute swim, two per cent of body weight was attached (a lead sinker).
12/28/61	Two fifteen minute swims (A.M.), (P.M.), with two per cent of body weight attached.

Objective of Phase I

To accustom the animals with the experimental procedures.

[1]The treatment in phases I, II, and III were part of another study. The actual treatment the animals received is summarized.

DATA SHEET--TREATMENT OF ANIMALS

Summary of Phase II

Dates	Experimental Animals N-100	Controls N-20
12/29/61 to 1/17/62	Experimental animals were forced to exercise by attaching a lead sinker which was four per cent of their body weight to their tails. Time was to be increased until animals could carry four per cent for thirty minutes.	No Treatment
1/18/62 to 2/25/62	Animals are losing weight, coughing and have bloody noses, therefore, a rest period was necessary.	No Treatment
2/26/62 to 3/20/62	Resumed exercising animals. Animals were forced to swin with one per cent of body weight attached. Weight was increased if animals could swim for thirty minutes. The purpose of this phase was to have the animals reach the objective of Phase II. Because the objective of this phase was not reached the maintenance study was cancelled.	No Treatment

Objective of Phase II

To train the animals to swim for thirty minutes carrying four per cent of their body weight attached to their tail.

DATA SHEET--TREATMENT CF ANIMALS

Phase III

Date	Experimental Animals	Controls
3/21/62	N-95 First All Out Swim: The experimental and control animals carried 3.5 per cent of body weight during the all out swim.	N-19
3/22/62 to 3/23/62	N-95 New design is a training study. The experimental animals were divided into nine groups on the basis of the first all out swim. The mean swim time of the groups was equated as nearly as possible.	N-19 No treatment, except for all out swims.

Exercise Schedule

Group A*	Group B*
I Every day (N-10) II Every 2 days (N-10) III Every 5 days (N-10) IV Every 10 days (N-9) V Same treatment as controls (N-9)	I Every day (N-9 II Every 2 days (N-10) III Every 5 days (N-9) IV Every 10 days (N-9) V Same treatment as controls (N-9)
A--groups exercised for thirty minutes with a gradual increase in weight over previous exercise day.	B--groups exercise according to exercise schedule with four to five per cent of body weight attached until they reach the crucial point.

Phase III (continued)

Date	Experimental Animals	Controls
3/24/62 to 4/26/62	N-95 Training according to exercise schedule.	N-19 No treatment
4/27/62 to 4/28/62	N-90 Animals rested on 4/27/62. Second all out swim on 4/28/62. Experimentals and controls carried 3.5 per cent of body weight attached to their tails.	N-19
4/29/62 to 6/ 1/62	N-90 Training according to exercise schedule.	N-19
6/2/62 to 6/3/62	N-74 Animals rested on 6/2/62. Third all out swim on 6/3/62. Experimentals and controls carried 3.5 per cent of body weight attached to their tails.	N-18

<u>Objective of Phase III</u>

To discover reasons for decline in swimming ability. To study two methods of improving poor swimming ability.

DATA SHEET--TREATMENT OF ANIMALS

Phase IV

Date	Experimental Animals	
6/5/62	Group IA (N-6) Group IB (N-9) Group V (N-8) Controls (N-10)*	The animals in Phase IV are the same animals that received exercise under the exercise schedule which is listed under Phase III. All animals were placed in water which was 15° centigrade on 6/5/62. Survival time in cold water was recorded.

*The ten controls were a random selection from the control animals in Phase III.

Objective of Phase IV

To determine whether adult male albino rats can acquire cross-resistance to cold water through exercise.

APPENDIX B

WEIGHT OF ANIMALS

WEIGHT OF ANIMALS BY DATES

Group	12/30/61	1/3/62	1/13/62	1/17/62	1/20/62
IA					
2	261	314.5	363.5	360	378.5
3	348.5	354	370.5	358	363
4	288	296.5	293.5	369.5	385
7	253	288.5	287.5	306.5	320.5
8	316	334.5	343	344	356.5
9	264	279	280	291.5	299
IB					
1	253.5	284	268.5	300	317.5
2	273	259.5	275	287.5	297.5
3	320.5	334	335	278	287
4	329	363.5	378.5	399	414
5	276	301.5	307	302.5	312
6	320.5	352.5	374	397	415
7	290	291.5	292	313	324.5
8	310.5	317.5	343.5	344	347
9	294.5	317.5	332.5	292	305
V					
1	307.5	346	378	371.5	382
2	272.5	291.5	326	324	327
3	334.5	311	333	340	355
4	268	294	310.5	321	321
6	273.5	289	287.5	263.5	260
7	304	273.5	304.5	316.5	324.5
8	279	306.5	322	334	340
9	247.5	272	283	281	285
Controls					
1	257	286	336.5	357	345
2	313	342.5	258	342.5	355.5
3	284	309.5	350.5	372.5	372.5
4	249.5	293.5	328.5	347	332.5
5	302.5	327	373.5	400	408.5
6	288.5	320	350	378.5	379.5
7	339	379	422	432.5	441
8	316.5	344	382	403.5	412
9	332	375.5	411	434.5	437
10	270	296.5	335	346	330

WEIGHT OF ANIMALS BY DATES (continued)

Group	Dates 1/24/62	1/27/62	1/31/62	2/3/62	2/10/62
IA					
2	405	412	427.5	437	465.5
3	349.5	336.5	328	332	355
4	410	416.5	430.5	455	481
7	290	310	322	340	375
8	373.5	386.5	414.5	429.5	461
9	309.5	323.5	336	347.5	373
IB					
1	338.5	355.5	363	375	393.5
2	319	334.5	357.5	371	377.5
3	304.5	315.5	311.5	333	355
4	435	444	454	469	496
5	321	327.5	341	354	382
6	441	446	445	484.5	489.5
7	337.5	343.5	355	382	403.5
8	367	366.5	381.5	389	415
9	341	351	365	387.5	400
V					
1	394.5	402.5	406.5	417	430
2	338	327	332	346.5	368
3	380	380.5	394	396	420
4	310.5	316	316.5	333.5	361
6	266	278	284.5	340.5	332
7	345	351	374	396.5	414
8	363	371	390	405	430
9	300	307.5	314.5	329.5	351
Controls					
1	368.5	370.5	387.5	390.5	405.5
2	382	389	413.5	416	432
3	384.5	382	399.5	405.5	421.5
4	356.5	385.5	363	360	361
5	404	417	409.5	404	377.5
6	388	366	333	318	353
7	452.5	420	388.5	380	350
8	415	406	403.5	403.5	399
9	456.5	458	476.5	487.5	505
10	348.5	328.5	315.5	---	---

WEIGHT OF ANIMALS BY DATES (continued)

Group	2/17/62	2/24/62	2/28/62	3/3/62	3/7/62
IA					
2	483.5	513	496	477	481
3	395	410.5	422	414.5	432
4	408	510.5	525	502.5	507
7	400.5	433	437.5	433	444
8	468	485	483	482	477.5
9	396	405.5	410	403	410
IB					
1	420	437	437	430.5	438
2	415	433	441	437.5	436
3	370	384.5	392.5	385.5	391.5
4	506	517	526.5	508	510.5
5	412	424	431	420	455
6	543	574.5	575.5	554.5	557.5
7	428	451	452	442.5	455.5
8	438.5	461	465	446.5	460
9	405	425	435	423.5	445
V					
1	465	469	466	460	479
2	392	406	418.5	408	420
3	435	460.5	463	451	448
4	359	378.5	378	382	393
6	351	377	385	375	391
7	426	440	450	433.5	451.5
8	446.5	456.5	462.5	458	440
9	374	389.5	393.5	384.5	397.5
Controls					
1	411.5	421		432	444
2	449	460		477.5	484
3	440.5	452		469	477
4	386	401		408	417
5	355	381.5		422	444
6	368	395		416	437
7	400	441		463	497.5
8	370	406		450	471
9	529	537.5		542.5	565.5
10	---	---		---	455.5

WEIGHT OF ANIMALS BY DATES (continued)

	Dates				
Group	3/10/62	3/12/62	3/17/62	3/21/62	3/27/62
IA					
2	480	491.5	491	492	499.5
3	426	428.5	464	411	428.5
4	499.5	518	507	502	501
7	437	447.5	448.5	448.5	454.5
8	460	466.5	460	462	462.5
9	401	416	402.5	398	395.5
IB					
1	434.5	442	443.5	444.5	446.5
2	419.5	431	432	433.5	441
3	389.5	398	387.5	398.5	400
4	507.5	503.5	503	507	520
5	452	456	461	464.5	464.5
6	557.5	554.5	662	553.5	550
7	436.5	443	436.5	442	449
8	447.5	453.5	454.5	454.5	465
9	445	457	456	461	455
V					
1	471	480	484	421.5	415.5
2	410	421.5	420.5	421	436
3	442	457	457.5	464	475
4	394	410	421	410	428
6	391	397	394	397	414
7	437.5	449	447	445	463
8	435	438	442.5	443.5	449
9	400	409.5	420	419	446
Controls					
1	449	452.5	460	467	466
2	494	497.5	508	500	475
3	482	491.5	499	493.5	503.5
4	426	428.5	441.5	438.5	447
5	455	465	473	475.5	492.5
6	449	458.5	464	460.5	514
7	505	519	528	520	434.5
8	479	499.5	507.5	506.5	527
9	567	572	577.5	584	585
10	468	470	482.5	465.5	480

WEIGHT OF ANIMALS BY DATES (continued)

Group	3/31/62	4/4/62	4/7/62	4/11/62	4/14/62
IA					
2	480	466	457.5	447.5	448
3	423.5	436.5	425.5	425.5	420
4	487	487.5	469	467	461.5
7	446.5	453.5	456	449	454
8	458	463.5	459	460	468.5
9	394	401.5	400	398	397.5
IB					
1	437.5	447	442	444.5	446
2	436	438	432	427	431
3	388	389.5	385	376	382
4	513	522	520.5	515	517
5	454	464.5	461	462	462
6	529	518.5	507.5	509	507
7	442	448	440	432.5	436
8	453	456	449.5	447.5	449
9	459.5	456	456	460	466
V					
1	409	412.5	414	413.5	417
2	448	458	465.5	472	481.5
3	470	473.5	463.5	467.5	468.5
4	435	441.5	441	449	454.5
6	417	432	433.5	441	450
7	467.5	480	485	493.5	504.5
8	457	470	471	476	483
9	448	461	466	470	474
Controls					
1	479	481	490	491.5	491.5
2	475	482.5	486.5	494.5	495
3	506	520	517	521.5	524
4	457.5	473	475.5	485.5	491
5	500	506.5	510.5	510.5	513
6	518.5	524.5	532	532	537
7	430	449	448.5	454	462
8	530.5	550	556.5	562.5	577
9	584.5	599.5	600	608.5	611
10	484	494.5	497.5	511	515.5

WEIGHTS OF ANIMALS BY DATES (continued)

	Dates				
Group	4/18/62	4/21/62	4/25/62	4/28/62	5/3/62
IA					
2	460	458.5	413.5	457.5	460
3	413.5	404.5	400	387	378
4	473	466.5	464.5	474	474.5
7	452.5	451.5	451	461	458
8	475	476	482.5	487	483
9	405.5	400	396.5	403.5	409
IB					
1	453	447	446	445.5	451.5
2	436	426	424	430	423.5
3	387	385.5	387.5	388.5	394
4	518	515.5	504	504.5	494.5
5	466	460	465	458	456.5
6	502.5	490	486	492	493
7	434	433.5	432	439	430
8	450	445	446.5	453.5	452
9	469	466.5	468	474.5	475
V					
1	413.5	419	418.5	422.5	418
2	493.5	493.5	498.5	505	510
3	480	480	467	452	437
4	465	465	475.5	477	475.5
6	457.5	457.5	465	466.5	473.5
7	513.5	513.5	520	533	528
8	495.5	495.5	496	499.5	498
9	489	489	499	507	503
Controls					
1	598.5	501	501.5	506.5	507
2	506.5	512.5	520	525	522
3	533.5	540	551	550	559.5
4	498.5	502.5	505	510	506
5	520	524	527	522	509.5
6	548	545.5	549.5	559	555.5
7	475	476	481	479	481
8	588	588	598	600	598
9	622	623.5	619	610.5	618
10	523	523.5	534.5	538.5	537.5

WEIGHTS OF ANIMALS BY DATES (continued)

Group	5/5/62	5/9/62	5/12/62	5/16/62	5/19/62
	Dates				
IA					
2	461	458	461.5	469	475
3	380	388	386.5	388	393
4	477	490	478.5	474	495
7	455.5	460	454.5	462.5	460
8	486	484	486	494	497
9	403	413	413.5	410	417
IB					
1	449	450	448.5	453	458
2	425.5	428.5	425.5	426	428.5
3	389.5	389.5	386	390	391
4	488.5	478	470	469	466
5	457	460	457	468.5	467
6	500	509	506.5	511.5	513
7	428.5	427	426	428	431
8	446	446	449	452	455
9	476	481	475.5	480	478.5
V					
1	414.5	430	424.5	431.5	428
2	511.5	516	514	521	520
3	441.5	444	434	430	424
4	483.5	497	494.5	484	507
6	472	482	474	481	480
7	534	538	539	552	561.5
8	505.5	509.5	504	509	513
9	511	517	514.5	523	528
Controls					
1	509.5	514	508	516.5	525.5
2	524.5	535	534.5	534	541
3	561.5	573.5	572	576	581
4	507	500	510	508	511.5
5	508	507	494.5	490	470
6	561	474.5	566	574	575.5
7	480	492	492	496	501
8	601.5	624	613	616	627
9	613.5	626.5	604.5	610	593
10	537.5	534.5	551	554.5	560

WEIGHTS OF ANIMALS BY DATES (continued)

Group	5/23/62	5/26/62	5/30/62	6/2/62	6/5/62
IA					
2	467	470	472	473.5	481
3	401	401	404.5	407	408.5
4	430	460	495	501.5	501.5
7	457	459	463	458	473
8	494	494.5	493	492.5	501
9	415	421.5	420	419	427.5
IB					
1	459	454.5	457	451.5	455.5
2	428	429.5	433	430	439.5
3	393	394.5	396.5	392.5	401
4	486.5	427.5	410	397.5	392
5	460	469	469	473.5	380
6	511	510	510	505	508
7	433.5	435.5	439	439.5	443
8	449.5	454.5	449	450	460
9	485.5	487.5	492	490	502
V					
1	429	434	421	416.5	414
2	524.5	529	531.5	533	531
3	411.5	414	404	403	396.5
4	508	520	517.5	521	510.5
6	472.5	482	457	484	478.5
7	560	565.5	566.5	568.5	596
8	518	523.5	525.5	523.5	519.5
9	529.5	540	547	550	542
Controls					
1	521	529	532	538.5	538.5
2	539.5	542.5	544.5	549	545
3	580	585	590.5	587	589
4	512.5	517.5	514	520	519
5	471	473.5	460	458	455
6	575	578	584.5	585.5	582.5
7	504	510	510	516	506
8	627.5	627	629	632	612
9	595	584	594	589	589
10	559	563	569	567	555

APPENDIX C

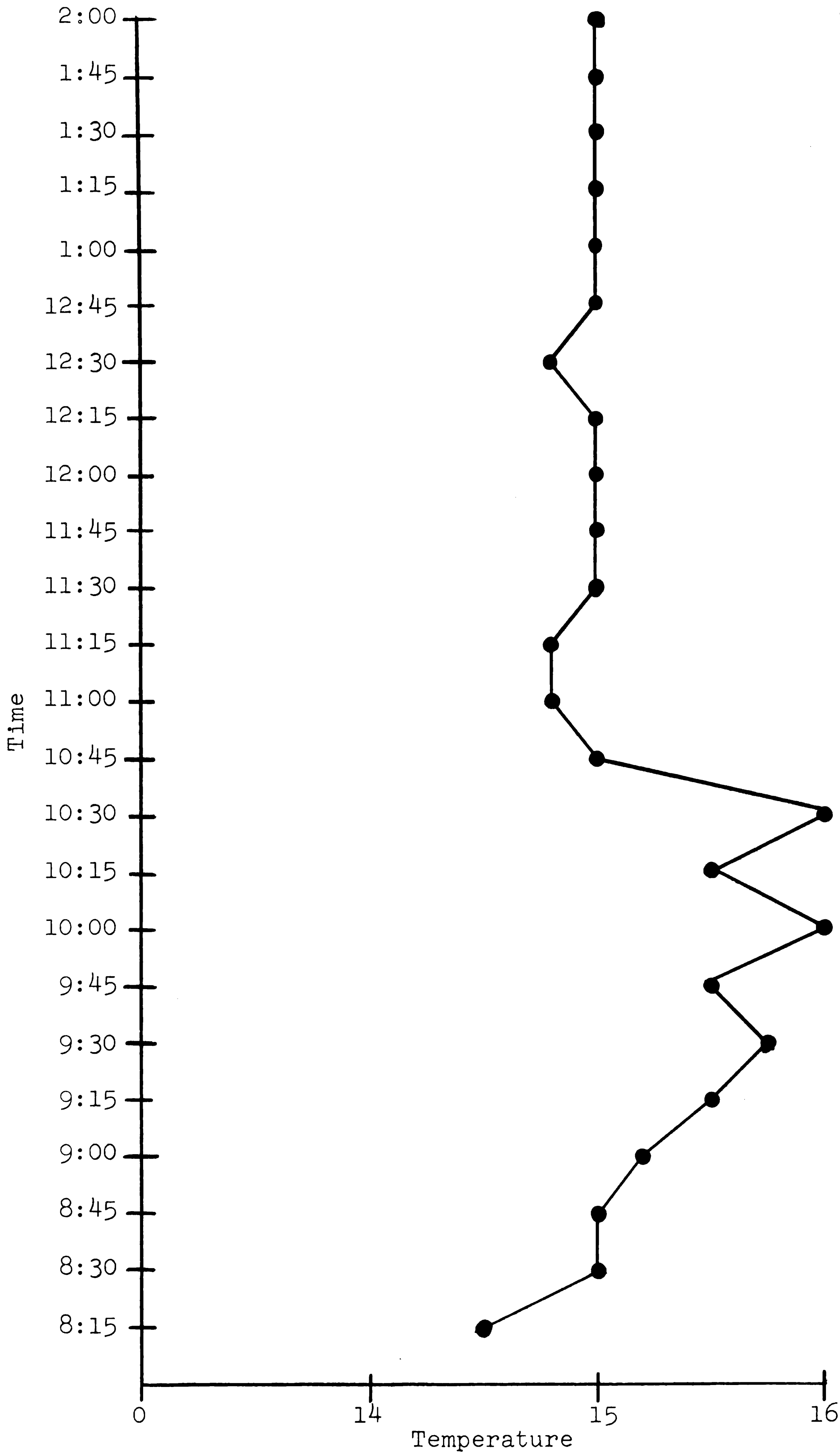
COLD WATER SURVIVAL TIME

DATA SHEET--COLD WATER SURVIVAL TIME

Group	Animal	Minutes
IA	2	125
	3	73
	4	126
	7	134
	8	117
	9	154
IB	1	88
	2	86
	3	65
	4	55
	5	97
	6	59
	7	147
	8	125
	9	85
V	1	66
	2	88
	3	55
	4	84
	6	117
	7	100
	8	95
	9	116
Controls	1	133
	2	105
	3	113
	4	133
	5	71
	6	143
	7	157
	8	137
	9	84
	10	101

APPENDIX D

WATER TEMPERATURE



2:00
1:45
1:30
1:15
1:00
12:45
12:30
12:15
12:00
11:45
11:30
11:15
11:00
10:45
10:30
10:15
10:00
9:45
9:30
9:15
9:00
8:45
8:30
8:15
Time
0
14
15
16
Temperature

APPENDIX E

ALL OUT SWIM TIME

DATA SHEET--ALL OUT SWIM TIME[1]

Group	Animal	Time 3/22/62	Time 4/28/62	Time 6/3/62
IA	2	8:00	4:30	3:30
	3	6:15	9:00	31:55
	4	4:40	5:15	5:00
	7	4:05	5:30	5:30
	8	4:00	4:00	21:15
	9	3:20	3:45	3:45
IB	1	6:00	4:45	8:45
	2	9:50	4:00	5:15
	3	4:45	8:00	6:45
	4	4:50	7:45	67:45
	5	4:00	3:45	3:50
	6	3:30	9:00	63:30
	7	4:10	7:00	5:30
	8	4:30	6:00	5:30
	9	2:30	4:50	4:00
V	1	69:45	4:45	51:00
	2	9:25	6:00	13:30
	3	5:15	5:15	32:40
	4	3:45	6:00	17:00
	6	4:05	4:45	5:10
	7	2:45	3:45	3:25
	8	3:50	1:45	2:35
	9	3:10	4:00	4:30
Controls	1	Pilot	4:00	7:20
	2	205:30	62:30	72:30
	3	Pilot	2:30	2:25
	4	3:45	11:00	63:40
	5	114:45	63:00	41:10
	6	163:20	7:00	5:25
	7	Pilot	6:30	56:35
	8	94:25	3:15	5:40
	9	3:05	2:30	4:15
	10	5:50	3:15	62:30

[1]All animals carried 3.5% of their body weight during all out swims.