EVALUATION OF THE HEART RATE RESPONSE OF WOMEN IN AN ADULT FITNESS PROGRAM

by

MARY LOUISE HASKER MORGAN

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Approved by:

William B. Zuti

Major Professor

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CHAPTER I

INTRODUCTION

The sedentary living habits so characteristic of a technologically advanced society have alleviated much of the physical exertion once required in the daily routine. This is especially noted with an increase in hypokinetic diseases attributed to a lack of physical activity (1). Coronary heart disease is one such disease, occuring in epidemic proportions taking more than 700,000 lives annually (2).

A realization that physical exercise will benefit the individual's health has prompted many people to participate in some form of exercise program as a possible preventative measure. Consequently, numerous exercise programs have developed throughout the nation. Some of the more popular programs include weight-lifting, isometrics, yoga, aerobics, Canadian XBX-5XBX, slimnastics, endurance and adult fitness programs.

Although a variety of programs are available, the sedentary adult is especially concerned with participating in a program which will improve his cardiovascular fitness, thus decreasing his chances of developing coronary heart disease. Cardiovascular fitness cannot be attained from just any type of exercise program. The question then arises as to what type of program produces cardiovascular improvement.

Research (3, 4, 5) dealing with cardiovascular fitness reveals that three factors must be considered. These are intensity, frequency, and duration. The average adult usually wants to participate in a

program which requires a minimum amount of time; thus, intensity becomes the most important factor.

A certain amount of intensity or stress is necessary for improvement in cardiovascular fitness. An exercise program must include activities which work the heart muscle at a desired level. The minimum amount of stress required for a training effect to occur is referred to as the "threshold of training level". One means of evaluating the threshold level of training is through the utilization of heart rate response to a particular exercise program.

The merits of heart rate as a measurement of cardiovascular stress have been well established (6, 7, 8). Heart rates taken during exercise provide guidelines concerning the intensity of the program. Therefore, existing programs may be evaluated to determine whether or not they provide adequate heart rate for a training effect to occur.

One such program designed to promote cardiovascular improvement was instigated at Kansas State University in 1972. With over 200 individuals participating in Kansas State's Adult Fitness Program, an evaluation of its benefits seems warranted. This program involves rhythmical endurance activities which include running and jogging interspersed with a variety of calisthentics.

THE NEED FOR THE STUDY

It has been generally accepted that cardiovascular fitness can be obtained through activities which elicit a substantial increase in heart rate, such as running, jogging, swimming, or bicycling. Exercise programs generally involve a variety of different activities or

calisthenics. The fitness program at Kansas State University is one program which is similar to many others in that several aspects of physical fitness are involved, i.e., strength, flexibility, coordination, muscular endurance, and cardiovascular fitness. Can such a program still fulfill the cardiovascular fitness needs?

To answer this question it is first necessary to know how high the heart rate must be to insure cardiovascular fitness. Numerous studies have been performed to find what heart rate is necessary to elicit cardiovascular improvements. Karvonen (9) concluded from his work that a heart rate of at least 140 beats per minute is necessary for such improvements to occur. Faria (3) confirmed this with his work on untrained males in which a significant increase in physical working capacity was noted for those individuals who trained at a heart rate above 140 beats per minute. Similar conclusions resulted from the work of Sharkey and Holleman (10). They concluded that a heart rate above 150 beats per minute was necessary for a cardiovascular training effect to occur. Although most of the research in this area have limited their studies to males, the same principles are applicable to women.

In order to assess the relative benefits of an exercise program in conjunction with cardiovascular fitness, the heart rates obtained throughout the program must be determined. This study was especially concerned with the response of women who were participating in a program designed to meet several aspects and levels of fitness. Specifically, this study was to evaluate the effects of a variety of exercises on heart rates throughout an exercise period.

PROBLEM STATEMENT

The purpose of this investigation was to study the heart rate responses of the women participating in Kansas State's Adult Fitness Program. More specifically, this study was to determine (1) if the intensity of the exercises was sufficient for a threshold of training level, (2) if the intensity was at threshold value, the amount of time it was maintained, and (3) to compare the heart rate responses of high and low fitness groups.

LIMITATIONS OF THE STUDY

Certain limitations were present in this study and should be pointed out to the reader:

1) The exercise program was basically the same from day to day but varied slightly as exercise leaders changed.

2) Although there was no control over environmental conditions, the variations in temperature and humidity were minimal throughout the testing period.

DEFINITION OF TERMS

In order to gain a full understanding of the study, certain terms require definition:

1) Coronary Heart Disease (CHD) -- general term for the forms that apply to any or all of the conditions which cause narrowing or blocking of the coronary arteries (2).

2) Aerobic -- work or activity done in the presence of an adequate supply of oxygen (14).

3) Threshold of Training -- amount of work required to achieve physiological changes that can be reflected by a lowered heart rate; amount of work required to improve the exercise tolerance of the heart. In this study intensity of work was the variable of convenience (11).

4) Overload Principle -- use of a muscle or group of muscles which is greater than normal (12).

5) Maximal O_2 Uptake (Max. VO_2) -- the maximum amount of oxygen that the cardiovascular system is able to utilize during stressing exercise (11). In this study the estimated Max. VO_2 per kilogram of body weight will be referred to as estimated Max. VO_2.

6) Steady State -- occurs when the oxygen uptake corresponds to the demands of the tissues (13).

7) Cardiovascular Endurance -- the ability to sustain a series of repetitions of an activity without unduly taxing the physiolcgical systems that furnish the fuel and oxygen to the muscles (12).

8) Kilopond Meter (KPM) -- unit of work; one kilogram raised one meter against gravity.

CHAPTER II

REVIEW OF LITERATURE

This chapter presents a review of literature pertinent to this study. The studies will include two main areas: (1) studies pertaining to coronary heart disease and its relationship to physical activity, (2) studies involving intensity, duration and frequency of exercise.

Relationship of Physical Activity to Coronary Heart Disease

Physical inactivity may have a direct relationship in the development of coronary heart disease. This is especially noted in the technologically advanced nations, where there has been a disastrous increase in coronary heart disease.

One of the first studies which brought attention to the relationship of CHD and physical activity was conducted by Morris et al. (14). London bus drivers, who were considered physically inactive, were compared to conductors who were active. They found a lower incidence of CHD among the conductors, and the disease which did appear was at a later age and less severe. This same investigation also compared sedentary postal workers, clerks, to carriers. It was again found that there was a lower incidence of CHD in the physically active individuals, the carriers.

A similar study conducted by Chapman and colleagues (15) investigated 2,253 Los Angeles civil service employees. The investigators were concerned with finding a practical method for the early detection

of heart disease. The subjects received medical examinations at intervals of 12-18 months. Preliminary findings were recorded with respect to physical exertion, weight, and blood pressure. The results indicated that individuals involved in sedentary or light physical work were more prone toward the development of CHD when compared to those involved in medium or heavy work.

Brunner and Manelis (16) studied individuals living in an Israeli Kibbutzim. This study was unique because social as well as economic factors, which affected persons in previous studies, were eliminated. Each person living in the commune performed a specific work task; thus, the nature of the jobs enabled the investigators to study non-sedentary workers with the more sedentary. The results of this investigation showed that in all age brackets and for both sexes, sedentary workers had a higher incidence of heart attacks than the non-sedentary workers.

The frequency of CHD over a period of ten years in a heart disease epidemiology study in Framingham, Massachusetts, was investigated by Kannel and associates (17). Again the subjects were classified according to degree of activity. The investigators found that of the 207 individuals who developed coronary heart disease, those persons were classified as most sedentary. These people also tended to have more serious attacks, often resulting in death. The investigators concluded that moderate physical exercise may protect the individual from a coronary attack. Dawber and associates (18) continued this epidemiological study and they found that in women the development of this disease occurred after the age of forty-five.

Another approach to investigating the relationship between physical activity and coronary heart disease was noted in a study conducted of a community in Tecumseh, Michigan (19). The community studied consisted of approximately 10,000 persons. A questionnaire survey method was used to determine the amount and frequency of physical activity of men aged 20-64. The men were then classified as sedentary, moderately active, or active according to their occupational exertion and leisure time activities. Montoye and associates felt that such an investigation would provide more accurate findings than the previous occupational studies because leisure time activity would be included in their results. When an individual's activity classification was determined by both work and leisure, the largest differences in CHD risk factors appeared. It was found that active men had lower systolic and diastolic blood pressure and significantly lower total serum cholesterol.

Several concise summaries of the review of literature in this area have been written by Fox (20), Fox and Haskell (21), Fox and Skinner (22), and Zuti (2). These reviews conclude that physically active people, both occupationally and non-occupationally active, appear to have a lower incidence of coronary heart disease. Furthermore, for exercise to be of a benefit for the prevention of cardiovascular disease, it must be continuous throughout one's life. From these conclusions, in order to prevent a further increase in the epidemic development of coronary heart disease, adults need to find a means in which to increase their activity and fitness levels.

Intensity, Duration, and Frequency Studies

In considering the relationship between cardiovascular fitness and exercise, three variables encountered in exercise programs must be reviewed. These include intensity, duration, and frequency, all of which have an effect on the cardiovascular system.

One of the first studies to investigate the effect of varied intensities on cardiovascular improvement was conducted by Karvonen et al. (9). Six untrained male students, aged 20-23, served as subjects. The men were subjected to a 4-week training program in which they ran on a treadmill for 30 minutes a day, five days a week. The speed of the treadmill was adjusted so that each subject was working at a predetermined pulse rate and this speed was periodically adjusted so that the subjects' heart rates remained at that specific level. It was concluded that in order to improve the exercise tolerance of the heart, the exercise intensity must exceed a critical threshold value. They found that there was a significant decrease in the working heart rate at an intensity which elicited heart rates above 60 percent of the range from rest to maximum. The average threshold value for training was an intensity which elicited a heart rate of 140 beats per minute.

Faria (3) did a similar study which confirmed Karvonen's findings when he studied 40 untrained males, aged 19-24. During a 4-week training period, he studied the effects of three training heart rate levels: 120-130, 140-150, and 160-170. The subjects tested were randomly assigned to one of the three training groups. The training sessions consisted of a constant workload, stepping on a 17' 1/2" bench, for five consecutive days. The results of a pre and post test of

physical working capacity was used to assess the effectiveness of the intensities. The results indicated that a significant difference appeared in the groups which trained to heart rates of 140-150 and 160-170 beats per minute. He concluded from these results that there may be a threshold level for a training effect on the cardiovascular system. He estimated that the threshold level of training for the normal untrained male adult lies around 140 beats per minute.

Another investigation involving cardiorespiratory adaptations to training at specific intensities was conducted by Sharkey and Holleman (10). They studied the effects of a six-week training program which elicited heart rates of 120, 150, or 180 beats per minute. Sixteen college men, aged 18-19, were randomly divided into one of the three training groups and a control group. The training sessions consisted of a treadmill walk for ten minutes a day, three days a week. A pre and post test using the Astrand-Rhyming Step-Test and the Balk Treadmill Test served as gauges of work capacity and endurance. The results showed that significant cardiovascular improvements were found for individuals who trained at either 150 or 180 beats per minute. The investigators concluded that a heart rate above 150 beats per minute was necessary for a training effect to occur.

These same results were also confirmed by Jackson (23). He studied the effect of training at different intensities of 130, 145, or 160 beats per minute. Twenty-one men, aged 17-25, were assigned to work at one of the intensity levels. The training session consisted of a treadmill workout 12 minutes per day, 4 days per week for six weeks. The groups training at 145 and 160 beats per minute showed significant

improvements in cardiovascular fitness. From these results Jackson concluded that training at an intensity of 145 beats per minute or higher was necessary to improve cardiovascular fitness.

Roskamm (24) further emphasized the need to elevate the heart rate in order to acquire a training effect. He investigated the training effects of intensity on long-distance ski runners in Germany. He found that heart rates of 130-135 are needed for a training effect to occur. It must be pointed out that these individuals were in better physical condition than the subjects involved in the previous studies and would have required lower heart rates to produce the same relative change.

A subsequent study conducted by Roskamm et al. (25) involved 18 men, aged 18-60, and 6 women, aged 20-30 years. The subjects trained for 30 minutes daily for four weeks. The heart rate during the training sessions for the younger subjects was about 150 beats per minute. The older individuals (50-60 years) trained at a heart rate of 130 beats per minute. After 4 weeks of training a significant increase in cardiovascular fitness was noted; however, the training effect for the 50-60 year old subjects was less pronounced.

The effects of rope skipping on the physical work capacity of women was investigated by Jones et al. (4). Seven sedentary women aged 19-42 served as subjects. The exercise session consisted of 5 minutes of rope skipping daily. The mean heart rate during the rope skipping was 168 beats per minute at the beginning of the program but dropped to 145 beats at the end. A significant difference in physical working capacity was noticed at the end of the testing period.

An attempt was made by Durnin and associates (26) to measure whether there was an improvement in physical fitness through varying degrees of exercise which lasted for only 10 days. Forty-four untrained men, aged 18-22, were divided into four groups. One group acted as a control and did only a minimum of exercise, while the other three walked either 10, 20, or 30 KMs daily. A pre and post treadmill test was used to assess the individual's fitness with respect to pulmonary ventilation, oxygen extraction, oxygen consumption, and heart rate. From the results obtained the investigators concluded that an effective exercise for the improvement of cardiovascular efficiency during a short time was walking 20 KMs daily. Walking at 30 KMs proved too strenuous for the subjects. These results differ from the previous investigations which found that a heart rate above 140 beats per minute was necessary for a training effect to occur. The highest heart rates obtained in this study were 120-130 beats per minute. Although significant improvement did occur, this can probably be attributed to the extreme duration of the exercise period, which was much longer than the previous investigations which involved 30 minutes of exercise, typical of most exercise programs.

Sharkey (5) studied the relationship between intensity and duration regarding cardiovascular endurance during a six-week training period. Thirty-six male college students were randomly assigned to a 3X2 factoral design. Three levels of heart rate intensity, 130, 150, and 170 beats per minute, and two levels of work production, 7500 KPM and 15000 KPM were investigated. Actual work time averaged 15, 10, and 7 1/2 minutes for the 7500 KPM work output at the above corresponding

heart rates. For the 15000 KPM output, the work time was 30, 20, and 15 minutes respectively to produce the above heart rates. The subjects rode a bicycle ergometer three days a week at an assigned intensity and duration. Pre and post training estimates of Max. VO_2 were recorded using the Astrand-Rhyming Step Test, Balke Treadmill Test, and Sjostrand PWC Test. The results indicated that there were no significant differences between intensity and duration or an interaction of the two regarding the extent of training changes which occurred.

An investigation of the effects of the interaction of frequency and intensity of training on physical work capacity was conducted by Crews (27). Forty-six sedentary male subjects, randomly assigned to one of six training groups, participated in a seven-week exercise program involving walking and jogging at a specific intensity level. Three levels of frequency of training were studied; these included one, three and five days per week. Two intensity levels of either 120 or 150 heart beats per minute were also studied. A pre-post test on the following variables was used to assess the effects of the frequency-intensity differences: physical work capacity, exercise and recovery heart rates, oxygen consumption, oxygen debt, respiratory quotient, ventilation, and percent body fat. The results of the tests indicated a greater training effect resulted for the 150 intensity level. A significant improvement in physical work capacity was noted in the three and five day frequency groups.

The effects of training 45 minutes, two days per week at varied intensities of either 90% of maximal heart rate (173 beats per minute), or 80% of maximal heart rate (161 beats per minute) was investigated by

Pollock et al. (28). Their results showed that both groups improved significantly in cardiovascular fitness. A similar study of the effects of training two or four days per week in a program involving running, jogging, and walking was also conducted by Pollock et al. (29). It was again found that there was no significant differences between exercise groups. Jackson et al. (30) also concluded that a frequency of two or three times a week was sufficient to improve cardiovascular fitness. His study involved twenty women, aged 17-23, who ran on a treadmill until their heart rates reached 180 beats per minute. Four training groups were studied; the groups differed only in the number of days per week that they trained.

A frequency of training three days per week in a 30-45 minute program of continuous rhythmical exercises was investigated by Elder (31) to determine if improvements in cardiovascular fitness would occur. From the results obtained, he concluded that such a program significantly improved cardiovascular fitness. A similar study of the effects of participating in a program of continuous rhythmical exercises for 5 days a week was conducted by Tooshi (32). He concluded that a significant improvement in resting, exercise, and recovery heart rates resulted from such a program.

Although intensity, duration, and frequency are all factors to be considered in an exercise program, Wilmore and Haskell (33) feel that intensity is the most important variable when prescribing an exercise program for the average adult. Activities performed above certain intensities could have serious medical consequences. An intensity which corresponds to 75% of a person's predicted maximal O_2 uptake can be performed safely. They also stated that a duration of 15-20 minutes and

a frequency of every other day is sufficient to improve cardiovascular fitness. One-hundred and fifty subjects participated in this type of exercise program for a three month period. Significant cardiovascular improvements were noted; thus, confirming the practicality of this guideline.

Cooper (34) summarized his research dealing with exercise and cardiovascular fitness and stated that certain principles must be followed in order for a beneficial effect to occur. The exercise period must be vigorous enough to produce or sustain a heart rate of 150 beats per minute, for at least 5 minutes. If the exercise is not of this intensity then the total period of time must be continued longer than 5 minutes.

In summarizing the literature review it is evident that intensity, duration, and frequency are factors which must be considered if the exercise is to benefit the cardiovascular system. Thus, certain recommendations seem appropriate to serve as guidelines for such programs. The following guidelines are applicable to the average adult desiring to increase his cardiovascular fitness:

1) Participation should occur at least 2-3 times per week.

2) Exercises should be "oxygen-demanding" and carried out at an intensity level of at least 140 beats per minute for periods of 5-15 minutes.

3) The level of intensity and the length of the exercise period for any single participant should take into account the subject's initial level of fitness.

CHAPTER III

PROCEDURE

The methods and procedures used in this study included selection of subjects, a preliminary test, evaluation of motivation, collection and statistical treatment of data.

Subjects

The adult women studied in this investigation were volunteers from the population of participants in Kansas State's Adult Fitness Program. Nineteen women with an age range of 24 to 39 served as subjects. This sample of women averaged 5'5" in height, 132 pounds in weight, and had an average of 42/ml/kg VO_2. These women regularly participated in the fitness program, exercising at least three times a week.

Preliminary Test

The subjects were scheduled for a ten minute laboratory testing period in which their cardiovascular fitness was estimated. At that time recordings were also made concerning age, height, weight, and amount of time in the fitness program. A motivation questionnaire was then filled out by each woman.

To estimate cardiovascular fitness, an assessment of each subject's maximal oxygen uptake was determined using the Astrand-Rhyming bicycle test (35). This test required a six minute ride on a bicycle

ergometer. The subjects rode at a given work load, 300-450 KPMs, at a constant frequency of 50 RPMs on a Monarch bicycle. An average heart rate, based on the last two minutes of the ride, was determined. This average heart rate and the work load were then used to estimate maximal VO_2 (maximum oxygen uptake) using the Astrand-Rhyming nomogram with the age correction factor included (36). The estimated max. VO_2 was then divided by the subject's weight to obtain maximal VO_2 per kilogram of body weight.

Each subject filled out a questionnaire, designed by this investigator, to quantify the extent of her motivation towards the exercise program (see Appendix A). Motivation was determined by a point system. Those scoring the higher point totals were considered to be more highly motivated. From 1 to 5 points were awarded for each question dependent upon the subject's response. Five points were awarded for the response "always" which indicated the highest level of motivation, four points for the response "almost always," three for "frequently," two for "occasionally," and one for "never." The cumulative point total from the eight item test, was used as a relative assessment of the individual's motivation. The reliability of the test was established by its administration to a random selection of ten subjects on two separate occasions (r=.78).

The investigator felt that a motivational assessment was necessary to determine to what extent, if any, motivation affected the degree of participation throughout the exercise program. The more highly motivated individual may tend to exert more effort during the program, which could be reflected by a higher heart rate.

Collection of Data

The heart rate responses of the women during the exercise program were telemetered using a Narco-bio systems transmitter, FM receiver, and a 4 channel physiograph recorder. Prior to each testing session, an explanation of the equipment and its use was given to each subject. This was to help alleviate anticipatory reactions which might result due to an apprehension of the equipment.

Two electrodes were placed on the subject's chest, one on the upper part of the sternum and the other directly below the left breast on the fifth intercostal space of the rib cage. Before the electrodes were placed in position the skin was carefully cleansed with alcohol to remove any excess dirt or oil. Tough Skin was then sprayed over this area to help secure the electrodes. Adhesive washers placed on the electrodes held them tightly in position. The wires were taped to the chest to eliminate excessive movement. The transmitter was secured to the chest in the same manner, at a location which would not interfere with movement during the exercise routine.

Each subject was tested once, all testing was completed within an eight week period. Two subjects were telemetered during the exercise testing sessions. Although the exercise sessions consisted of 5 minutes of passive stretch and 15 minutes of rhythmical endurance exercises, the heart rates were only recorded during the 15 minutes of active exercises. A continual recording of the exercises encountered during the testing session was also maintained. The exercise program was basically the same but varied slightly as exercise leaders changed. A typical program included:

1) Five minute period of passive warm-ups

   a. lateral stretches

   b. cat backs

   c. prone arches

   d. bend and stretch

   e. knee lifts

   f. lateral leg lifts

   g. arm circles

   h. sitting passive stretches

2) Fifteen minutes of rhythmical endurance exercises

   a. jogging

   b. bent knee sit-ups

   c. jog side straddle

   d. back leg lifts

   e. side kick hops

   f. jumping jacks

   g. jogging in place

   h. jog-long stride steps

   i. competition run

   j. partner push and pull

   k. sprints

   l. pull-ups with partner

   m. jogging backward

After the data were collected, heart rates were counted for every 30 second interval of the bout. Each subject's average heart rate was determined for minutes 1-3, 4-6, 7-9, 10-12 and 13-15. These

intervals were chosen for the purpose of evaluating the extent to which the subjects responded during the exercise period. Furthermore, the effects of various exercises encountered during these intervals could be assessed.

In order to study the relationship between cardiovascular fitness and heart rate response during the exercises, the subjects were categorized into two groups dependent upon their estimated max. VO_2. Astrand's classification of estimated Max. VO_2 was used for this purpose (36). Group 1 comprised nine individuals with good to excellent cardiovascular fitness, that was an estimated max. VO_2 of 43 ml/kg or above. The second group, ten women, included those individuals possessing fair to average estimated max. VO_2 below 43 ml/kg.

Based on the literature, a heart rate of 140-150 beats per minute is generally considered necessary for a threshold level for training. Karvonen stated that this specific level could be determined by measuring 60 percent of the range from resting to maximal heart rate (9). According to Astrand's work (37) a maximal heart rate for this age of woman would be 198 beats per minute and a resting heart rate of 72 beats per minute was used; thus, the threshold level of 148 beats per minute would be needed during the exercise program for a training effect to occur.

Statistical Treatment of Data

Twelve variables were statistically analyzed in this investigation. The relationship existing between the variables was determined using a Pearson Product Correlation. The variables studied included the following:

1) Estimated maximal VO_2 per/kg of body weight
2) Motivational score
3) Age
4) Weight
5) Time in program
6) Average heart rate for 1-3 minutes of exercise
7) Average heart rate for 4-6 minutes of exercise
8) Average heart rate for 7-9 minutes of exercise
9) Average heart rate for 10-12 minutes of exercise
10) Average heart rate for 13-15 minutes of exercise
11) Average heart rate for the entire exercise period
12) Percent of time that the heart rates were at or above the threshold of training level of 148 beats per minute

These variables were further analyzed by placing the subjects into two groups. Group 1 (est. max. $VO_2 \geq 43$ ml/kg) consisted of the women possessing good to excellent cardiovascular fitness. Group 2 were those women with fair to average ranges in cardiovascular fitness (est. max. $VO_2 \leq 42$ ml/kg). A one way analysis of variance was computed to see if a difference existed between the two groups studied on all the variables with the exception of the 5 average heart rate intervals which were analyzed using a repeated measure ANOVA. The null hypothesis was assumed and the .05 level was the criterion for statistical significance.

CHAPTER IV

RESULTS AND DISCUSSION

This study investigated heart rate and several other variables of women as they were affected by an adult fitness program. The following chapter presents the results obtained from this study and a discussion of these results. The results will include (1) interrelation of the 12 variables, (2) ANOVA of all variables excluding heart rate intervals, and (3) a repeated measure analysis of the 5 heart rate intervals.

Interrelation of the Variables

The inter-correlations are presented in a 12 variable matrix. As Table I indicates, significant correlations were found to exist between several variables including estimated max. VO_2, heart rate intervals, average heart rate, and percent of time at or above threshold level.

Estimated maximal oxygen uptake (VO_2) scores significantly correlated to body weight, however it must again be mentioned that VO_2 scores were assessed by dividing weight into estimated max. VO_2 to obtain the estimated max. VO_2 per kilogram of body weight. This was the only variable to which estimated max. VO_2 was significantly related.

The results also indicated that four other variables showed no interrelationships with each other or any of the other variables. These include motivational score, age, weight, and amount of time in

TABLE I

RELATION BETWEEN THE VARIABLES

		1 VO_2	2 Mot. Score	3 Age	4 Wt.	5 Time	6 HR 1-3	7 HR 4-6	8 HR 7-9	9 HR 10-12	10 HR 13-15	11 Ave HR	12 %Thre.
1	VO_2	-**											
2	Mot. Score	0.23	-**										
3	Age	-.28	-.03	-**									
4	Wt.	-.55*	.01	.41	-**								
5	Time	-.25	-.25	-.03	.00	-**							
6	HR 1-3	-.20	.06	-.20	.13	-.12	-**						
7	HR 4-6	-.05	-.00	-.25	-.24	.13	.66**	-**					
8	HR 7-9	.03	-.09	-.39	-.51*	.14	.53*	.77**	-**				
9	HR 10-12	-.12	-.17	-.18	-.45*	.29	.26	.74**	.76**	-**			
10	HR 13-15	-.38	-.37	.06	-.21	.01	.13	.59**	.47*	.74**	-**		
11	Ave. HR	-.17	-.16	-.29	-.30	.12	.61**	.92**	.88**	.85**	.70**	-**	
12	% Thre.	-.26	-.06	-.26	-.14	.05	.67**	.82**	.80**	.71**	.56*	.90**	-**

* .05 significant level
** .01 significant level

the fitness program. The only noted exception was body weight which correlated significantly to the heart rates during the 7-9 ($r = .5$) and 10-12 ($r = .45$) minute exercise intervals.

The remaining variables which included heart rates during 1-3, 4-6, 7-9, 10-12, and 13-15 minute intervals, average heart rate and percent of time at or above threshold level were significantly related to one another. One exception was found in the heart rate intervals of 10-12 and 13-15 minutes which did not significantly correlate to the heart rates elicited in the 1-3 minute period.

ANOVA of the Variables

A one way ANOVA was performed to see if a difference existed between group 1 and group 2 for the following variables: estimated max. VO_2, motivation score, age, weight, time in program, average heart rate, and percent of time at or above the assumed threshold level. The mean scores for both groups are shown in Table II. The greatest differences in the means were found for weight and estimated max. VO_2. Only a slight difference in mean scores was found between the remaining variables. The results showed that the only significant difference was found for the estimated max. VO_2 variable (see Table III), as would be expected since this was the variable used to group the subjects. (Mean, SD, and ANOVA for each variable can be found in Appendix C).

Repeated Measure Analysis of Variance

A repeated measure ANOVA of the heart rates during intervals 1-3, 4-6, 7-9, 10-12, and 13-15 minutes are shown in Table IV. The results indicated that there were no significant differences between the groups for each of the intervals. However, significant differences

TABLE II

GROUP MEAN AND STANDARD DEVIATION

Variable	Units	Mean	S.D.
Est. Max. VO_2	ml/kg	42.00	6.58
Motivational score	-	21.21	3.39
Age	yrs.	30.52	5.32
Weight	lbs.	132.26	23.05
Time in program	mos.	7.89	5.18
Avg. H.R.	beats/per min.	161.81	8.51
% of time above threshold level	%	.92	.11

TABLE III

COMPARISON OF MEAN AND STANDARD DEVIATION

Variable	Group I N=9 $\bar{x}$	Group I N=9 SD	Group II N=10 $\bar{x}$	Group II N=10 SD
VO_2	47.11	4.78	37.40	4.08
Mot. score	20.88	3.05	21.50	3.80
Age	30.11	6.00	30.90	4.93
Weight	123.55	16.62	140.10	25.93
Time in program	6.66	5.00	9.00	5.35
H.R. Avg.	160.59	10.32	162.89	6.90
% of time above threshold	.89	.14	.94	.07

TABLE IV

REPEATED MEASURE ANALYSIS OF VARIANCE

Source	df	ss	ms	f
Group	1	62.16	62.16	1
Sub/group	17	6417.36	377.49	
Time	4	3018.41	754.60	14.46
Group x Time	4	58.07	14.52	NS
Error	68	3547.82	52.17	

were found between these heart rate intervals. The average heart rate for 1-3 minutes of exercise were significantly lower than the heart rates during the remaining intervals. It was also found that the heart rates during the 10-12 minutes were significantly higher than the heart rates during 13-15 minutes; however, there was no significant difference between the intervals of 4-6, 7-9, and 13-15 minutes.

DISCUSSION OF RESULTS

The women observed in this study, average age 10.5 yrs., weight 132.2 lbs., and est. max. VO_2 of 42 ml/kg of body weight, closely resembled the subjects studied by Jones (4) and Roskamm et al. (25). Their investigations, along with the present one, studied the cardiovascular responses of women to exercise. Jones found that improvement in cardiovascular fitness would result from a 5 minute exercise session in which the average heart rate was 145 beats per minute. Roskamm found that cardiovascular improvements resulted from a 30 minute exercise session with an average heart rate of 150 beats per minute. The present study, involving exercise intensity, found that an average heart rate of 161 beats per minute occurred during a 15 minute exercise program. A heart rate of 148 beats per minute was the assumed threshold level of training.

The purpose of this study was to determine the extent the women's heart rates responded to a particular exercise program involving a variety of calisthenics and cardiovascular endurance type of exercise. Specifically, the objectives were to determine if a threshold level of training, 148 beats per minute, was obtained and the percentage

of time spent at or above this level. Twelve variables were considered in this investigation.

The correlation matrix indicated that several of the variables were interrelated. The first variable, estimated max. VO_2, had a significant correlation with a second variable, weight ($r = -.55$). This is understandable because the estimated max. VO_2 score was determined by dividing the subject's weight into her estimated maximal VO_2 per/ml/kg of body weight.

A motivational score was assessed because the investigator felt that the highly motivated subjects would tend to work harder during the exercise period eliciting higher heart rates (38). The results indicated that this was not so. Motivation did not significantly correlate with any of the other variables. This can probably be attributed to the fact that this population of women were fairly equal in motivation because they all voluntarily participated in the program for several months. The questionnaire used to determine motivation was not tested for its validity, therefore, it may not have sufficiently detected differences existing between the subjects.

It was found that age, weight, and time in the fitness program did not significantly correlate with each other or any of the other variables. Although this was true of the age variable this result was of value to the exercise program because during the program the heart rate responses of subjects of varying ages responded similarly. This was especially noted because of the non-significant correlations between age and the heart rate variables.

With one exception, estimated max. VO_2, weight did not correlate well with the other variables. Weight correlated with the heart

rates during the intervals of 7-9 and 10-12 minutes. This suggests the subject's weight, especially that of the heavier subject, may have influenced heart rate response causing an elevation during this approximate time period. Excess weight may cause an added strain on the heart requiring it to work harder to meet the existing physiological demands of the body for the exercises (13). The non-significant relationship existing between weight and heart rate during the 13-15 minutes suggested that the women slowed down their work pace. This resulted in a lower heart rate than was noted during the previous two intervals, thus enabling the women to finish the exercise session.

Significant correlations were found between almost all of the heart rate intervals, average heart rate, and the percentage of time that the heart rates remained above the threshold level. Therefore, this study indicated that an average heart rate obtained during the exercise session may serve as a guideline to determine if the heart was working at or above a threshold level. This is especially important where large groups of individuals are involved in an exercise program. They can take their own pulse rate several times, at intervals of 3-5 minutes, and get an assessment of their average heart rate. In this manner they can determine whether or not they are working at an intensity sufficient enough to maintain an adequate threshold of training level.

The ANOVA showed that there was a significant difference between the mean scores of group 1 and group 2 on estimated max. VO_2. This difference was valuable in order to ascertain if individuals of varying fitness levels would elicit similar heart rate responses during this

type of open-ended exercise. The results from the repeated analysis, clearly indicated that the subjects did have similar responses. Although the lower cardiovascular fitness group appeared to maintain higher heart rate levels during the exercises, these did not differ significantly from the levels maintained in group 1. Figure I shows this relationship and the fact that both groups were above threshold level during all exercise intervals.

The differences between each of the heart rate intervals, 1-3, 4-6, 7-9, 10-12, and 13-15 minutes, showed that the heart rates were significantly lower during the first three minutes of exercise. This suggested that the women began exercising at a lower intensity, and then gradually increased their pace at a rate which they could comfortably pursue. This was noted by the non-significant differences which existed between the intervals of 4-6, 7-9, and 13-15 minutes. Although significantly higher heart rates occurred during the 10-12 minutes, the subjects appeared to alter their work intensity so that the heart rates were again lowered during the remaining minutes.

Because there was no significant difference between the groups regarding their heart rates during the intervals studied, it appeared that the subjects regulated their work out-put. Although work out-put was not assessed in this study, the degree of heart rate ranges found throughout the exercise periods indicated that such a regulation was occurring. The fact that the heart rates were never too high or too low during the exercise period supported the idea that the women controlled their work intensity.

This type of self-regulation is important to this exercise program because the individuals participating in the program possess

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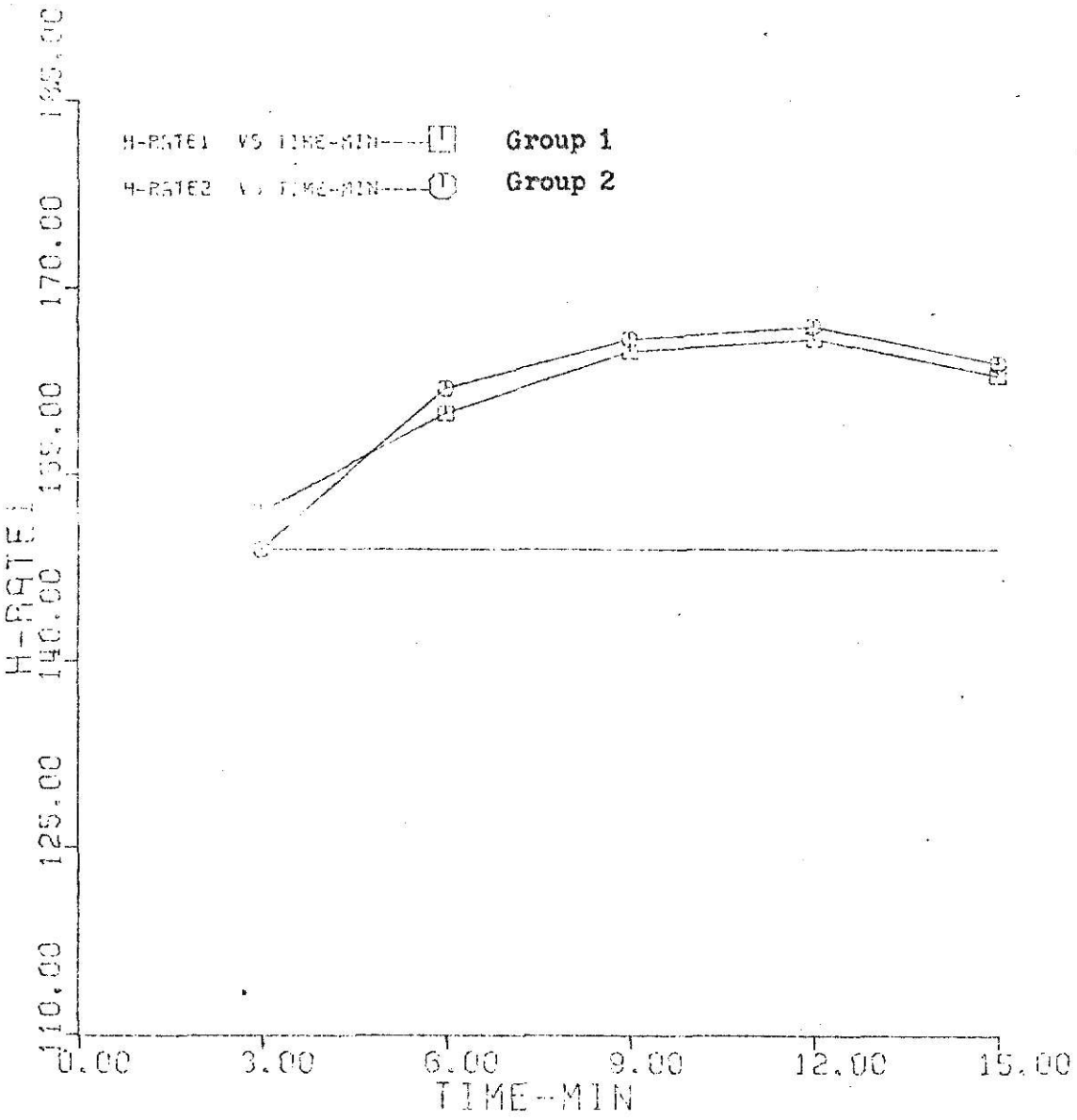
Figure I

A COMPARISON OF H. R. INTERVALS TO THRESHOLD LEVEL



varying degrees of cardiovascular fitness. Consequently, each person involved in the exercise session controlled her pace so that her heart rate did not elevate beyond a point which she could not pursue. An exceedingly high heart rate could produce medical complications. With numerous adults participating in exercises throughout the country, an occurrence of heart stroke, exhaustion, and coronary attacks (39) have resulted from intense and highly regimented exercises. The exercise program in this present study is not strictly regimented. Therefore, it appeared that individuals were able to "slack off" at times in order to prevent such occurrences, and work harder at other intervals permitting a constant heart rate level. For a person who is less fit, a high heart rate could be extremely dangerous. Wilmore and Haskell (33) stated that it is especially important for middle aged adults to make certain that the intensity at which they work was controlled at a beneficial level which is approximately 75 percent of one's maximal oxygen uptake.

Although a variety of different exercises were encountered during the exercise sessions, the results revealed that the sequence of the program enabled the participants to maintain a heart rate sufficient for a threshold level of training, 148 beats per minute. Karvonen (9), Cooper (34), and Sharkey (5) stated that a heart rate of at least 140-150 beats per minute must be reached if cardiovascular improvement was to occur. The subjects' average heart rate of 161 beats per minute was therefore considered sufficient for cardiovascular improvement. It was also noted that all the heart rate intervals had an average heart rate above the threshold level. Cooper stated that this threshold

level must be maintained for at least 5 minutes for improvement to result. The data revealed that the women were either at or above the assumed threshold level 92 percent of the time, thus exceeding the 5 minutes requirement. Corbin and Rose (40) found that this program did improve cardiovascular fitness. Therefore, it may be stated that this exercise program provided a sufficient heart rate intensity for improvement in cardiovascular fitness.

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

The heart rate responses of nineteen women during a 15-minute exercise program were recorded in order to assess the degree of intensity encountered in the program. The following conclusions can be drawn from the results of the data collected:

1) The rhythmical endurance exercise program is intense enough to elicit and maintain average heart rates at or above a threshold of training value.

2) The heart rates maintained are above the threshold level and are consistent for subjects regardless of their fitness level.

3) The women appeared to have the ability to regulate their work pace and their heart rate during continual rhythmical endurance exercises.

4) Age, weight, motivational level, and previous exercise experience do not appear to affect the individual's performance during the exercise program.

RECOMMENDATIONS

Based on the data it is evident that the intensity of the exercise program provided a threshold level of training. It is recommended that this type of program be incorporated into existing programs to insure improvements in cardiovascular fitness.

Further research is also needed ragarding threshold levels obtained during existing exercise programs. The program investigated provided sufficient intensity levels throughout the 15 minutes. It would therefore seem essential to study other programs to determine what heart rate levels are encountered.

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APPENDIX A

MOTIVATION QUESTIONNAIRE

PROCEDURES

Read the following questions and answer them Never, Occasionally, Frequently, Almost Always, or Always. Give the one answer that best indicated the way you feel and place the number which corresponds to your answer in the space provided.

1. Never
2. Occasionally
3. Frequently
4. Almost Always
5. Always

QUESTIONS

_____1. Does competition with individuals in the group help boost your performance level?

_____2. Do you set weekly or monthly goals pertaining to your performance in the fitness program?

_____3. How often does the feeling of fatigue or discomfort cause you to "slow down" during the exercise routine?

_____4. How often do you exercise on your own outside of the scheduled noon-hour program?

_____5. Do you consider yourself aggressive?

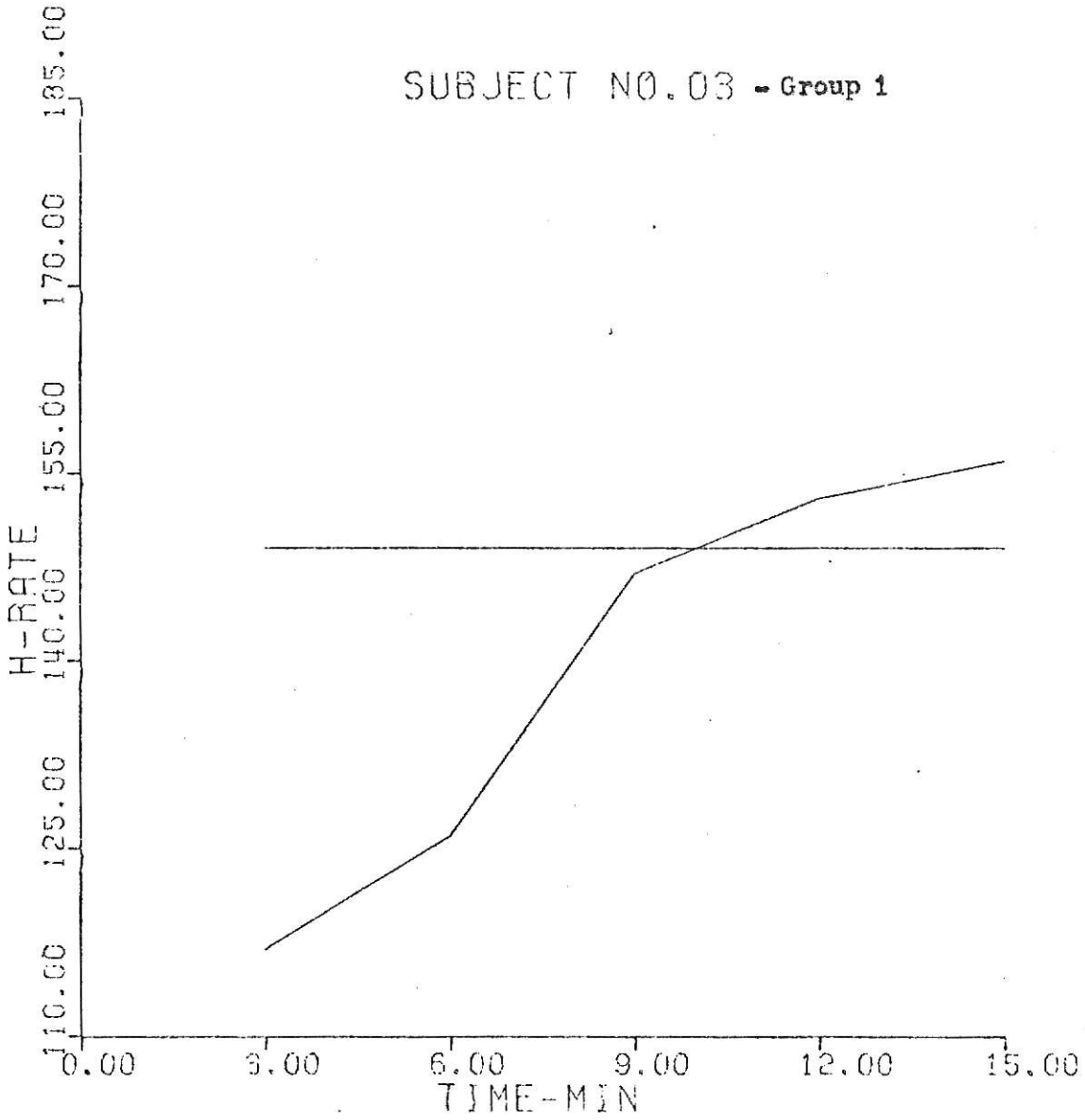
_____6. How often do you push yourself beyond the limits which induce normal fatigue?

_____7. Have you participated in other scheduled exercise programs?

_____8. How do you rate the social atmosphere of the fitness group? Indicate either Poor, Fair, Comfortable, Good.

APPENDIX B

INDIVIDUAL HEART RATE RESPONSES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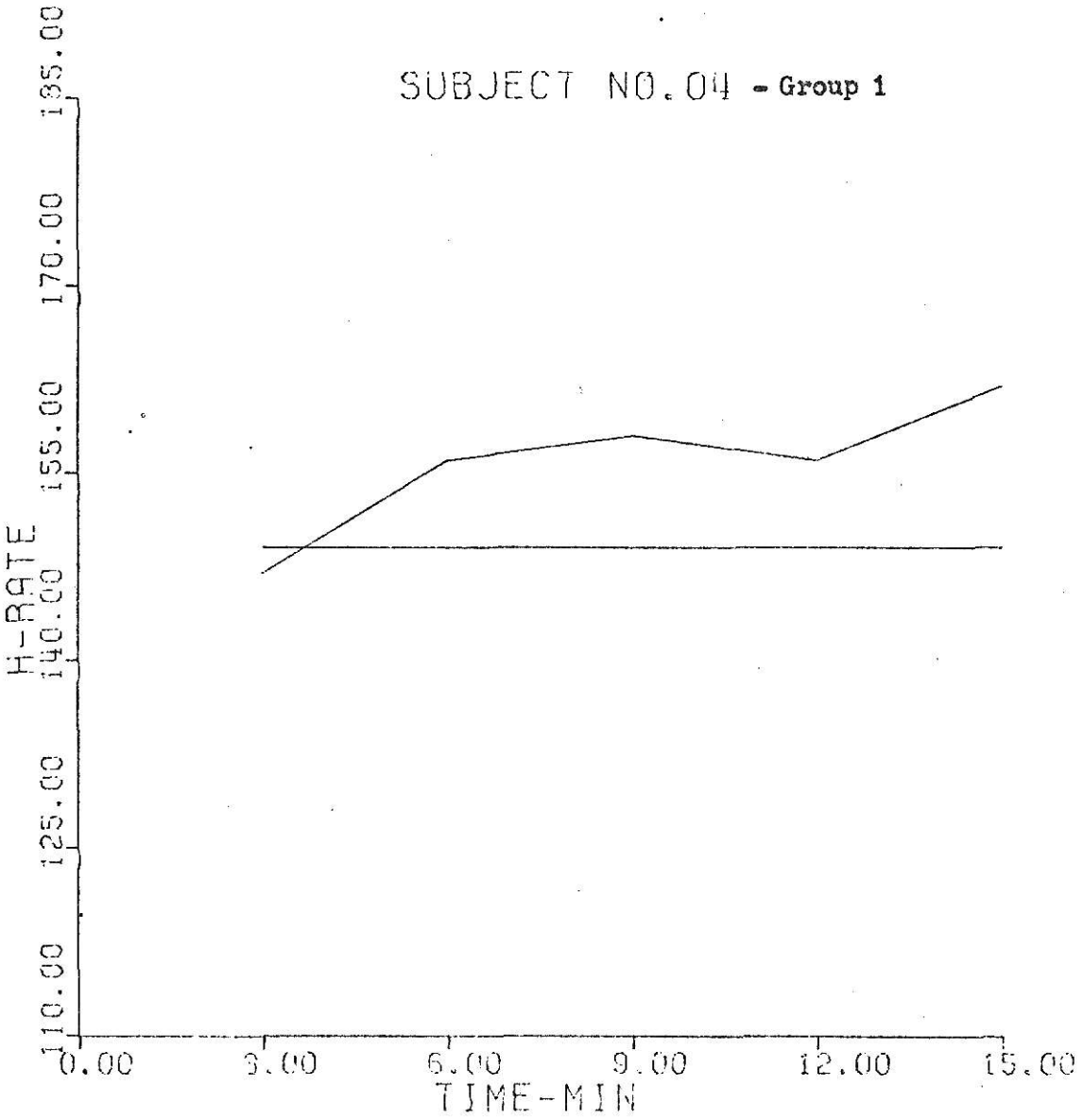
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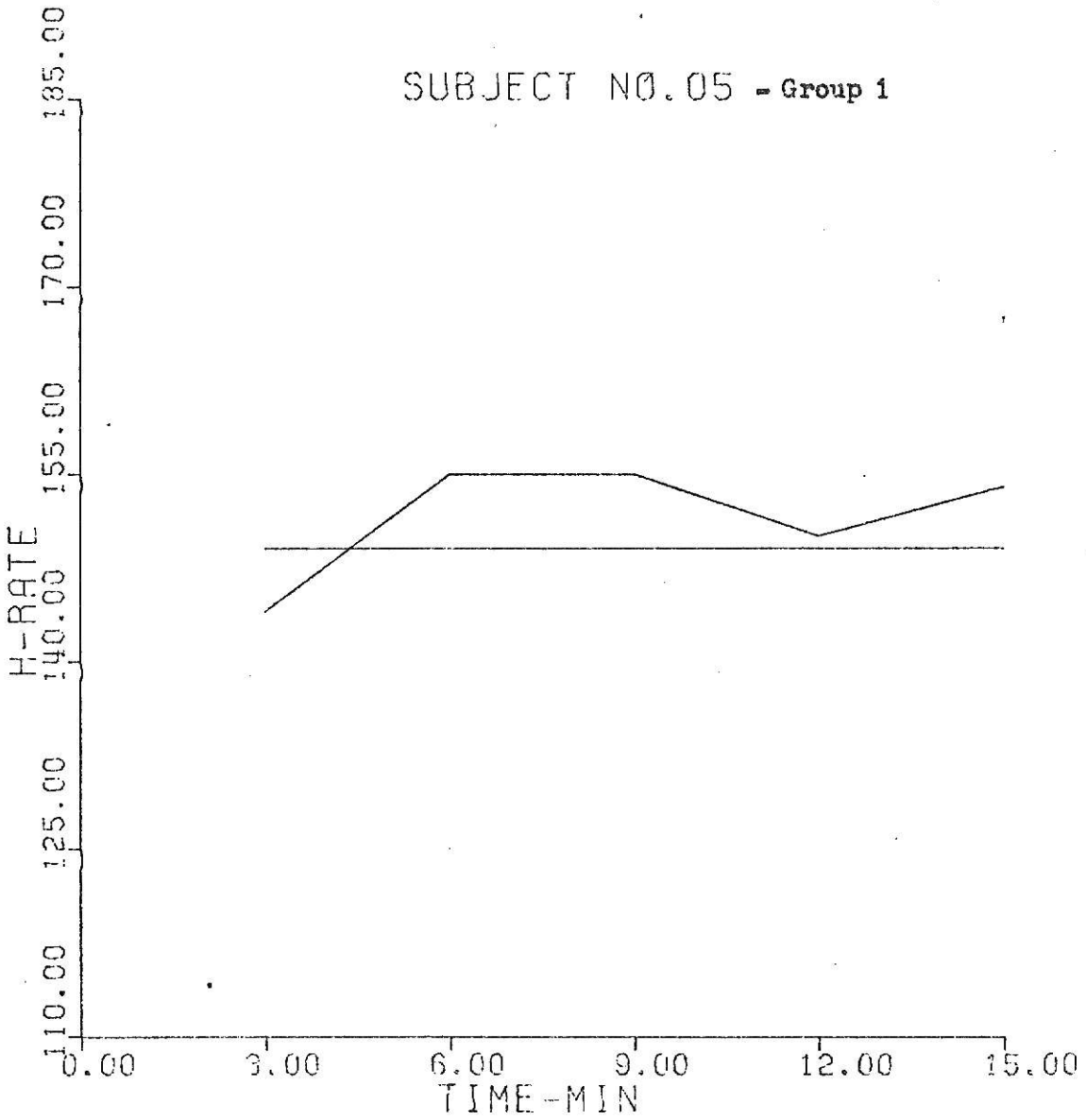
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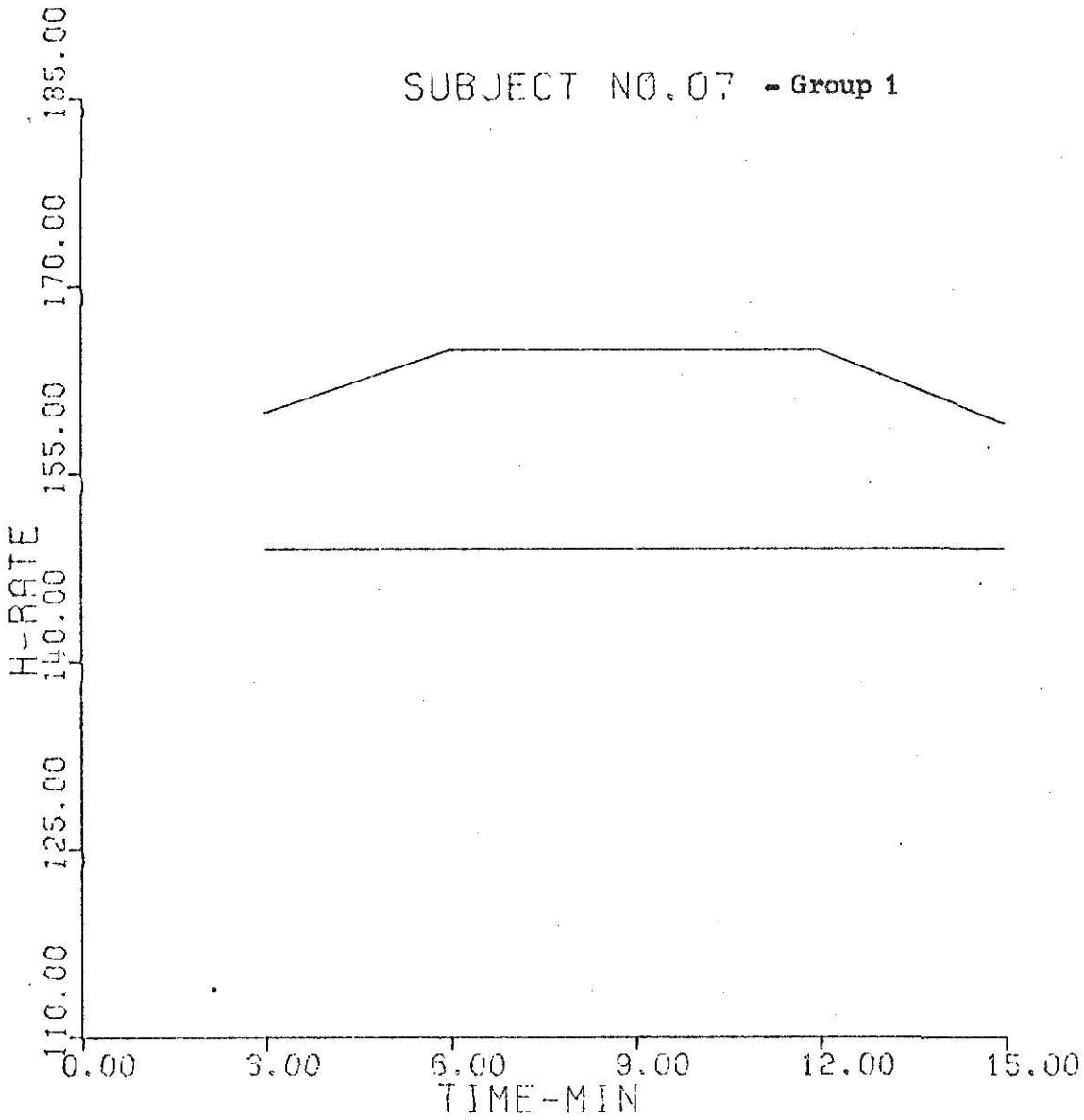
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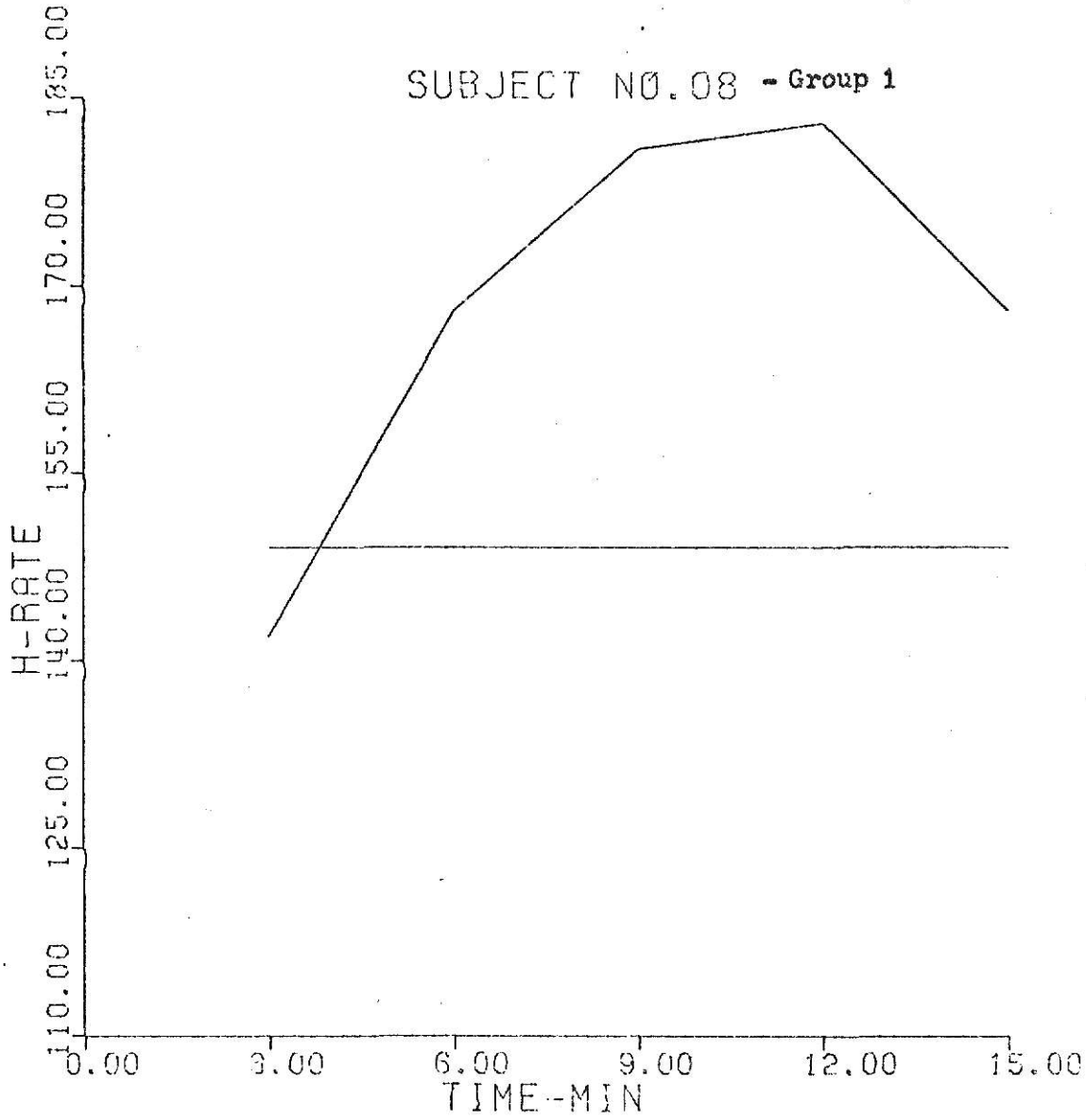
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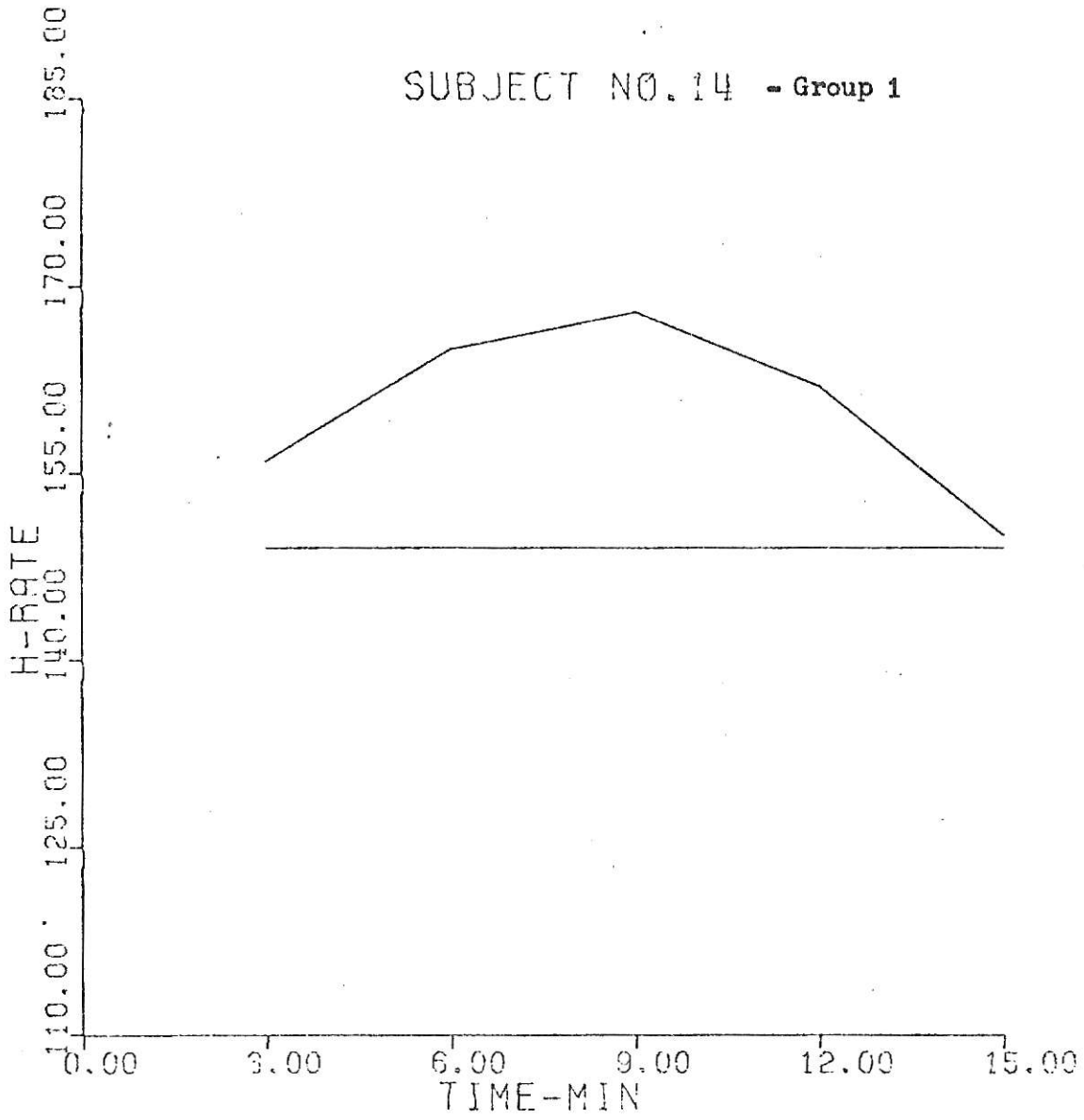
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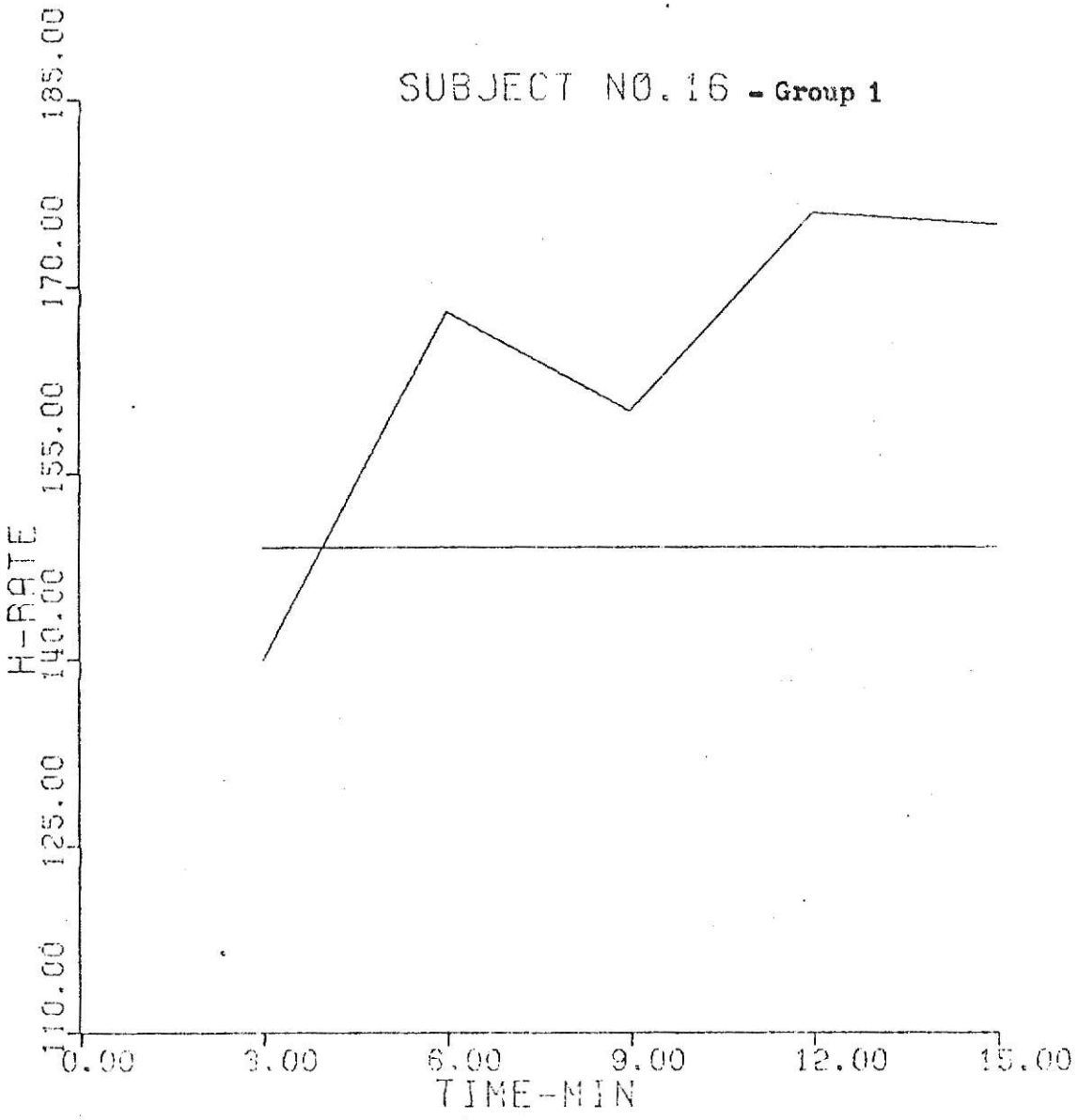
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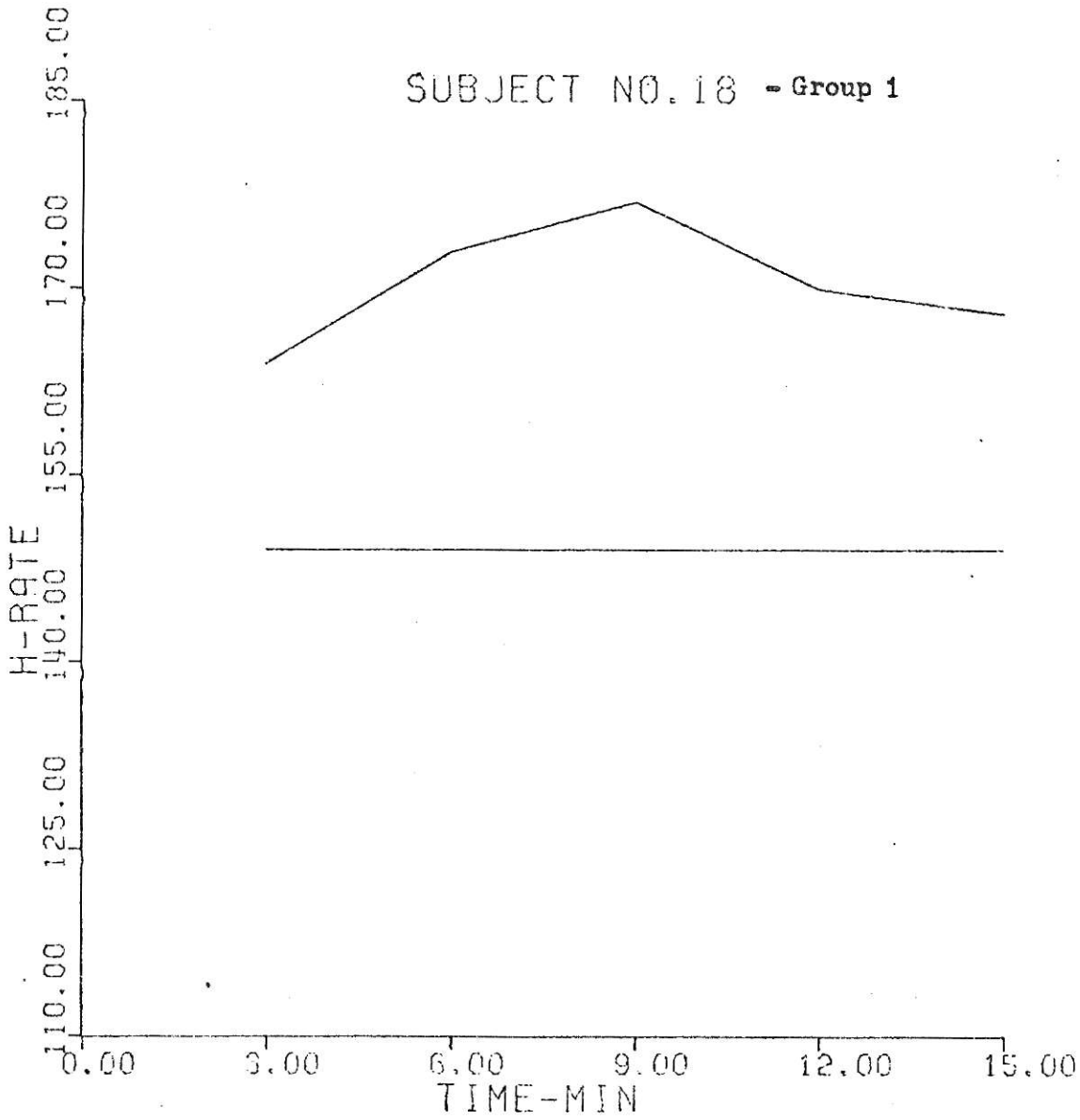
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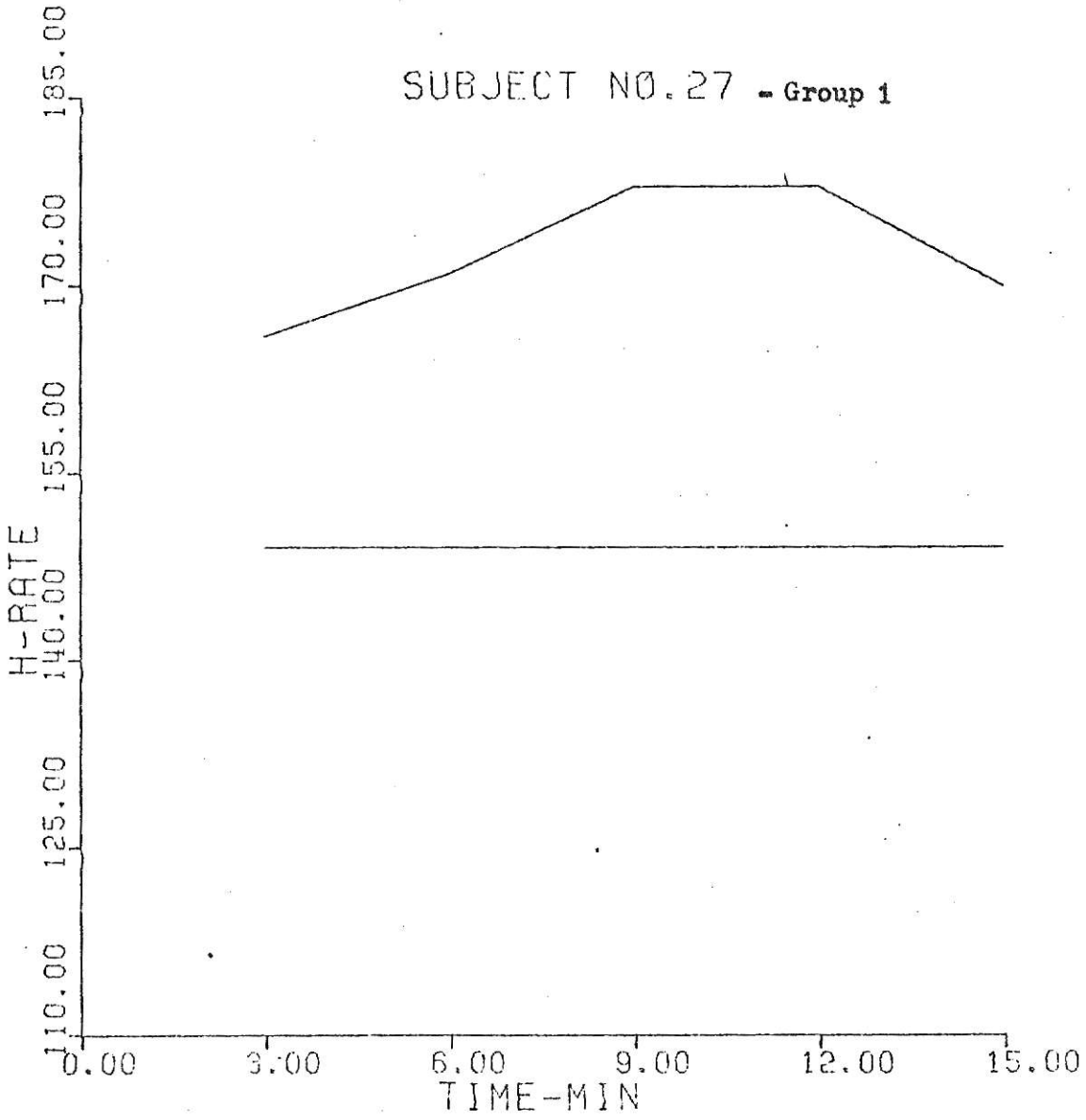
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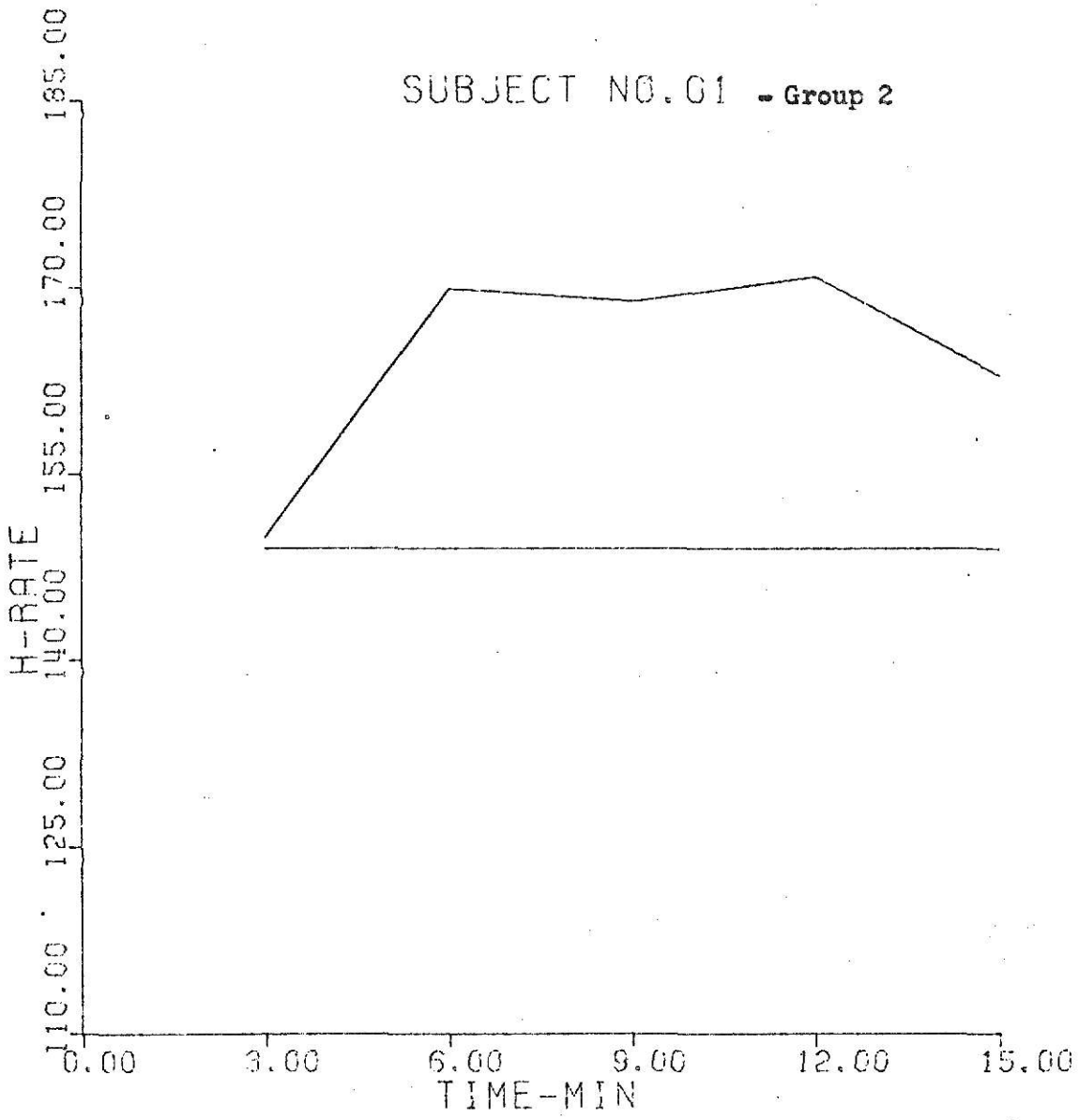
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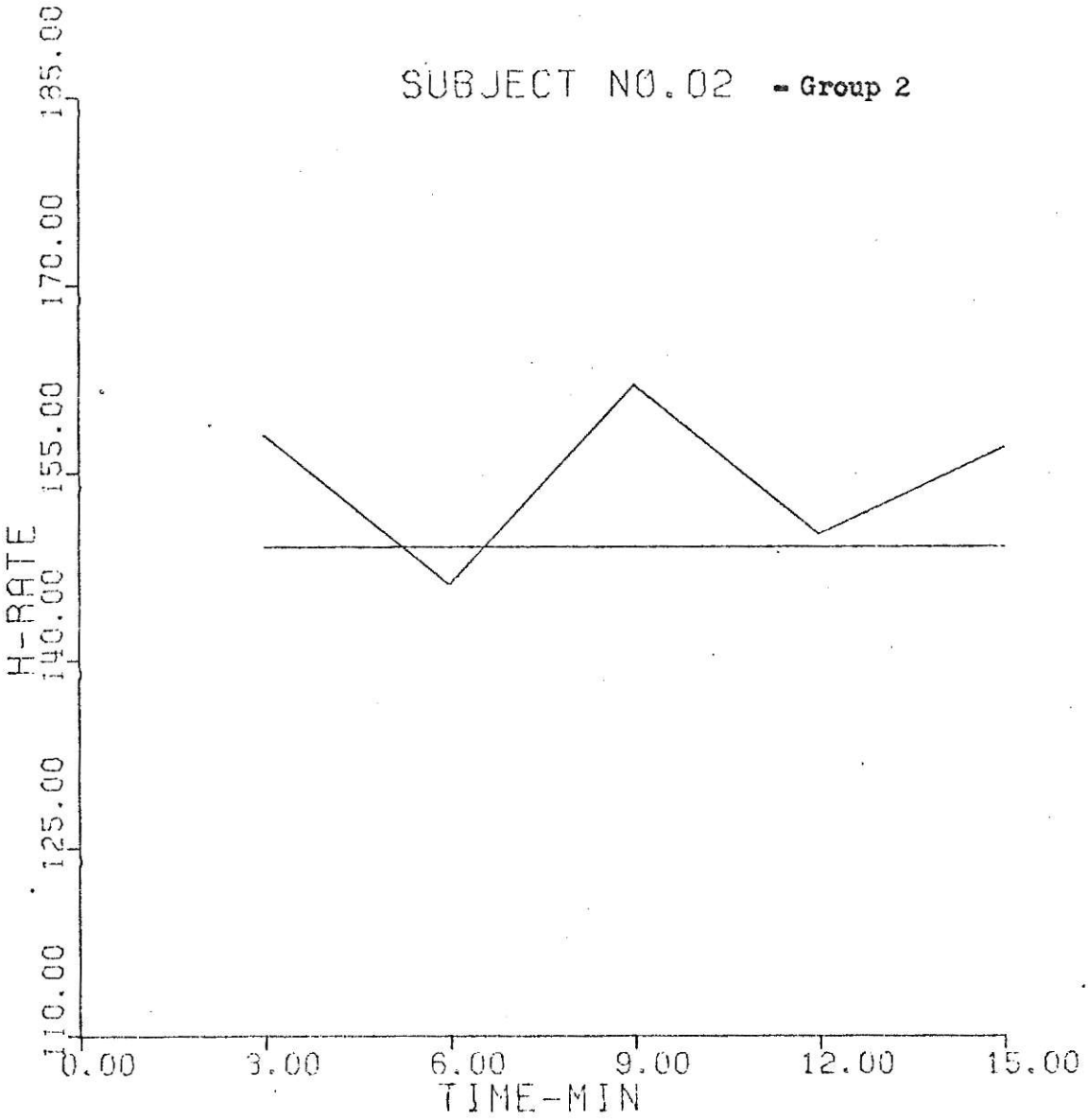
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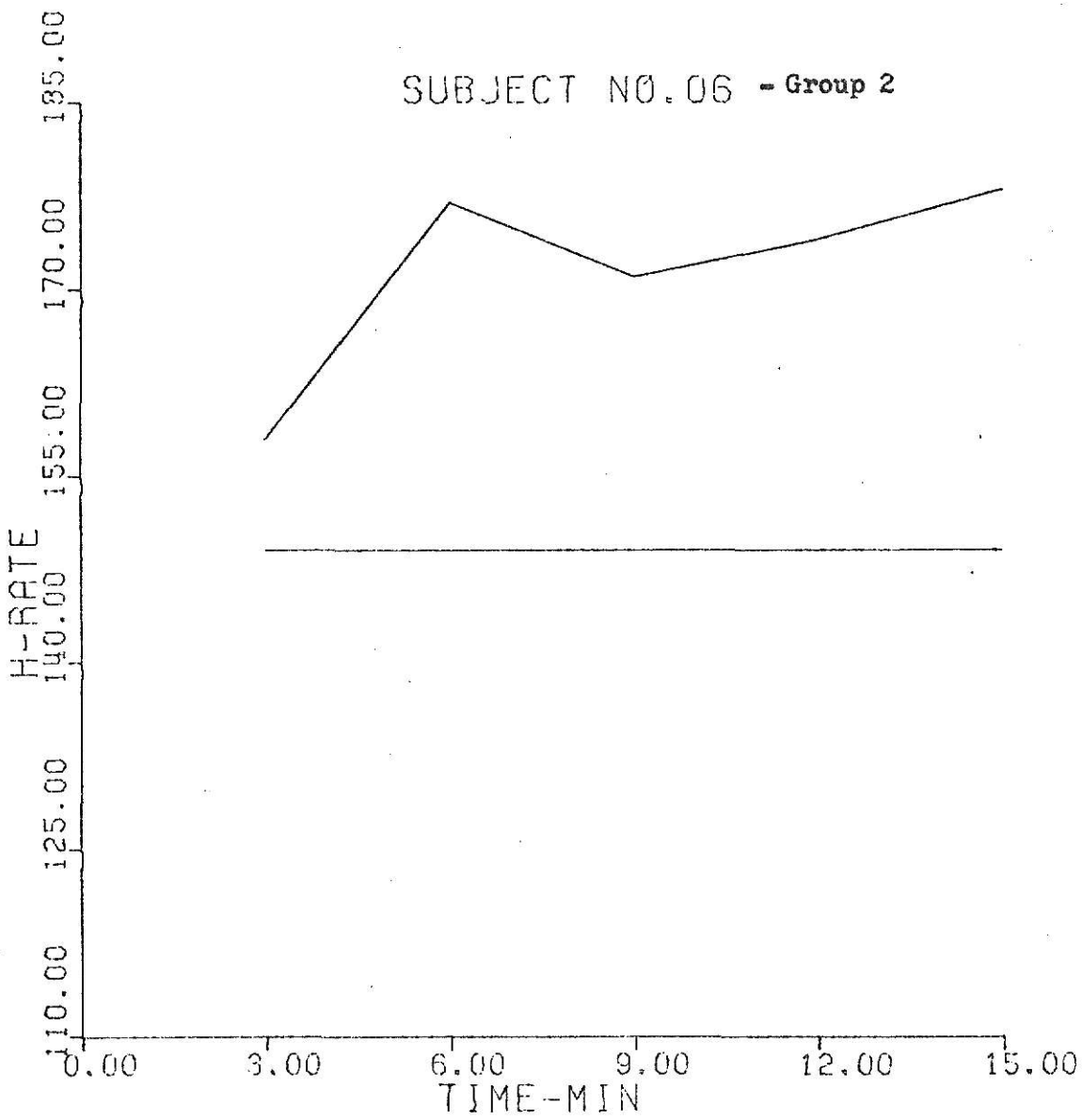
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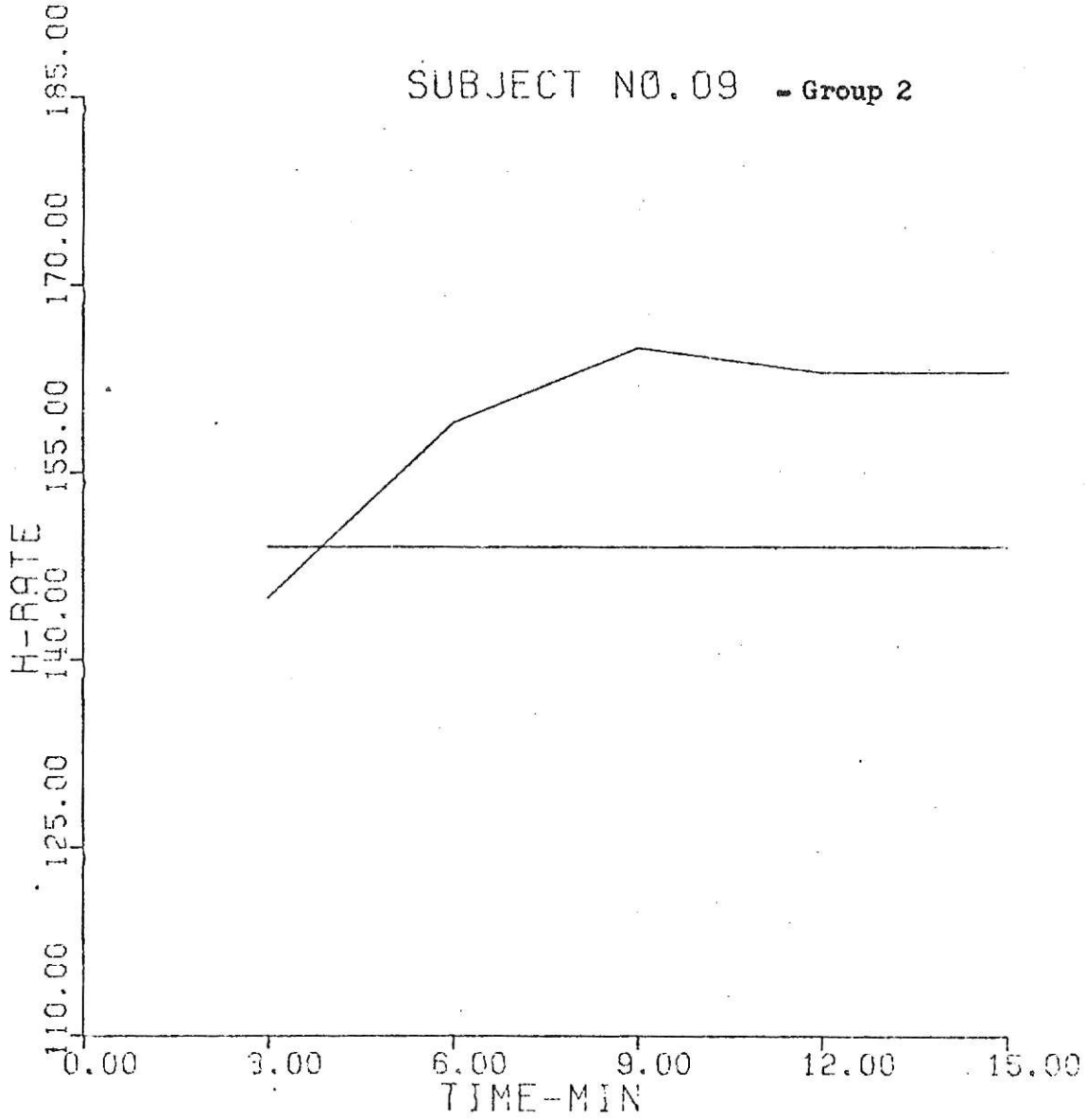
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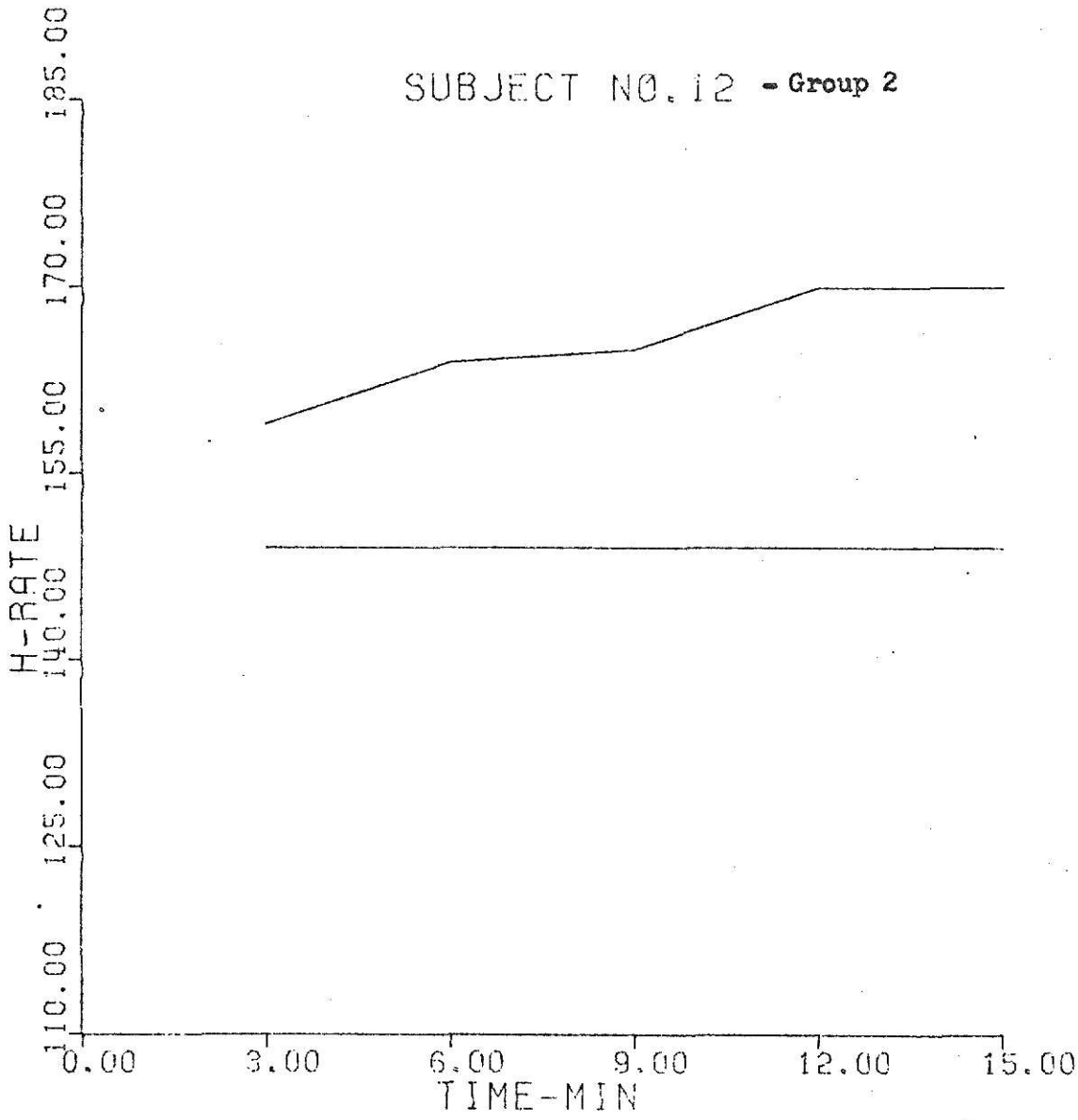
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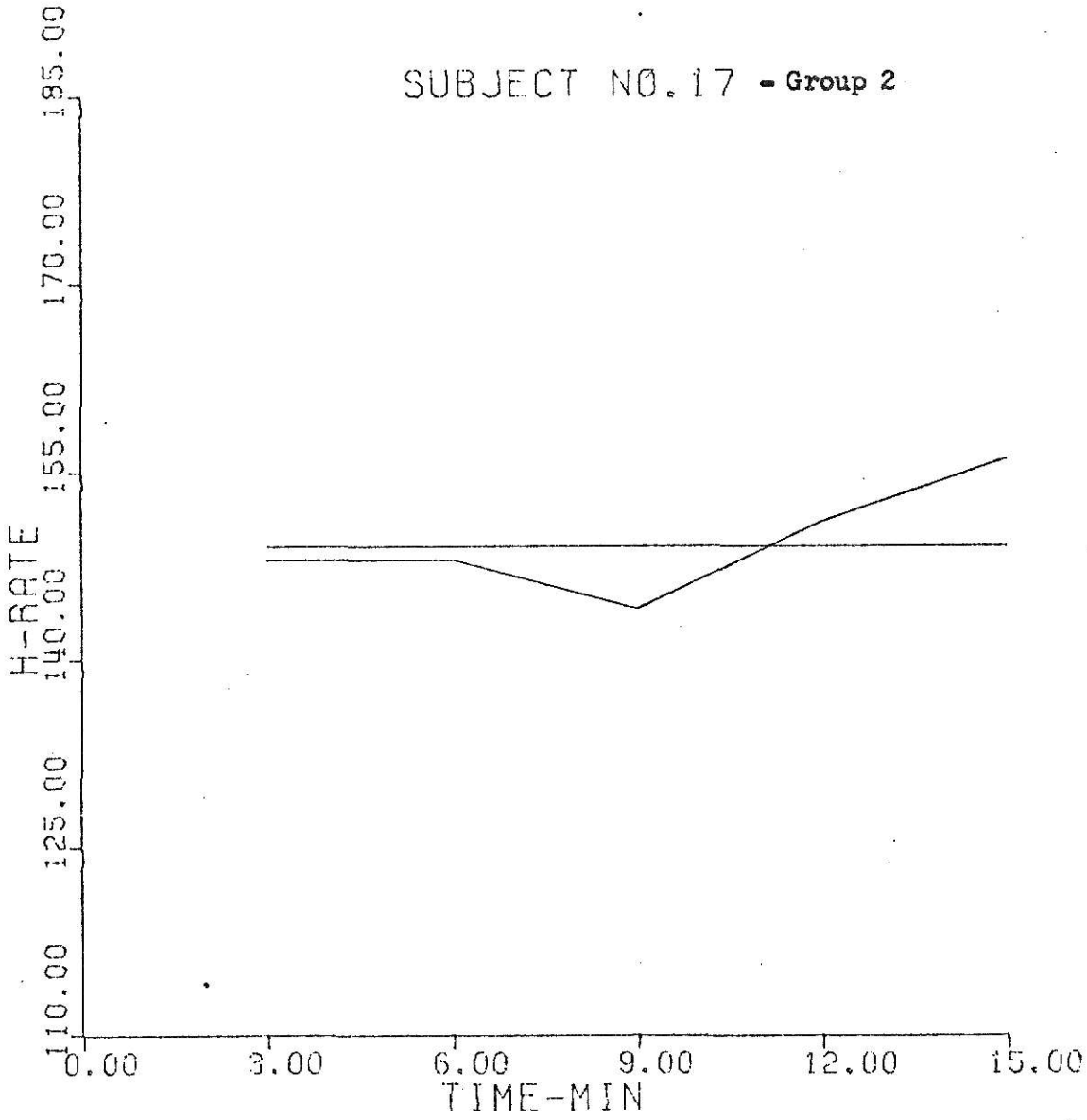
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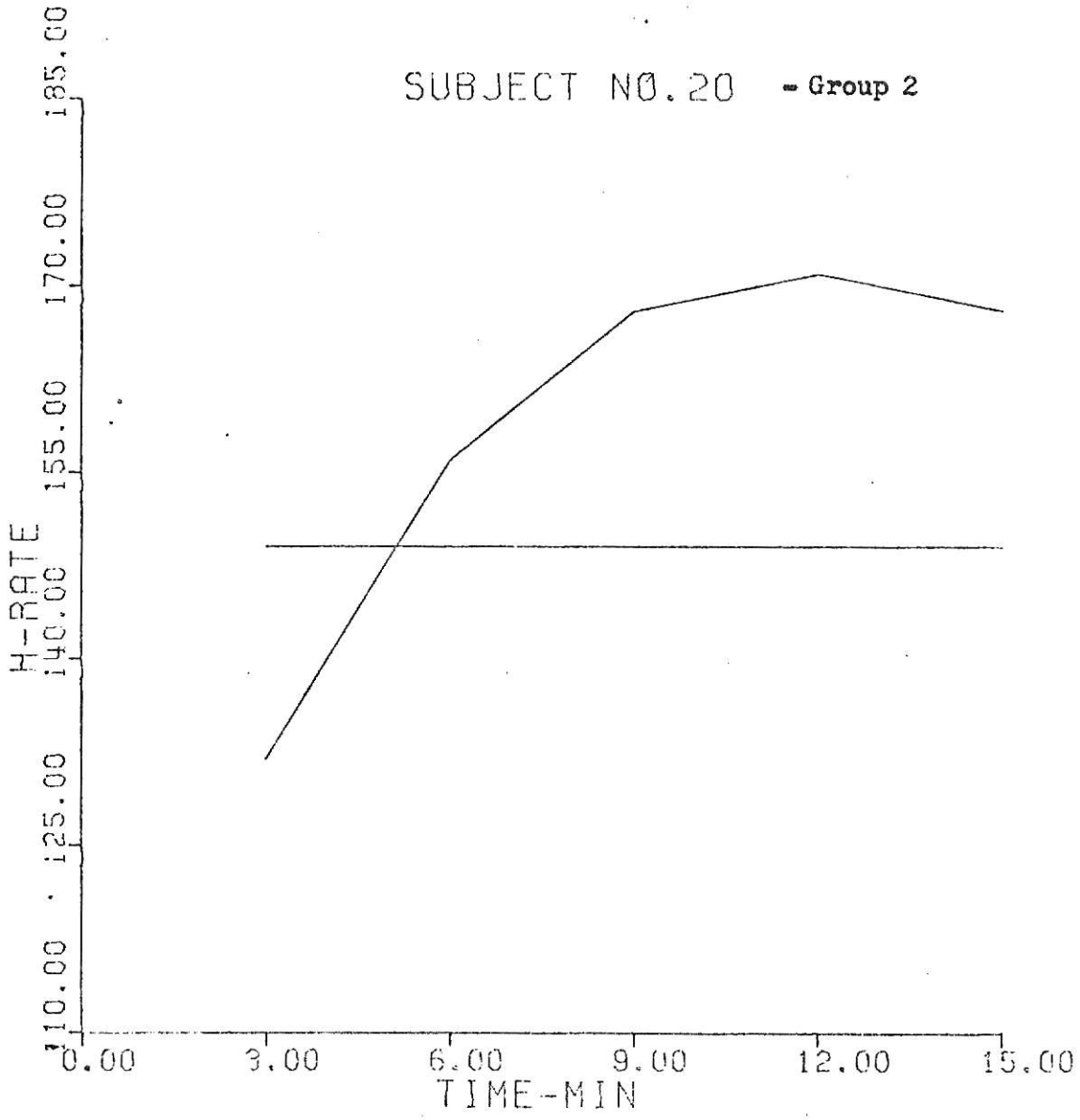
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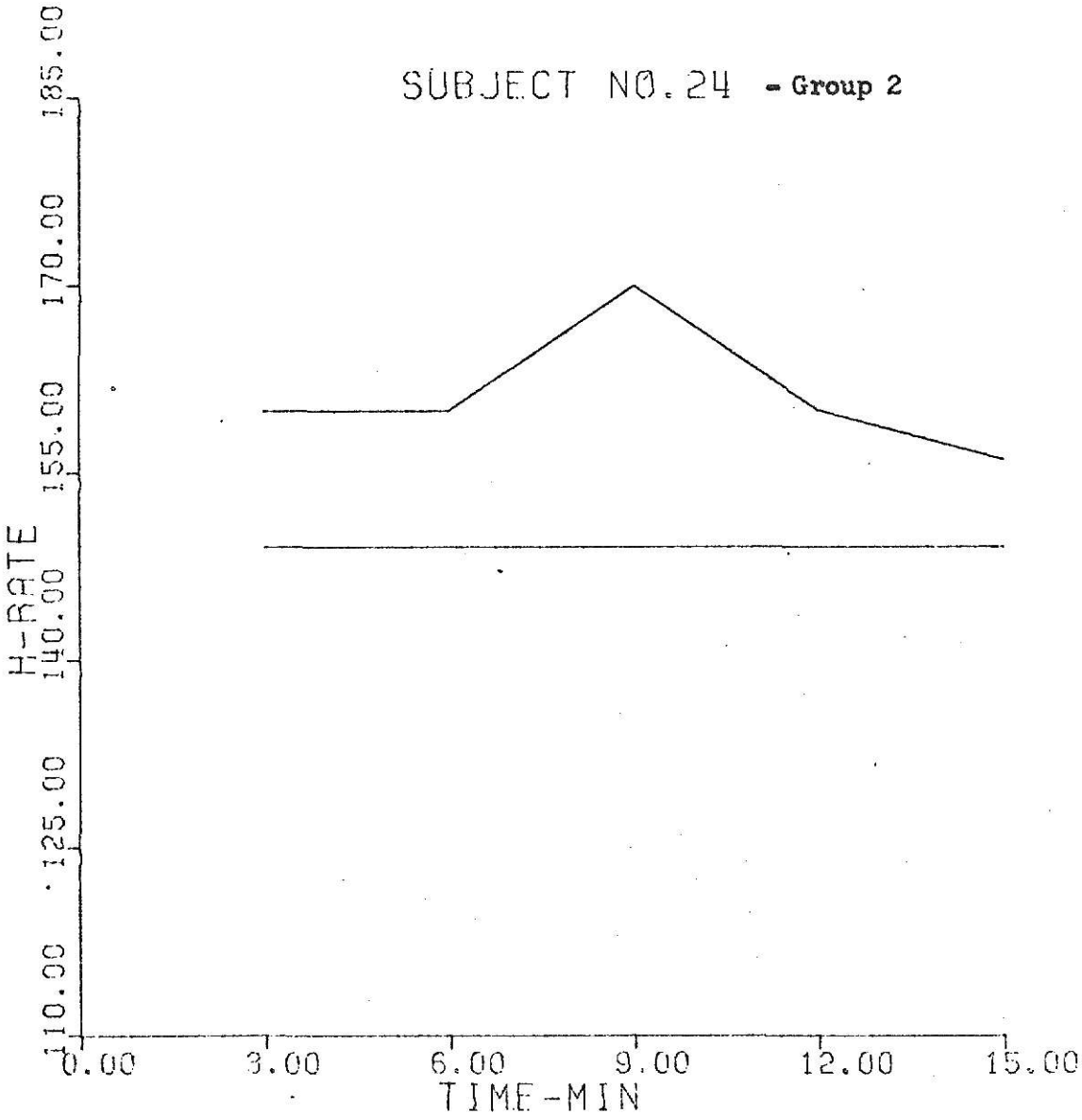
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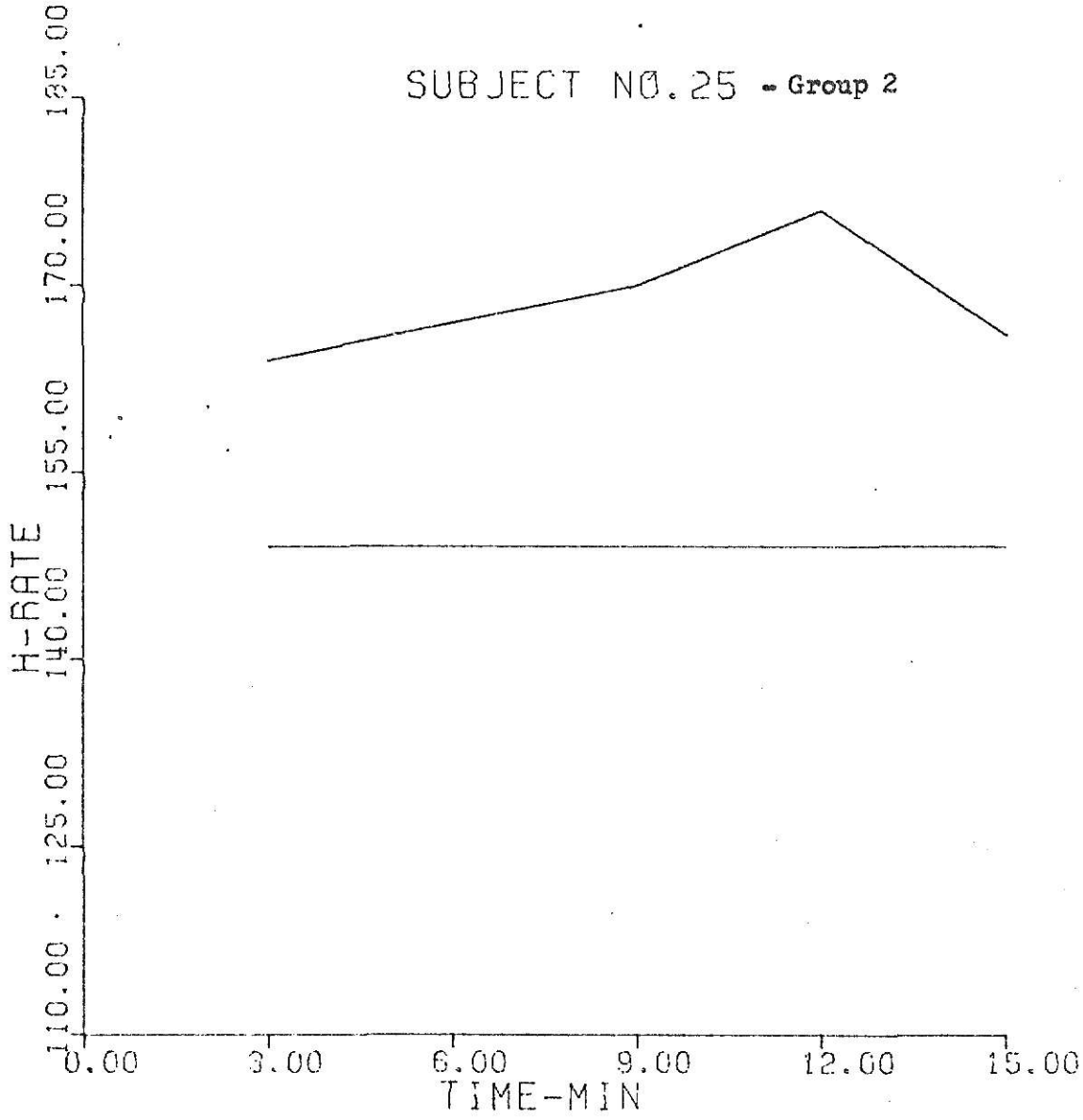
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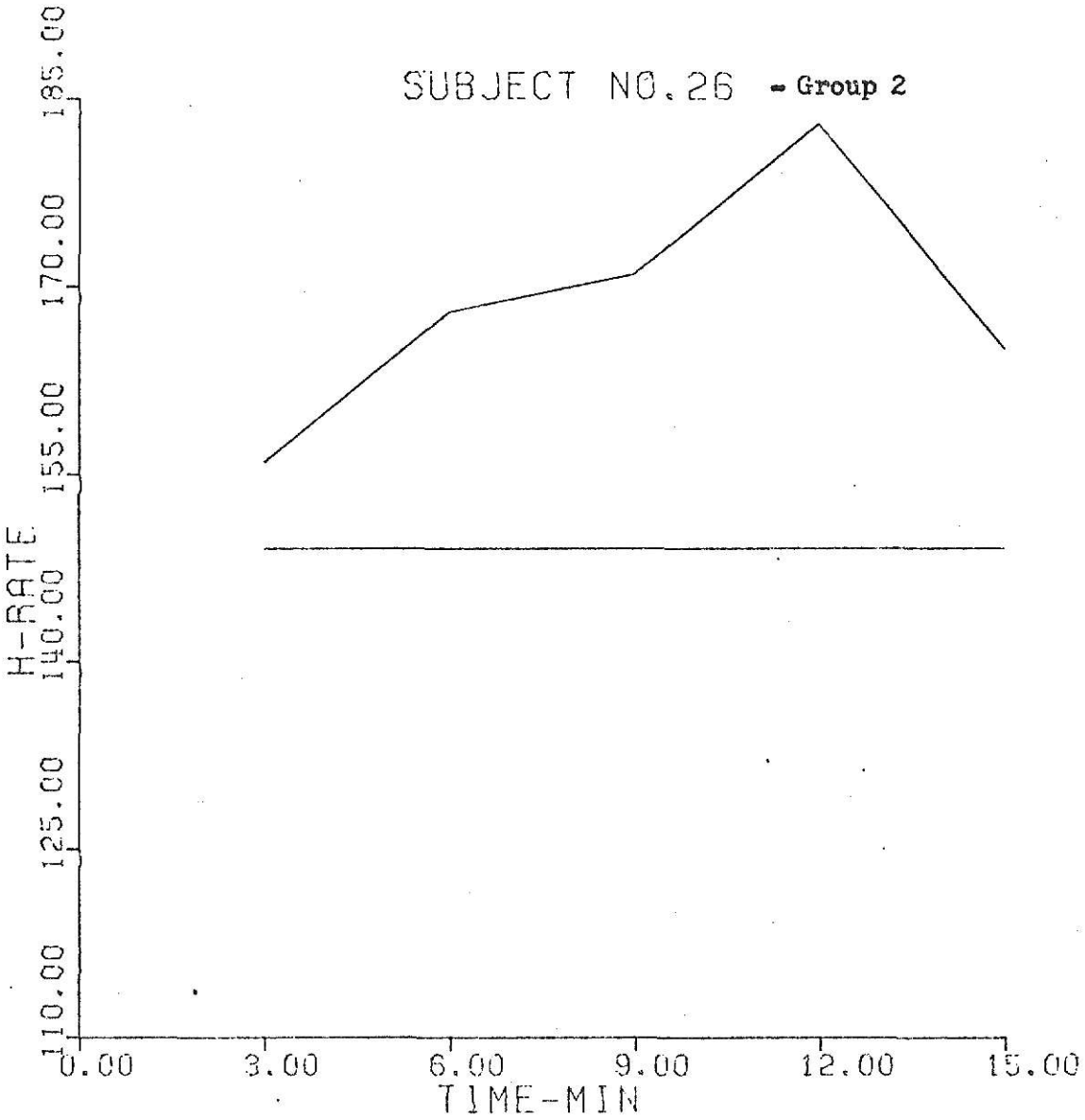
15.00
TIME-MIN


SUBJECT NO. 26 - Group 2
H-RATE
110.00
125.00
140.00
155.00
170.00
185.00
0.00
3.00
6.00
9.00
12.00
15.00
TIME-MIN

APPENDIX C

GROUP MEAN AND STANDARD DEVIATION FOR THE VARIABLES

ESTIMATED MAX. VO_2 SCORES

Group No.	Means	Standard deviation
1	47.11	4.78
2	37.40	4.08

MOTIVATIONAL SCORES

Group No.	Means	Standard deviation
1	20.88	3.05
2	21.50	3.80

AGE

Group No.	Means	Standard deviation
1	30.11	6.00
2	30.90	4.93

WEIGHT SCORES

Group No.	Means	Standard deviation
1	123.55	16.62
2	140.10	25.93

TIME IN PROGRAM

Group No.	Means	Standard deviation
1	6.66	5.00
2	9.00	5.35

AVERAGE H.R.

Group No.	Means	Standard deviation
1	160.59	10.32
2	162.89	6.90

PERCENT OF TIME AT THRESHOLD LEVEL

Group No.	Means	Standard deviation
1	.89	.14
2	.94	.07

APPENDIX D

ANALYSIS OF VARIANCE FOR THE VARIABLES INVESTIGATED

ESTIMATED MAX. VO_2 SCORES

	df	ss	ms	f	p
Treatment	1	446.71	446.71	22.78	.0001
Within	17	333.28	19.60		
Total	18	80.00			

MOTIVATIONAL SCORE

	df	ss	ms	f	p
Treatment	1	1.76	1.76	0.14	.70
Within	17	205.38	12.08		
Total	18	207.15			

AGE

	df	ss	ms	f	p
Treatment	1	2.94	2.94	0.09	.75
Within	17	507.78	29.86		
Total	18	510.73			

WEIGHT SCORES

	df	ss	ms	f	p
Treatment	1	1296.56	1296.56	2.6	0.12
Within	17	8267.12	486.30		
Total	18	9563.68			

TIME IN PROGRAM

	df	ss	ms	f	p
Treatment	1	25.78	25.78	.95	.14
Within	17	457.99	26.94		
Total	18	483.78			

AVERAGE H.R.

	df	ss	ms	f	p
Treatment	1	14.59	14.59	.25	.62
Within	17	987.82	58.10		
Total	18	1002.42			

PERCENT OF TIME AT THRESHOLD

	df	ss	ms	f	p
Treatment	1	.01	.01	1.19	.28
Within	17	.21	.01		
Total	18	.22			

EVALUATION OF THE HEART RATE RESPONSE OF WOMEN IN AN ADULT FITNESS PROGRAM

by

MARY LOUISE HASKER MORGAN

A. B., Kansas Wesleyan University, 1970

AN ABSTRACT OF A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Health, Physical Education and Recreation

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1973

The purpose of this investigation was to study the heart rate responses of nineteen female volunteers who were participating in Kansas State's adult fitness program. Specifically the study was to determine (1) if the intensity of the exercises was sufficient for a threshold of training, (2) if the intensity was at threshold value, the amount of time it was maintained, and (3) to compare the heart rate responses of high and low fitness groups. The heart rate responses were compared to the following variables: estimated maximal VO_2; motivation score; age; weight; amount of time in program; heart rate intervals for 1-3, 4-6, 7-9, 10-12, and 13-15 minutes; average heart rate; and the per cent of time the heart rates were above assumed threshold value of 148 beats per minute for the group. The Astrand-Rhyming Test was used to divide the sample into two groups so that a comparison of the heart rates of motivational levels were determined by a questionnaire and used to study effect of different motivation on intensity as reflected by heart rates. Each subject's heart rate was telemetered and recorded using a physiograph during one fifteen minute exercise session. From the data collected, the heart rates were studied to determine what relationship existed between variables. A correlation matrix revealed a significant interrelationship between all the heart rate intervals, average heart rate and per cent of time above the threshold level. An ANOVA was calculated to see if a difference existed between the two groups studied on all the variables with the exception of the 5 heart rate intervals which were analyzed using a repeated measure ANOVA. The only significant difference was found between the mean scores for estimated maximal VO_2. The data showed that this exercise program produced an average heart rate of 161 beats per minute and that the subjects were at threshold level 92 per cent of the time. It was

therefore concluded that the variety and sequence of the exercises involved in this self-regulation program were considered adequate to provide for cardiovascular improvements without being dangerous to the less fit participants.