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A Comparison of Reaction Times of High and Low Level Fitness Groups Before, During and After Treadmill Exercise

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A COMPARISON OF REACTION TIMES OF HIGH AND LOW LEVEL FITNESS GROUPS BEFORE, DURING AND AFTER TREADMILL EXERCISE

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BY

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CHAPTER I

INTRODUCTION

There are instances when it appears that individuals who are participating in vigorous physical activity, seem to lose the ability to react with the quickness they displayed at the start of the activity. It also appears that some persons maintain the ability to react quickly for a longer duration of time than others.

In athletics, the coach stresses the importance of quick reaction. Drills are constructed and practiced in an effort to develop and maintain quick reactions among athletes. Although many coaches have agreed that reacting quickly is advantageous in the physical activities of today, few have thoughts concerning the maintainance of quick reaction time of the athlete throughout the duration of the activity.

Little has been said about reaction time during exercise. Most studies to date have dealt with reaction time during a resting state or after a certain bout of exercise.

Purpose of the Study

The primary purpose of the study was to compare the mean reaction times of subjects at various work loads.

In addition, the mean reaction time of subjects with low levels of physical fitness was compared to the mean reaction time of subjects with high levels of physical fitness, at specified work loads.

Need for the Study

The study provided data pertaining to reaction time during exercise. There is also a need to determine if the physical fitness of a person is a factor in maintaining a rapid reaction time under stress.

The need for this study is accentuated by the lack of existing literature concerning reaction times during exercise.

Null Hypotheses

The reaction time of an individual does not digress as the work load increases and the person tires. Physical fitness is not a factor in maintaining rapid reaction time during a bout of exercise.

Delimitations of the Study

The study was limited to 30 college students attending Eastern Illinois University. Because of time and availability the subjects were given only one physical fitness test and one test of reaction time at the specified work loads.

Definition of Terms

1. High level of physical fitness (H.L.P.F.) -

Those subjects with physical fitness index scores in the upper 50 percent of those taking the treadmill test.

2. Low level of physical fitness (L.L.P.F.) - Those subjects with physical fitness index scores in the lower 50 percent of those taking the treadmill test.
3. Specified work load - The speed and grade at which the treadmill was set during the bout of exercise.
4. Reaction time - The time the subject took, after hearing the audio stimulus, to press the stop button which was in contact with the index finger.

CHAPTER II

REVIEW OF RELATED LITERATURE

Numerous investigations have been conducted concerning reaction and movement time. The literature reviewed is divided into four major areas: I. Variables that May Influence Reaction Time, II. Reaction Time of Athletes Versus Non-athletes, III. Reaction Time and Movement Time, and IV. Reaction Time and Exercise.

I. Varibles that May Influence Reaction Time

There exists a number of studies concerning factors that may influence reaction time. These studies indicate that reaction time may differ under varied conditions.

In a study by Munro,[1] sixty males took part in a ball snatch test. It was found that varying the fore-period (the time between the ready signal and the beginning of the stimulus) between two, three and four seconds did not influence the speed of response.

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[1]Sandford J. Munro, "The Retention of the Increase in Speed of Movement Transferred from a Motivated Simpler Response," Research Quarterly, 22:233, May, 1951.

Woodworth[2] stated that a foreperiod of two seconds was optimum for a quick reaction.

It was also reported by Garrett[3] that the optimum foreperiod was between one and four seconds.

Teichner,[4] in a review of completed studies concerning reaction time concluded that the optimum foreperiod for rapid reaction time was in a range between 1.5 and 8.0 seconds. Its placement in this range being dependent on a large number of factors including the duration and intensity of the warning signal and of the stimulus, the amount, and time of production of muscular tension.

Wilson,[5] in a study of rhythmic and non-rhythmic presentation of the stimulus found that individuals reacted faster when potential stimuli were presented in rhythmic rather than non-rhythmic series.

Studies by Colgate[6] and Garrett[7] agreed that

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[2]Robert Woodworth, Experimental Psychology (New York: Henry Holt Co., 1947), p. 314.

[3]Henry E. Garrett, Great Experiments in Psychology (New York: D. Appleton-Century Co., 1932), p. 210.

[4]Warren H. Teichner, "Recent Studies of Simple Response Time," Psychological Bulletin, 51:144, 1954.

[5]Donald J. Wilson, "Quickness of Reaction and Movement Related to Rhythmicity of Signal Presentation," Research Quarterly, 30:109, March, 1959.

[6]Thomas P. Colgate, "Reaction and Response Times of Individuals Reacting to Auditory, Visual, and Tactile Stimuli," Research Quarterly, 39:784, October, 1968.

[7]Garrett, op. cit., p. 208.

reaction to an audio stimulus was faster than light-stimulus reaction times.

Forbes[8] studied the effect of certain variables on visual and auditory reaction time. He found that there was a significant increase in reaction time to sound with age, but a low correlation between age and light. A full stomach slowed reaction time to sound, but had no effect on the reaction time to the visual stimulus.

The work of Gould and Dye,[9] Garrett,[10] Woodworth,[11] and McCurdy and Larson[12] indicated that practice had an effect on reaction time.

Forbes[13] stated that practice brought about no improvement in reaction time.

In a similar study by McCormick and others[14] it was found that quick reaction times were sustained over longer periods if the subject was given knowledge of

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[8] Gilbert Forbes, "The Effects of Certain Variables on Visual and Auditory Reaction Time," Journal of Experimental Psychology, 35:161, 1945.

[9] A. D. Gould and J. A. Dye, Exercise and Its Physiology (New York: S. S. Barnes & Co., 1932), p. 68.

[10] Garrett, op. cit., p. 211.

[11] Woodworth, op. cit., p. 332.

[12] J. H. McCurdy and L. A. Larson, Physiology of Exercise (Philadelphia: Lea and Febiger, 1939), p. 165.

[13] Forbes, loc. cit.

[14] P. C. McCormick, et al., "Effects on Reaction-Time of Knowledge of Results of Performance," Perceptual and Motor Skills, 14:372, 1962.

of the previous trial. This was substantiated in a second study.[15]

In other studies by Henry,[16] Fairclough,[17] Munro,[18] and Henry[19] it was agreed that it was possible to initiate quick responses to the stimulus by use of sensory motivators (bright light, sound, or shock).

Garrett[20] came to the conclusion that the effect of fatique upon reaction time was almost negligible.

Phillips[21] and Welch[22] also found that even at the point of considerable physical fatique the reaction

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[15]P. D. McCormick, et al., "Effects on Reaction-Time of Knowledge of Results of Performance," Perceotual and Motor Skills, 17:281, 1963.

[16]Franklin M. Henry, "Increase in Speed of Movement by Motivation and by Transfer of Motivated Improvement," Research Quarterly, 22:228, May, 1951.

[17]Richard H. Fairclough, "Transfer of Motivated Improvement in Speed of Reaction and Movement," Research Quarterly, 23:27, March, 1952.

[18]Sandford J. Munro, "The Retention of the Increase in Speed of Movement Transferred from a Motivated Simpler Response," Research Quarterly, 22:233, May, 1951.

[19]Franklin M. Henry, "Independence of Reaction and Movement Time and Equivalence of Sensory Motivators of Faster Responses," Research Quarterly, 23:53, March, 1952.

[20]Henry E. Garrett, Great Experiments in Psychology (New York: D. Appleton-Century Co., 1932), p. 212.

[21]William H. Phillips, "Influence of Fatiquing Warm-Up Exercises on Speed of Movement and Reaction Latency," Research Quarterly, 34:380, October, 1963.

[22]Marya Welch, "Specificity of Heavy Work Fatique: Absence of Transfer from Heavy Leg Work to Coordination Tasks Using the Arms," Research Quarterly, 40:406, May, 1969.

time of the subjects did not exhibit a significant change.

Forbes[23] and Edwards[24] measured fatique by hours since the person aroused from sleep. Waking hours ranged from 21½ to 100 hours. It was concluded that fatique had no relationship to auditory reaction time.

McFarland[25] investigated the effects of oxygen deprivation (anoxemia) on reaction time. One hour of breathing 9.05 percent oxygen had no statistically significant effect on simple reaction time. It was found that simple responses of this kind were not markedly impaired until the subject approached collapse. It was suggested that a simple response of this type became largely habitual or less complex in function and less dependent on the cerebral cortex.

Elbel[26] reported that even though the subjects complained of a marked sense of fatique, the responses after athletic competition were an improvement over the before exercise readings. It was suggested that in

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[23]Gilbert Forbes, "The Effects of Certain Variables on Visual and Auditory Reaction Time," Journal of Experimental Psychology, 35:161, 1945.

[24]A. S. Edwards, "Effects of the Loss of 100 Hours of Sleep," American Journal of Psychology, 54:91, 1941.

[25]Ross A. McFarland, "The Psychological Effects of Oxygen Deprivation (Anoxemia) on Human Behavior," Archives of Psychology, 22:145, 1932.

[26]E. R. Elbel, "A Study of Response Time Before and After Strenuous Exercise," Research Quarterly, 11:95, May, 1940.

competitive exercise an emotional component arose which may have been an influencing factor in the reduction of responsive time.

The work of McCurdy and Larson[27] and Gould and Dye[28] stated that reaction time was lengthened by fatique.

II. Reaction Time of Athletes Versus Non-athletes

Existing studies concerning reaction time of athletes and non-athletes indicate that athletes respond quicker than non-athletes.

In a study by Younger[29] 122 women athletes and non-athletes were given a hand reaction time test. It was found that the women athletes were significantly faster than the women non-athletes in reaction time.

Beise and Peaseley,[30] and Knapp[31] in similar studies also concluded that the women athletes reacted quicker than non-athletic women.

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[27]J. H. McCurdy and L. A. Larson, Physiology of Exercise (Philadelphia: Lea and Febiger, 1939), p. 68.

[28]A. D. Gould and J. A. Dye, Exercise and Its Physiology (New York: S. S. Barnes & Co., 1932), p. 165.

[29]Lois Younger, "A Comparison of Reaction and Movement Times of Women Athletes and Non-athletes," Research Quarterly, 30:349, October, 1959.

[30]Dorothy Beise and Virginia Peaseley, "The Relation of Reaction Time, Speed, and Agility of Big Muscle Groups to Certain Sport Skills," Research Quarterly, 8:133, March, 1937.

[31]Barbara N. Knapp, "Simple Reaction Times of Top-Class Sportsmen and Research Students," Research Quarterly, 32:409, October, 1961.

It was reported by Slater-Hammel[32] that varsity athletes had significantly shorter over-all reaction time than physical education, music and liberal arts majors.

Buckellew,[33] in investigating peripheral perception and reaction time concluded that five athletic groups (football players, basketball players, baseball players, track athletes, and gymnasts) were all faster than the non-athlete group.

Studies by Jackson[34] Olsen[35] also agreed that athletes were able to react quicker than non-athletes.

Contrary to the preceeding reports Pierson[36] found that fencers and non-fencers did not differ in discriminatory or simple reaction time when measured by the finger press method.

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[32]A. T. Slater-Hammel, "Comparisons of Reaction-Time measures to a Visual Stimulus and Arm Movement," Research Quarterly, 26:470, December, 1955.

[33]William F. Buckellew, "Peripheral Perception and Reaction Time of Athletes and Non-athletes," (unpublished Master's thesis, University of Illinois, 1962).

[34]Willie C. Jackson, "Explosive Muscular Power, Reaction Time, and Running Speed Within and Between College Athletes and Non-athletes," (unpublished Master's thesis, Eastern Illinois University, 1971)

[35]Einer A. Olsen, "Relationship Between Psychological Capacities and Success in College Athletics," Research Quarterly, 27:79, March, 1956.

[36]William R. Pierson, "Comparison of Fencers and Non-fencers by Psychomotor, Space Perception and Anthropometric Measure," Research Quarterly, 27:90, May, 1956.

III. Reaction Time and Movement Time

At one time it was assumed that individuals who reacted the fastest were the same people who moved the fastest. Research disproving this theory is quite abundent.

In studies involving 12 and 13-year-old boys Clarke and Glines[37] and Mendryk[38] found no significant correlation between movement time and reaction time.

Nine hundred and thirty men, women, and children were tested by Hodgkins.[39] He concluded that men are both faster reactors and movers than women. There was no significant relationships between reaction time and movement time for the men or women tested.

Hipple[40] conducted a study concerning racial differences in tension, reaction time and speed of movement among athletes. The results showed no statistically significant difference between Caucasian and Negroes in

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[37] Harrison H. Clarke and Don Glines, "Relationships of Reaction, Movement and Completion Times to Motor, Strength, Anthropometric, and Maturity Measures of 13-Year-Old Boys," Research Quarterly, 33:194, May, 1962.

[38] Stephen Mendryk, "Reaction Time, Movement Time, and Task Specificity Relationships at Age 12, 22, and 48 Years," Research Quarterly, 31:162, May, 1960.

[39] Jean Hodgkins, "Reaction Time and Speed of Movement in Males and Females of Various Ages," Research Quarterly, 34:335, October, 1963.

[40] Joseph E. Hipple, "Racial Differences in the Influence of Motivation on Muscular Tension Reaction Time, and Speed of Movement," Research Quarterly, 25:305, October, 1954.

reaction time and movement time.

Using undergraduate students, Henry,[41] Fairclough,[42] and Smith[43] found reaction time and movement time independent and uncorrelated.

Measuring athletes and non-athletes, Pierson[44] reported that neither group demonstrated significantly related speed of arm movement and reaction times.

Henry[45] found reaction time uncorrelated with speed in sprint races. He substantiated this finding in later studies.[46] [47]

The following three studies are not in agreement with the conclusions of the previous investigators.

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[41]Franklin M. Henry, "Independence of Reaction and Movement Time and Equivalence of Sensory Motivators of Faster Response," Research Quarterly, 23:53, March, 1952.

[42]Richard H. Fairclough, "Transfer of Motivated Improvement in Speed of Reaction and Movement," Research Quarterly, 23:27, March, 1952.

[43]Leon E. Smith, "Reaction Time and Movement Time in Four Large Muscle Movements," Research Quarterly, 32:88, March, 1961.

[44]Pierson, loc cit.

[45]Franklin M. Henry, "The Velocity Curve of Sprint Running with Some Observations on the Muscle Viscosity Factor," Research Quarterly, 22:409, December, 1951.

[46]Franklin M. Henry, "Force-Time Characteristics of the Sprint Start," Research Quarterly, 23:301, October, 1952.

[47]Franklin M. Henry, Time-Velocity Equation and Oxygen Requirements of 'All-Out' and 'Steady-Pace' Running," Research Quarterly, 25:177, May, 1954.

Four hundred subjects ranging from eight to 83 years of age were studied by Pierson.[48] He reported a statistically significant correlation ($r = +.56$) between reaction time and movement time.

Jackson,[49] in a study of explosive muscular power, reaction time, and running speed found reaction time and movement time to be correlated. However, he also suggested that due to the very low intensity of the audio stimulus these findings may have been invalid.

It was concluded by Pierson and Rasch[50] that there was a low, but statistically significant relationship between reaction time and movement time ($r = 0.33$).

IV. Reaction Time and Exercise

Relatively few studies dealing with exercise and reaction time were found while no reports were discovered concerning reaction time during exercise.

The reaction time of forty male volunteers was

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[48]William R. Pierson, "The Relationship of Movement Time and Reaction time from Childhood to Senility," Research Quarterly, 30:231, May, 1959.

[49]Willie C. Jackson, "Explosive Muscular Power, Reaction Time, and Running Speed Within and Between College Athletes and Non-athletes," (unpublished Master's thesis, Eastern Illinois University, 1971).

[50]William R. Pierson and Philip Rasch, "Generality of a Speed Factor in Simple Reaction and Movement Time," Perceptual and Motor Skills, 11:123, 1960.

studied by King.[51] It was determined that during continuous arm movements at rates of 75 and 135 revolutions per minute, reaction times during the faster rate were significantly slower than those during the slower rate of arm movement.

In a study by Tweit and others,[52] 26 low fitness subjects trained for 30 minutes, four times a week. It was concluded that total body reaction time was improved by training.

Meyers and others[53] reported that no statistically significant relationship existed between the level of cardiovascular function, as measured by the step test, and foot or finger reaction time.

The work of Phillips[54] concluded that reaction time was not influenced by heavy warm-up exercises that did improve speed of movement. Futhermore, reaction time influenced by activities that were carried on to a point of considerable fatique.

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[51] Peter G. King, "Reaction Time During Two Rates of Continuous Arm Movement," Research Quarterly, 39:308, May, 1968.

[52] A. H. Tweit, et al., "Effect of a Training Program on Total Body Reaction Time of Individuals of Low Fitness," Research Quarterly, 34:370, October, 1963.

[53] Carton R. Meyers, et al., "Effects of Strenuous Physical Activity Upon Reaction Time," Research Quarterly, 40:337, May, 1959.

[54] William H. Phillips, "Influence of Fatiquing Warm-Up Exercises on Speed of Movement and Reaction Latency," Research Quarterly, 34:378, October, 1963.

Welch[55] also supported the previous findings when he reported that performing very heavy and fatiquing work with the legs did not impair performance in motor coordination, speed, and accuracy tasks.

Using the finger as the responding member, Elbel[56] found that stoolstepping and pushups caused no significant change in response time.

McCurdy and Larson[57] reported that light physical exercise resulted in an improvement in reaction time to the audio stimulus, but that severe physical exercise resulted in a decrease in reaction time to the audio stimulus which was more marked, as the severity of the exercise was increased.

Summary

The studies cited seem to indicate the following: (1) Reaction time is dependent on a number of intrinsic and extrinsic variables; (2) Generally, the reaction time of athletes is significantly faster than non-athletes; (3) In the majority of studies conducted there was not a statistically significant relationship between reaction

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[55]Marya Welch, "Specificity of Heavy Work Fatique: Absence of Transfer from Heavy Leg Work to Coordination Tasks Using the Arms," Research Quarterly, 40:406, May, 1969.

[56]E. R. Elbel, "A Study of Response Time Before and After Strenuous Exercise," Research Quarterly, 11:95, May, 1940.

[57]J. H. McCurdy and L. A. Larson, Physiology of Exercise (Philadelphia: Lea and Febiger, 1939), p. 165.

time and movement time; (4) There exist some controversy concerning the effect of exercise and fatique on reaction time. It is also apparent that there is a definite lack of information dealing with reaction time during a bout of exercise.

CHAPTER III

METHODOLOGY

In order to provide an accurate account of the methodology used in the collection of data, a description of the subjects, test equipment and procedure employed are presented in this chapter.

Subjects

The subjects were 30 undergraduate students at Eastern Illinois University. Ten volunteers were from the varsity track team and 20 of the volunteers were students not participating in spring varsity athletics. Each subject was placed into one of two groups--high level of physical fitness (H.L.P.F.) or low level of physical fitness (L.L.P.F.) as described earlier. The mean height and weight for the H.L.P.F. Group was 178.5 centimeters and 74.2 kilograms respectively. The mean Physical Fitness Index of the group was 101.0. Subjects in the L.L.P.F. Group had a mean height of 182.5 centimeters, a mean weight of 96.5 kilograms, and a mean Physical Fitness Index of 43.4.

Design of Study

The researcher and each subject met on two sepa-

rate days in the Physical Education Research Laboratory at Eastern Illinois University. After filling out the necessary information on a data card, the subject was given an orientation to the DeKan Automatic Performance Analyzer and the A. R. Young Treadmill. The subject was then administered the Johnson Treadmill Test for Physical Fitness as described by Consolarizo[1]. Recovery heart rates were used to compute the Physical Fitness Index score from the following formula[2]:

$$PFI = \frac{\text{(seconds the subject ran)} \times 100}{2 \times \text{sum of 3 half-min. recovery pulse rates}}$$

Each subject was placed into either the H.L.P.F. Group or the L.L.P.F. Group according to his computed Physical Fitness Index score.

The reaction time test during exercise was administered at the second meeting. The purpose of this test was to determine the reaction time of the subject at rest, during a bout of exercise and in recovery.

Orientation and Physical Fitness

In the first meeting each volunteer received a period of orientation to the DeKan Automatic Performance Analyzer and the treadmill.

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[1]C. Frank Consolazio, Robert E. Johnson and Louis J. Pecora, Physiological Measurements and Metabolic Functions in Man (New York: McGraw-Hill Book Co., 1963), p. 368.

[2]Ibid., p.369.

Orientation to DeKan Timer. Each subject was administered 50 reaction time trials to diminish any practice effect and acclimate the subject to the test situation. The subject was seated on a stool with the reaction time stop button in the dominant hand. The distal end of the index finger was placed in contact with the stop button. Prior to each trial, the researcher gave the command "ready" before pressing a delayed start button on the DeKan Timer. Two to five seconds elasped before the audio stimulus sounded and the clock started. Upon hearing the audio stimulus the subject pressed down on the stop button and stopped the clock. Concentration on the audio stimulus and quick reaction to this stimulus were emphasized.

Orientation to Treadmill Running. The orientation run on the treadmill was presented in four stages. The subject placed both hands on the support bar and the treadmill was set at three miles per hour and zero percent grade. The subject walked at this rate until he felt confident. Then he was instructed to drop one hand at a time until he felt he was able to walk comfortably without the aid of the support bar.

For the second stage of the orientation run, the grade of the treadmill was raised in progressions of two percent each until a maximum of ten percent was reached. At each grade, the subject was given time to acclimate himself to the new work load.

During the third stage of the orientation the grade was lowered to zero percent. The speed was increased at increments of one mile per hour until a speed of seven miles per hour was attained. The subject was allowed sufficient time to become accustomed to each increase in speed.

The final stage consisted of taking 15 reaction time practice trials while running at seven miles per hour and zero percent grade. Concentration on the audio stimulus and quick reaction to this stimulus were again emphasized. At the end of the 15 trials the treadmill was stopped.

Johnson Treadmill Test for Physical Fitness. Upon completion of the orientation session, the subject was seated on a stool on the treadmill. After resting five minutes the subject was asked to stand and the stool was taken away. He was informed that the physical fitness test would last five minutes, but if he should become too fatigued the test would be terminated and the total time of the run recorded. At the end of five minutes the treadmill was stopped and the subject again seated on the stool. He was told to sit quietly, relax, and not to talk. A towel was made available to wipe perspiration and after one minute of rest a 30 second heart rate was recorded. The researcher placed two fingers on the neck of the subject in proximity of the carotid artery. While watching the clock he counted the heart beats to himself.

Thirty second heart rates were also recorded from 2.0 to 2.5 minutes and 4.0 to 4.5 minutes into recovery.

Reaction Time Test at Rest, During, and in Recovery from Treadmill Run

Upon arriving at the research laboratory for the second meeting, the subject was seated on a stool and given the stop button. Twenty-five practice trials of reaction were administered at rest.

Sixteen trials of reaction time at rest were administered to the subject. The stool was taken away. The treadmill was set at six miles per hour and two percent grade. With the starting of the treadmill the subject began running. Sixteen trials were given during the first two minutes of running and every two minutes thereafter. Correspondingly the treadmill was raised four percent every two minutes. After running two minutes at the grade of ten percent the treadmill was stopped and the subject was again seated on the stool. A towel was provided and the subject was asked to remain quiet. After one minute of recovery the final 16 trials were administered. Concentration on the audio stimulus and quick reaction to this stimulus were emphasized.

In the event the subject pressed the stop button before the audio stimulus sounded, the trial was not counted and an additional trial administered. To arrive at a true estimate of reaction time for each series of responses, the slowest three responses and the fastest

three responses were eliminated in computing the mean reaction time.

CHAPTER IV

ANALYSIS OF THE DATA

The study was conducted to compare the reaction times of 30 college students at rest, during a bout of exercise, and in recovery from the exercise. In addition, the mean reaction times of the subjects in the High Level of Physical Fitness Group were compared to the mean reaction times of the subjects in the Low Level of Physical Fitness Group, at each of the specified work loads.

Statistical Treatment

A *t* test for correlated data was applied to determine any statistical difference within group means.

A *t* test for uncorrelated data was applied to determine any statistical difference between the group means.

The raw data was punched on I.B.M. computer cards. The *t* test programs by DiPietro and LeDuc,[1] and

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[1] A. J. DiPietro and R. J. LeDuc, "Student *t* Scores for Means Between Groups," (Charleston: Eastern Illinois University, May, 1964).

Crewell[2] were employed for the analysis. Both programs were made available through the services of the Eastern Illinois University Data Processing Center.

The .05 level of confidence was selected to denote statistically significant differences for both the correlated and uncorrelated data. Statistical significance for the correlated data necessitated *t* ratio equal to or greater than 2.14 for 14 degrees of freedom. For the uncorrelated data a *t* score equal to or greater than 2.04 for 28 degrees of freedom was required.

Presentation of Findings

The findings are presented under the following three headings: I. Comparisons Within the H.L.P.F. Group, II. Comparisons Within the L.L.P.F. Group, and III. Comparisons Between the H.L.P.F. Group and the L.L.P.F. Group.

I. Comparisons Within the H.L.P.F. Group. The comparisons of primary concern were those between the mean reaction time at rest and the mean reaction time during running at grades of two, six and ten percent, and also in recovery.

Table I reveals a statistically significant difference between the mean reaction time at rest and the

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[2] N. J. Crewell, "Student *t* Test for Differences Between Correlated Pairs of Means," (Charleston: Eastern Illinois University, June, 1972).

mean reaction time at the two (.01), six (.001), and the ten percent (.01) work levels respectively. There was also a statistically significant difference between the mean reaction time in recovery and the mean reaction time at the two (.01), six (.01), and ten percent (.05) work levels respectively.

TABLE I

MEAN AND t RATIO COMPARISONS WITHIN THE H.L.P.F. GROUP

Variable	Mean (Sec)	Rest	2%	6%	10%	Recovery
Rest	.146	___				
2%	.163	4.05[c]	___			
6%	.159	4.29[d]	1.43	___		
10%	.157	2.99[c]	1.61	.803	___	
Recovery	.147	.480	3.89[c]	4.02[c]	2.51[a]	___

[a]Significant at the .05 level of confidence.

[c]Significant at the .01 level of confidence.

[d]Significant at the .001 level of confidence.

It should be noted that the mean reaction time of the group was slowest at the two percent level, but became progressively faster although not significantly, at the six percent and the ten percent levels respectively. It is also noted that this group displayed no significant

difference between the mean reaction time at rest and the mean reaction time in recovery from the exercise.

II. Comparisons Within the L.L.P.F. Group. It is revealed in Table II that there existed a statistically significant difference (.001) between the mean reaction time at rest and the mean reaction time at the two, six, and ten percent work levels respectively. At the .001 level, there was also a statistically significant difference between the mean reaction time in recovery and the mean reaction time at the two percent, six percent, and ten percent levels respectively.

TABLE II

MEAN AND t RATIO COMPARISONS
WITHIN THE L.L.P.F. GROUP

Variable	Mean (Sec)	Rest	2%	6%	10%	Recovery
Rest	.152	—				
2%	.174	4.58[d]	—			
6%	.179	5.55[d]	1.30	—		
10%	.192	4.30[d]	2.55[a]	1.88	—	
Recovery	.154	.607	5.30[d]	5.89[d]	4.50[d]	—

[a]Significant at the .05 level of confidence.

[d]Significant at the .001 level of confidence.

The mean reaction times show (Table II) that during the bout of exercise this group was fastest at the two percent work level. The mean reaction time became slower at the six percent level. The mean reaction time at the ten percent work level was significantly slower than at the two percent level. There was no significant difference between the mean reaction time at rest and the mean reaction time in recovery.

III. Comparisons Between the H.L.P.F. Group and the L.L.P.F. Group. The two groups were compared at each of the five specified situations (three in exercise, and one each in rest and recovery). These findings are presented in Table III and Figure 1.

TABLE III

COMPARISON BETWEEN H.L.P.F. GROUP AND L.L.P.F. GROUP

Variable	H.L.P.F. Group Mean	S.D.	L.L.P.F. Group Mean	S.D.	t
Rest	.146	1.48	.152	2.14	.899
2%	.163	2.18	.174	2.67	1.21
6%	.159	1.59	.179	2.29	2.71[b]
10%	.157	2.14	.192	3.81	3.02[c]
Recovery	.147	1.23	.154	1.97	.110

[b]Significant at the .02 level of confidence.

[c]Significant at the .01 level of confidence.

The H.L.P.F. Group reacted faster than the L.L.P.F. Group in all five situations. However, only two of these comparisons, the six percent (.02) and ten percent (.01) work levels were statistically significant.

It should be noted that during the bout of exercise the difference in mean reaction times of the two groups became more pronounced with each increase in the work level.

Discussion of Findings

The writer feels that some of the findings presented warrant discussion. Since the purpose of the study was to measure effect and not to determine the

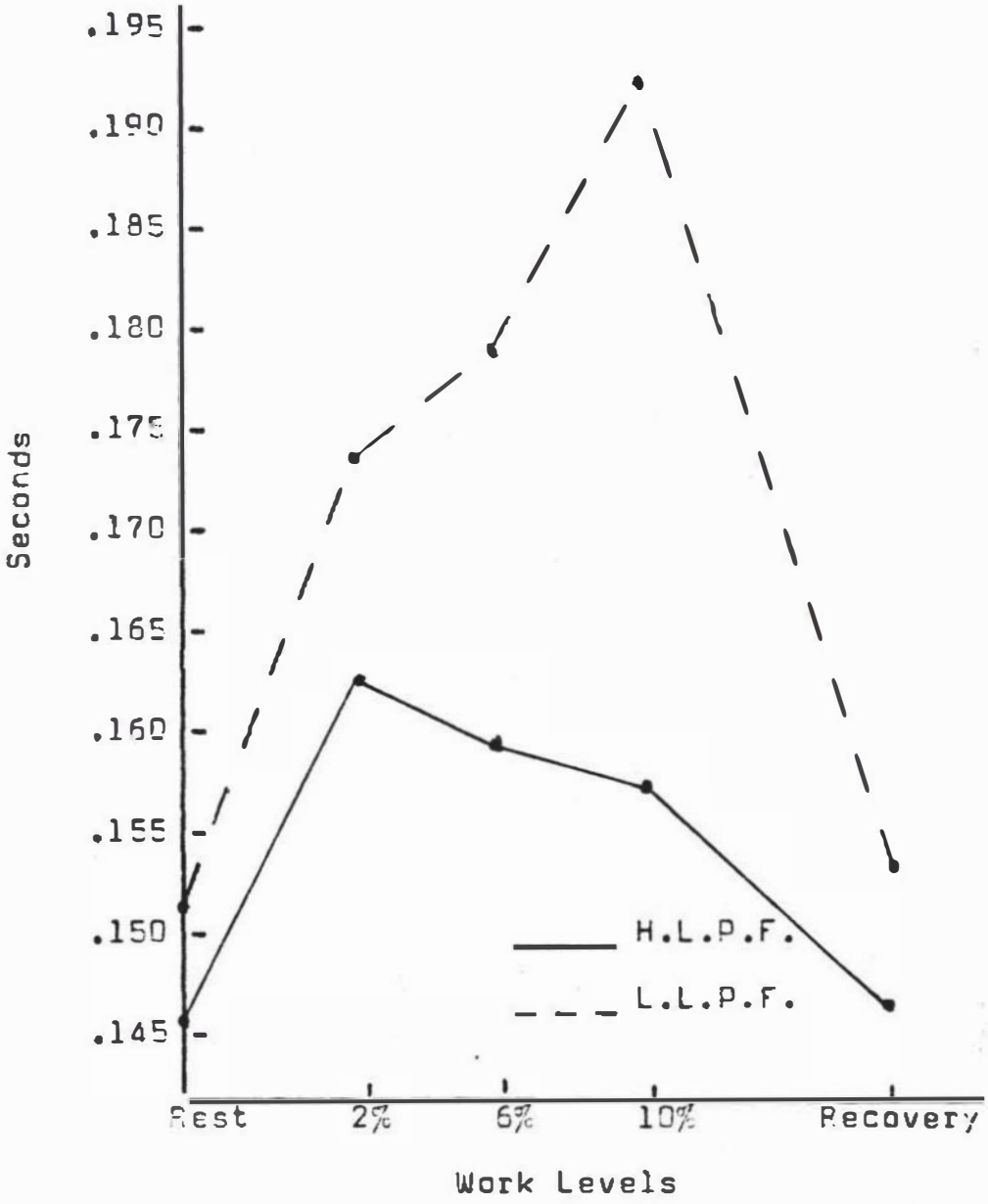

Figure 1

SUMMARY OF MEAN REACTION TIMES OF H.L.P.F. GROUP AND L.L.P.F. GROUP

cause, this discussion is based on the personal observations and the subjective reasoning of the researcher.

The H.L.P.F. Group. The majority of subjects in this group were either participating members of the university track team or individuals with previous athletic experience. Previous studies have indicated that athletes are faster reactors than non-athletes. The researcher feels that this athletic experience may have resulted in the quicker resting reaction time for this group.

The H.L.P.F. Group consisted of those subjects whose recovery heart rates from a standardized treadmill test revealed a physical fitness index score above 70. These subjects displayed little effort in running or in completing the required bout of exercise. The subjects seemed able to devote full attention to making a quick reaction to the audio stimulus.

It should also be noted that during the bout of exercise the mean reaction of the group became faster at the six percent and ten percent work levels respectively. The researcher feels that since each subject was given only 15 practice trials of reaction time while running on the treadmill, there might have existed some practice effect. It may have also been influenced by the releasing of any anxiety or tension which existed in the beginning of the treadmill run.

The L.L.P.F. Group. The L.L.P.F. Group consisted of those subjects that had a physical fitness index score of 55 or below. They were considerably heavier in body weight (H.L.P.F. = 74.2 kgs and L.L.P.F. = 96.9 kgs), and were not as skilled runners as the subjects in the H.L.P.F. Group. Many of these subjects expended considerable effort in completing the bout of exercise. Six subjects were unable to complete the last minute of the treadmill run. The researcher observed that while these subjects were unable to devote full attention to responding quickly, some of them who were seemingly as fatigued as the others maintained a rapid response to the audio stimulus. This ability to react quickly even though tired seemed to be an individual characteristic. It is suggested that perhaps these individuals may have had some past experience (athletic or otherwise) in which they practiced reacting fast during fatiguing exercise. Over a period of time this type of simple response became habitual and little attention was needed in retaining a fast reaction.

Similarities in Both the H.L.P.F. Group and the L.L.P.F. Group. Both the H.L.P.F. Group and the L.L.P.F. Group experienced a slowing of reaction time with the beginning of the treadmill run though all subjects were not effected the same. Again, it seemed to be individual in nature. It is felt that more practice reaction time trials during exercise may have diminished

this variance.

It is of interest to note that in both groups the mean reaction time in recovery was very close to the resting mean reaction time. It appears that the bout of exercise had little effect on the ability of either group to respond quickly when in recovery from the exercise.

The subjects in both groups seemed to give full attention to making a quick response even though many of the subjects of the L.L.P.F. Group were breathing quite heavily. It appeared that as long as the subject could devote full attention to making a quick response he was able to do so.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

The study was conducted to compare the reaction time of 30 college students at rest, during exercise and in recovery from treadmill running. In addition, the mean reaction times of those subjects with a high level of physical fitness were compared to the mean reaction times of those subjects with a low level of physical fitness at each specified level of work, rest or recovery.

Subjects were given a thorough orientation to treadmill running and the reaction time device. They were classified as to high or low level physical fitness on the bases of a Physical Fitness Index determined from recovery heart rates following a standardized treadmill run.

On the testing day, subjects were given 16 reaction time trials in each of five different situations; at rest, while running at two percent, six percent and ten percent grades on the treadmill and in recovery from the run. Data was punched on I.B.M. cards and computerized *t* tests were used to determine the significance of the differences of reaction time means in all five situations;

I., Within the High Level of Physical Fitness Group, II. Within the Low Level of Physical Fitness Group, and III. Between the High Level of Physical Fitness Group and the Low Level of Physical Fitness Group.

Conclusions

Based on the results presented and within the limitations of this study, the following conclusions appear warranted:

1. Reaction time during exercise is significantly slower than reaction time at rest.
2. There is no statistically significant difference between reaction time before exercise and after exercise.
3. The physical fitness of an individual is a factor in maintaining a rapid reaction time during exercise.

Recommendations

The researcher feels the following recommendations may warrant investigation:

1. A similiar study could be conducted to determine if a statistically significant relationship exists between reaction time during exercise and physical fitness.
2. An investigation measuring the reaction times of athletes and non-athletes during various work loads may be worthy.

3. A study concerning the effect of various running speeds on reaction time would seem warranted.

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APPENDIXES

APPENDIX A

RAW DATA
(MEAN REACTION TIMES FOR HIGH LEVEL PHYSICAL FITNESS GROUP)

Subject	Rest (Sec)	2% (Sec)	6% (Sec)	10% (Sec)	Recovery (Sec)	PFI
1	.117	.129	.128	.123	.125	71.3
2	.150	.163	.154	.157	.140	75.8
3	.144	.178	.159	.159	.148	77.1
4	.121	.135	.143	.123	.129	80.6
5	.153	.162	.158	.155	.160	81.9
6	.169	.153	.154	.157	.153	83.3
7	.127	.134	.146	.150	.136	85.7
8	.167	.190	.199	.214	.157	90.3
9	.149	.193	.180	.180	.156	97.4
10	.160	.189	.172	.178	.170	100.6
11	.147	.182	.166	.165	.163	106.4
12	.146	.188	.160	.151	.139	119.0
13	.137	.136	.148	.145	.142	141.5
14	.158	.163	.159	.154	.142	151.5
15	.147	.160	.161	.151	.151	153.1

APPENDIX B

RAW DATA
(MEAN REACTION TIMES FOR LOW LEVEL PHYSICAL FITNESS GROUP)

Subject	Rest (Sec)	2% (Sec)	6% (Sec)	10% (Sec)	Recovery (Sec)	PFI
1	.136	.171	.171	.185	.145	26.5
2	.121	.139	.154	.158	.130	28.3
3	.134	.163	.186	.194	.139	30.5
4	.161	.195	.184	.163	.163	35.7
5	.158	.198	.178	.271	.156	37.4
6	.168	.225	.209	.244	.193	40.8
7	.134	.136	.135	.145	.133	41.2
8	.161	.195	.209	.244	.180	43.4
9	.149	.173	.198	.235	.144	48.6
10	.134	.145	.151	.149	.142	50.4
11	.196	.199	.199	.192	.176	51.0
12	.195	.182	.191	.195	.180	53.2
13	.156	.199	.207	.199	.148	54.8
14	.152	.170	.169	.164	.159	55.1
15	.131	.133	.150	.155	.126	55.2

VITA

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The writer was born in Chicago, Illinois on June 1, 1945. He attended Blue Island Community High School, where he won letters in football, wrestling and track. As a senior he was awarded the Best All Round Athlete Trophy.

In 1963 he was awarded an athletic scholarship at Upper Iowa College. While attending Upper Iowa, he earned four letters in football and two letters in wrestling. He was elected captain of the wrestling team for the 1966-67 season.

After receiving the Bachelor of Science Degree, the writer was employed for four years as physical education instructor in the Central Community School at Elkader, Iowa. While at this position, he was head wrestling coach and assistant football coach.

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