A COMPARISON OF REACTION TIME AND MOVEMENT TIME MEASURES OF WOMEN ATHLETES AND NONATHLETES

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Lois Joy Youngen

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A COMPARISON OF REACTION TIME AND MOVEMENT TIME MEASURES OF WOMEN ATHLETES AND NONATHLETES

By

Lois Joy Youngen

A THESIS

Submitted to the College of Education of Michigan State University of Agriculture and Applied Science in partial fulfillment of the requirements for the degree of

MASTER OF ARTS

Department of Health, Physical Education, and Recreation

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Dedicated To

My Parents

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Lois J. Youngen

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ABSTRACT

The Problem

The problem was to compare the reaction time and movement time scores of women athletes to similar scores of women nonathletes. The reaction and movement times of forty-seven athletes and seventy-five women nonathletes were measured on an electronic apparatus. The resulting data were statistically analyzed.

The athletes were further studied by comparing the reaction time and movement time scores of four sport groups: eight tennis players, seven fencers, twelve swimmers, and twenty field hockey players. Within each sport group, the women were ranked by ability and these data compared to similar ranked reaction time and movement time measures.

Reaction and movement time scores and letter grades achieved by the nonathletes in three instructional courses, tennis, swimming, and fencing, were also compared.

The effect of menstruation on reaction time and movement time measures was determined from comparison of fourteen paired observations. Also, the relationship between reaction time and movement time was determined.

Review of Literature

In independent studies, Beise and Peaseley (1), Cureton (2), Keller (3), and Pierson (4) demonstrated that athletes in general have faster reaction times than nonathletes.

Recently, a distinction has been made between reaction time and movement time. Through investigations by Henry (5), Henry and Trafton (6), and Slater-Hammel (7) the concept that these two measures are highly correlated has been disputed and disproven.

Conclusions

From the statistical analysis of the data the following conclusions were drawn:

1. Women athletes are significantly faster than women non-athletes in speed of movement and speed of reaction.
2. Reaction time and movement time are not correlated with coach-assigned ability position within tennis, swimming, fencing, or field hockey.
3. Within the athletic group, tennis players, swimmers, fencers, and field hockey players differ significantly in speed of movement; but they do not differ in speed of reaction.
4. Nonathletes' reaction time and movement time in tennis, swimming, and fencing is unrelated to achievement as measured by letter grade.
5. A low, but significant correlation exists between reaction time and movement time.
6. Menstruation has no measurable effect on speed of movement or reaction time.

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2. Cureton, Thomas K. *Physical Fitness of Champion Athletes*. Urbana: The University of Illinois Press, 1951. 458 pp.

3. Keller, Louis F. "The Relation of 'Quickness of Bodily Movement' to Success in Athletics," *The Research Quarterly*, XIII (May, 1942), 146-155.

4. Pierson, William Russell. "A Comparison of Fencers and Nonfencers by Certain Psychomotor, Space Perception, and Anthropometric Measures." Unpublished Master's thesis, Michigan State College, East Lansing, 1955.

5. Henry, Franklin M. "Independence of Reaction and Movement Times and Equivalence of Sensory Motivators of Faster Response," *The Research Quarterly*, XXIII (March, 1952), 43-53.

6. Henry, Franklin M., and Irving R. Trafton. "The Velocity Curve of Sprint Running," *The Research Quarterly*, XXII (December, 1951), 409-421.

7. Slater-Hammel, A. T. "Reaction Time and Speed of Movement," *Psychological Abstracts*, XXVIII (July, 1954), 310.

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CHAPTER I

INTRODUCTION

"The neuromuscular co-ordination of the individual which includes the ability to learn new skills and finally to achieve competency in physical activities, is essential to all phases of physical education."[1] Among the factors involved in neuromuscular co-ordination are: movement of the body at high speeds, quick directional changes, and fast reactions to unexpected circumstances.[2] These factors, plus others, are deemed by many physical educators, both men and women, as being essential for proficiency in various sports activities. Although tradition, observation, and personal opinion have in the past been the primary source for making these claims, experimental data have been collected upon male subjects to support these views. However, in studying the various qualities supposedly needed by women for successful performance, only a paucity of data are available dealing with the factors of reaction time and speed of movement.

Statement of the Problem

This study was primarily designed to compare the reaction time and arm movement time of selected women athletes with women non-athletes at Michigan State University. Subproblems were:

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[1]H. Harrison Clarke, The Application of Measurement to Health and Physical Education (New York: Prentice-Hall, Inc., 1945), p. 251.

[2]Ibid.

(1) comparisons of reaction time and movement measures among four different types of sports: tennis, fencing, swimming, and field hockey; (2) correlation of reaction time and movement time of each nonathlete with her physical achievement as measured by letter grade; (3) comparison of the reaction and movement time data on individual athletes with their coach-assigned ability rank within a sport activity; (4) comparison of reaction and movement time scores during and after menstruation; and (5) correlation of reaction time with movement time.

Need for the Study

The trend in recent years has been toward increased participation in sports activities by girls and women.[3] With increased participation, physical education programs for women have been developed to include more diversified sports activities. Keeping pace with these trends, sports costumes have been designed to allow more freedom of movement, sports equipment has been improved, play facilities have been enlarged, and teaching methods have been remodeled. Physical educators are constantly striving for increased intelligent control and understanding of sports activities, and to give a scientific basis to many of our present concepts and assumptions.[4] Through the results of this study, scientific evidence may be found to repudiate or confirm the opinions and observations of many physical educators that fast reaction time

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[3] Jesse Feiring Williams, Principles of Physical Education (Philadelphia: W. B. Saunders Company, 1942), p. 38.

[4] Charles C. Cowell, Scientific Foundations of Physical Education (New York: Harper and Brothers, 1953), p. 18.

and movement time are among the attributes needed by women to become proficient in specific sports activities. These results may be used to clarify the position women should take in relation to participation in co-educational sports activities.

Definition of Terms

Athlete. An athlete is a woman who was an active member, at the onset of this study, of one of the following organizations: (1) varsity tennis team, (2) varsity speed swimming team, (3) Delta Gamma Mu, honorary fencing fraternity, and (4) women's field hockey club.

Nonathlete. For the purpose of this study, a nonathlete is a woman who was enrolled for the first time in an instructional class in either swimming, fencing, or tennis at Michigan State University during the spring of 1956.

Reaction time. The interval between the excitation of a stimulus and a muscular response.

Movement time. The time taken to move the total body or parts of the body a prescribed distance.

Limitations of the Study

At Michigan State University, only four sports--tennis, fencing, swimming, and field hockey--afford women athletes the opportunity to compete on an intercollegiate level; but the type and amount of competition is somewhat restricted. All the available subjects in each of these sports were tested. If more sports had been available, the number of women comprizing the athletic group would have been larger and selection could have been made on an ability rather than membership basis. The level of ability necessary for membership on any team was subjectively designated by the presiding coach. This level varied from sport to sport and from individual to individual. Another limitation was the subjective ranking of playing ability by the coach of each sport. More than one subjective ranking might have strengthened the study.

It was the purpose of this study to test only movement of the dominant hand and arm, and not of the total body. This measure may not be as representative of movement time as would another type of measurement. Another limiting factor in this study was lack of the knowledge of the degree of psychological motivation exhibited by the nonathletic group. Through observation, it was the writer's opinion that the athletes demonstrated a greater degree of motivation than the nonathletes. The effects of constant, periodical, or nonexistent training upon the athletic group may or may not have limited the results of this study.

Also, limiting the correlation of letter grades with individual reaction time and movement time scores, was the subjective grading system of each instructor. Letter grades were based, in part, on measures other than ability or skill.

CHAPTER II

REVIEW OF THE LITERATURE

Sports

To illustrate how important speed of reaction and movement are in various sports, typical views of coaches and physical educators are here expressed.

"Speed is a word used to indicate various types of quickness or rapidity." In sports, it may refer to either quickness in seeing or in acting, but it usually refers to a combination of perception with muscular action.[1]

Two qualities are thought to be necessary for good fencing: (1) instantaneous judgment and (2) muscular strength and speed.[2] Of all women's sports, fencing is the most attractive. "The average sports-loving American does not know that fencing is the fastest of all sports."[3] Instantaneous responses by the muscles to commands of the brain are essential in fencing.[4]

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[1]John D. Lawther, Psychology of Coaching (New York: Prentice-Hall, Inc., 1951), p. 216.

[2]Clovis Deladrier, Modern Fencing (Annapolis: The United States Naval Institute, 1948), p. 82.

[3]Aldo Nadi, On Fencing (New York: G. P. Putnam's Sons, 1943), p. 8.

[4]Department of Physical Education, Smith College, Individual Sports for Women, (Philadelphia: W. B. Saunders Company, 1943), p. 108.

Field hockey is a fast moving game which envolves continuous activity at top speeds.[5] Speed, rapid change of direction and pace, and quick starts and stops are necessary attributes of a field hockey player.[6,7,8,9]

"The quest for speed in swimming has brought about revolutionary changes in swimming styles."[10] Strength and power are essential to the swimmer, but conditioning in this sport includes the building of speed. For the sprint crawl, a swimmer must be quick in moving, fast on the turns, and quick to react to the starting gun; but the primary physiological qualification is speed.[11]

Driver, on tennis, avers that quick body action is necessary in proper footwork. The essentials of good stroking include accuracy and speed.[12] Successful tennis depends much on agility in covering the court[13] and on correct rhythm and balance.[14]

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[5]Josephine Lees, Field Hockey for Women (New York: A. S. Barnes and Company, 1942), p. 2.

[6]Bob Harman, and Keith Monroe, Use Your Head in Tennis (New York: Thomas Y. Crowell, 1950), p. 2.

[7]Lees, op. cit., pp. 27-30.

[8]Hilda V. Burr, Field Hockey for Coaches and Players (New York: A. S. Barnes and Company, 1930), p. 21.

[9]Wilbur Pardon Bowen, Applied Anatomy and Kinesiology, Revisor Henry A. Stone (sixth edition; Philadelphia: Lea and Febiger, 1949), p. 337.

[10]David A. Armbruster, and Lawrence E. Morehouse, Swimming and Diving (St. Louis: The C. V. Mosby Company, 1950), p. 10.

[11]Ibid., pp. 12-70.

[12]Helen Irene Driver, Tennis For Teachers (Philadelphia: W. B. Saunders Company, 1941), pp. 34, 76.

[13]Bowen, op. cit., p. 355.

[14]Department of Physical Education, Smith College, op. cit., p. 355.

Motor ability differs among individuals mainly due to the wide range in native capacity.

Reaction Time

One single definition of reaction time is the stimulus-response interval.[15] A complete reaction may be divided into many parts. The physiological process may possibly follow this sequence: (1) sensory preception, (2) latency period in the sense organ, (3) conduction of the afferent nerve impulses to the proper sensory centers, (4) elaborations in the cerebral hemispheres and spinal cord, (5) conduction of the efferent nerve impulses to the proper striated muscle, (6) latency period in the striated muscle, and (7) muscular response. Thomas K. Cureton would add strength, tone, and viscosity of the responding muscle as factors affecting a single response.[16]

The factors determining the speed of response in a simple reaction are undoubtedly very complex and include more than one organic variable.[17] One determining factor is the speed of nerve transmission.[18,19,20]

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[15] Robert S. Woodworth, Experimental Psychology, (New York: Henry Holt and Company, 1938), p. 30.

[16] Thomas K. Cureton, Physical Fitness of Champion Athletes (Urbana: The University of Illinois Press, 1951), p. 94.

[17] Lyle H. Lanier, "The Interrelations of Speed of Reaction Measurements," Journal of Experimental Psychology, XVII (April, 1934), p. 397.

[18] Ibid.

[19] Vernon W. Lemmon, "The Relation of Reaction Time to Measures of Intelligence, Memory, and Learning," Archives of Psychology, No. XCIV (1927), p. 34.

[20] Arthur Gilbert Bills, General Experimental Psychology (New York: Longmans, Green and Company, 193[illegible]), p. 400.

This value has been established, varying from 100 to 220 feet per second.[21,22] Lawther opposes this view by asserting that the speed of nerve conduction is so brief it should be ignored.[23] Which single factor exerts the most influence on the speed of a simple response is questionable. Synaptic co-ordination is the largest determining factor according to one author.[24] Although this may not be the primary determining factor, it nevertheless, affects the speed of response to some degree.[25,26] Myers avers that reaction time is dependent upon the time occupied at the peripheral sense organ.[27] The time consumed at the nerve centers, the central delay, has also been named as the primary factor affecting the speed of a simple response.[28,29] Simple reaction time is not a fixed quantity, but it apparently has a physiological limit around .10 second.[30]

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[21] *Ibid.*

[22] Woodworth, *op. cit.*, p. 299.

[23] Lawther, *op. cit.*, p. 222.

[24] V. A. C. Henmon, and F. Lyman Wells, "Concerning Individual Differences in Reaction Times," *Psychological Review*, XXI (March, 1914), p. 156.

[25] Gladys M. Scott, *Analysis of Human Motion* (New York: F. S. Crofts and Company, 1942), p. 82.

[26] Lemmon, *loc. cit.*

[27] Charles S. Myers, *A Text-Book of Experimental Psychology* (third edition; New York: Longmans, Green and Company, 1928), p. 130.

[28] Bills, *loc. cit.*

[29] Woodworth, *op. cit.*, p. 300.

[30] Woodworth, *op. cit.*, p. 323.

The relation of various phases of reaction time to reflex action remains debatable. According to Woodworth, a simple reaction is absolutely not a reflex, nor does it involve reflex action.[31] It is not illogical to assume that the basic structure of the simple response is the reflex arc.[32]

Simple reaction time depends upon the subject's being prepared or "ready" to receive the stimulus or to perform an act.[33,34] This process facilitates transmission of the nerve impulses through the nerve centers to the appropriate muscle.[35,36] The length of the fore-period or preparatory interval determines the organism's "readiness" to act, thereby affecting reaction time.[37,38] Most cited intervals producing effective responses range from one to four seconds.[39,40,41,42]

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[31]Robert S. Woodworth, Psychology (fourth edition; New York: Henry Holt and Company, 1940), p. 2__.

[32]Scott, loc. cit.

[33]Woodworth, Psychology, op. cit., p. 29.

[34]Myers, op. cit., p. 317.

[35]Ibid.

[36]Woodworth, Psychology, op. cit., p. 259.

[37]Woodworth, Experimental Psychology, op. cit., p. 314.

[38]H. Woodrow, "The Measurement of Attention," Psychological Monographs, XVII (December, 1914), p. 155.

[39]C. W. Telford, "The Refractory Phase of Voluntary and Associative Responses," Journal of Experimental Psychology, XIV (February, 1931), p. 7.

[40]Floyd L. Ruch, Psychology and Life (third edition; Chicago: Scott, Foresman and Company, 1948), p. 466.

[41]J. V. Breitweiser, "Attention and Movement in Reaction Time," Archives of Psychology, No. XVIII (August, 1911), p. 38.

[42]Sanford J. Munro, "The Retention of the Increase in Speed of Movement Transferred from a Motivated Simple Response," The Research Quarterly, XXII (May, 1951), p. 233.

For optimum efficiency, an interval of two seconds is favored.[43,44,45,46,47] Bills found the one-second interval most desirable.[48] Contradicting this statement, Munro concluded a one-second interval elicited slower responses.[49] The refractory period necessitates the use of an interval longer than one-half second.[50,51] Prolonged reaction time is obtained by using intervals less than one second.[52] Existence of individual differences in optimum intervals was proved by Breitweiser.[53]

The mental attitude of the subject prior to the activation of the stimulus may be directed toward three modes of reaction: "muscular," when attention is focused on the muscular response; "sensorial," when attention is confined to reception of the stimulus; and "natural," when attention is altogether undirected.[54,55,56] In general, reaction times are faster when the "muscular" mode is employed.[57,58,59]

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[43]Telford, loc. cit.

[44]Myers, op. cit., p. 131.

[45]Woodrow, op. cit., p. 64.

[46]Woodworth, Experimental Psychology, loc. cit.

[47]M. LeRoy Billings, "The Duration of Attention," The Psychological Review, XXI (March, 1914), p. 133.

[48]Bills, op. cit., p. 406.

[49]Munro, loc. cit.

[50]Bills, op. cit., p. 394.

[51]Telford, loc. cit.

[52]Bills, op. cit., p. 406.

[53]Breitweiser, loc. cit.

[54]Bills, op. cit., p. 401.

[55]Myers, op. cit., pp. 126-129.

[56]Breitweiser, op. cit., p. 1.

[57]Ibid., p. 7.

[58]Lawther, op. cit., p. 221.

[59]Woodworth, Experimental Psychology, op. cit., p. 305.

Practice tends to improve the speed of these responses,[60] but more noticeably the "sensorial" mode.[61] Henmon and Wells, as well as Henry, discovered the direction of attention during a simple response did not appreciably affect reaction time speeds.[62,63]

The typical value of reaction time to a visual stimulus has variously been cited between .15 and .225 second.[64,65,66,67,68] Responses to auditory stimuli are quicker than those to visual stimuli.[69,70,71,72] "The visual stimulus does not stimulate a nerve-ending directly."[73] A photochemical reaction within the retina produces a time lapse. Although light reaches the retina without loss of time, this latent period may be due to increased elaboration in the central process.[74] The part of the retina which receives the light partially

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[60]Bills, loc. cit.

[61]Myers, loc. cit.

[62]Henmon and Wells, loc. cit.

[63]Franklin M. Henry, "Conditions Under Which Increased Intensity of Motor Set Causes Slowing of Reaction Time," (Chicago: American Association of Health, Physical Education, and Recreation Research Section, 1956), p. 1. (Mimeographed.)

[64]Myers, loc. cit.

[65]A. T. Slater-Hammel, and R. L. Stumpner, "Batting Reaction-Time," The Research Quarterly, XXI (December, 1950), p. 353.

[66]Bills, op. cit., p. 400.

[67]Ruch, op. cit., p. 465.

[68]Woodworth, Experimental Psychology, op. cit., p. 324.

[69]Brent Baxter, "A Study of Reaction Time Using Factorial Design," Journal of Experimental Psychology, XXXI (November, 1942), p. 431.

[70]Lawther, loc. cit.

[71]Woodworth, Experimental Psychology, loc. cit.

[72]Ruch, loc. cit.

[73]Ibid.

[74]Woodworth, Experimental Psychology, op. cit., p. 327.

determines the speed of a simple reaction.[75] "If a visual stimulator makes a noise, the response...will probably be made to the noise rather than to the light."[76]

Many external factors affect the speed of reaction time. Increasing intensity of the stimulus shortens reaction time[77,78,79,80,81] by strengthening its attention power.[82] Reaction time increases as the distance between the subject and stimulus increases.[83]

Diurnal variations are found in measuring reaction time. Most favorable testing time is found in the afternoon.[84] Elbel, in testing twenty-three male subjects in a stimulus-hand response study, isolated the following factors: slowest responses are obtained at twelve noon, maximum speed is obtained in the early afternoon, and a near maximum point is reached in the middle of the morning.[85] In this investigation, he also found diurnal variations were affected by individual differences.[86]

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[75]A. J. Poffenberger, "Reaction Time to Retinal Stimulation," Archives of Psychology, XXIII (July, 1912), p. 23.

[76]Woodworth, Experimental Psychology, op. cit., p. 314.

[77]Woodrow, loc. cit.

[78]Bills, loc. cit.

[79]Ruch, op. cit., p. 466.

[80]Myers, op. cit., p. 131.

[81]Woodworth, Experimental Psychology, op. cit., p. 320.

[82]Woodworth, Psychology, op. cit., p. 45.

[83]Woodworth, Experimental Psychology, op. cit., p. 327

[84]Edward C. Schneider, and Peter V. Karpovich, Physiology of Muscular Activity, (Philadelphia: W. B. Saunders Company, 1949), p. 36.

[85]E. R. Elbel, "A Study in Variation in Response Time," The Research Quarterly, X (March, 1939), pp. 49-50.

[86]Ibid.

Reaction time varies between individuals. Sufficient practice does not equalize individual differences in response time.[87] Fatigue exerts a slowing effect on reaction time.[88,89,90,91] "It is reasonable to assume that every neuromuscular response is affected by fatigue."[92]

Practice of a response tends to shorten reaction time,[93,94,95,96] although Ruch states the physiological limit is soon reached.[97] Contradicting this concept, Lawther indicates training does not affect reaction time; but visual perception, which compensates for slowed reaction time, will improve through training.[98] During childhood and old age, reaction time is lengthened,[99,100] while maximum speed is reached at the college age.[101]

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[87] *Ibid.*

[88] Myers, *loc. cit.*

[89] Lawther, *op. cit.*, p. 222.

[90] Schneider and Karpovich, *op. cit.*, p. 37.

[91] Bills, *op. cit.*, p. 405.

[92] E. R. Elbel, "A Study of Response Time Before and After Strenuous Exercise," *The Research Quarterly*, XI, (May, 1940), p. 86.

[93] W. R. Miles, "Studies in Exertion II. Individual and Group Reaction Time in Football Charging," *The Research Quarterly*, II, (October, 1931), p. 7.

[94] Myers, *op. cit.*, p. 128.

[95] Scott, *loc. cit.*

[96] Bills, *loc. cit.*

[97] Ruch, *op. cit.*, p. 467.

[98] Lawther, *loc. cit.*

[99] Ruch, *loc. cit.*

[100] Myers, *op. cit.*, p. 130.

[101] Schneider and Karpovich, *loc. cit.*

Evans studied the influence of external distractions on speed of reaction time; and he concluded that light, sound, and touch distractions affected this speed by lengthening it.[102] Practice lessened the influence of the distraction but never overcame it.[103] Sound proved to be the most effective distractor.[104] The relationship of sex differences to all phases of reaction time has not been investigated to any degree. Gates, in studying diurnal variations, found sex differences non-existent.[105]

Related Studies of Reaction Time

Using athletes and nonathletes, the reaction time to simple and complex visual stimuli was determined by Burley.[106] The nonathletes were defined as non-letter-winners. The athletic group was comprised of football backs and linemen, basketball players, baseball players, and swimmers. Results showed the basketball and baseball players possessed the fastest reaction times.

Friedman[107] attempted to determine the relationship between reaction time and general athletic ability as determined by the Cozen's Indoor

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[102]John E. Evans, "The Effect of Distraction on Reaction Time," _Archives of Psychology_, XXV (November, 1916), p. 53.

[103]_Ibid._, p. 41.

[104]_Ibid._, p. 51.

[105]Arthur I. Gates, _Variations in Efficiency During the Day, Together with Practice Effects, Sex Differences, and Correlations_, (Berkeley: The University of California Press, 1916), p. 147.

[106]L. R. Burley, "A Study of the Reaction Time of Physically Trained Men," _The Research Quarterly_, XV (October, 1944), pp. 232-239.

[107]Edward D. Friedman, "The Relationship of Reaction Time to General Athletic Ability," (unpublished Master's thesis, New York University, New York, 1937), pp. 1-39.

Test Battery Number Twelve. Total body reaction time was measured through the use of an original apparatus. From the results, Friedman concluded that reaction time is not a reliable index of general athletic ability.

A study of the reaction time of male athletes by Burpee and Stoll[108] indicated a significant negative relationship exists between small muscle reaction time and proficiency in physical education activities. A large negative correlation was found between large muscle reaction time as tested, and successful participation in these activities. Lanier[109] tested thirteen graduate students, six men and seven women, to study the degree of relationship among various simple motor performances and reaction time measures. There was a lack of correlation between simple types of motor activities and reaction time measures. The concept that rate of nerve conduction conditions speed somewhat uniformly in diverse motor activities can now be disputed.

Elbel[110] studied the effects of physical fatigue on response time. Using male subjects, he found athletic competition, prior to testing, shortened hand reaction time as well as total body response time. A limitation of the study was the length of the period of competition. It was the author's belief that with an extended period of exercise the reaction time would have lengthened.

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[108] Royal H. Burpee, and Wellington Stoll, "Measuring Reaction Time of Athletes," The Research Quarterly, VII (March, 1936), pp. 110-118.

[109] Lanier, op. cit., pp. 371-399.

[110] Elbel, "A Study of Response Time Before and After Strenuous Exercise," op. cit., pp. 86-95.

Keller[111] experimented with 259 male athletes and 277 male non-athletes in an attempt to measure what he termed "total body quickness." Each subject moved his arm, foot, and trunk in one total action to either the right, left, or forward. Thirty-six measures were obtained for each subject. The athletes were significantly faster than the non-athletes in "body quickness." His conclusion was as follows: proficiency in athletic activities is positively related to the ability to move the body quickly.

In a recent experiment, Franklin M. Henry[112] used forty men and forty women in testing attention-directed responses to a visual stimulus. Forty-five responses were made by each subject under "set imposed" conditions. Two sets were employed, motor and sensory. Fifteen responses were made without attention direction. Henry found no significant differences in the patterns of the subject's "motor" and "sensory" responses, thereby disputing the validity of the generality that "motor" responses are the faster of the two. No sex differences were observed.

In another study,[113] fifty-seven athletes comprising five athletic groups--football, baseball, basketball, track, and gymnastics--and twenty-six nonathletes were tested to determine their peripheral visual reaction time. This stimulus was presented at angles from 60 to 105

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[111]Louis F. Keller, "The Relation of 'Quickness of Bodily Movement' to Success in Athletics," The Research Quarterly, XIII (May, 1942), pp. 146-155.

[112]Henry, loc. cit.

[113]Alfred W. Hubbard, "Peripheral Perception and Reaction Time," (Chicago: American Association of Health, Physical Education, and Recreation Research Section, 1956), pp. 1-6. (Mimeographed.)

degrees with forty-five trials being averaged to obtain the mean peripheral visual reaction time. All of the athletic groups differed from the nonathletes at the one per cent level of confidence. A further step was to determine the practice effect on peripheral reaction time using nineteen athletes and eighteen nonathletes as subjects. The previously used reaction time test was repeated by each subject at one-week intervals for approximately five weeks. Results indicated that, although the athletes remained superior, improvement by both groups proved the ability was trainable.

In 1937, Beise and Peaseley[114] conducted an experiment on reaction time using three groups of women. The study was designed to discover if women skilled in sports demonstrated similarity in speed of responses, and if "fundamentals" of reaction time differ from one sport activity to another. The skilled group was comprised of twenty-four tennis players, twelve golfers, and eleven archers. Fourteen subjects who failed to achieve an average grade in a sport activity were classified as unskilled. A third group of fourteen girls who had taken the Brace Motor Ability Tests was used. Reaction time of the arm and leg were measured for each group. The apparatus devised for testing large muscle reaction time consisted of a wooden plate placed on the floor. Reaction time to a visual stimulus was terminated by removing the foot from the plate. Hand reaction time used a similar apparatus. The subject, upon receiving a light stimulus, lifted her dominant hand from the plate. The sequence of trials required the subject to alternate

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[114]Dorothy Beise, and Virginia Peaseley, "The Relation of Reaction Time, Speed, and Agility of Big Muscle Groups to Certain Sports Skills," The Research Quarterly, VIII (March, 1937), pp. 133-142.

lifting and pressing the hand. For the skilled group, the mean reaction time for the large muscle tests was .5550. For the unskilled, the mean large muscle reaction time was .6490. This difference was considered significant. The mean hand reaction time for the skilled group was .2489, for the unskilled group, .2950. Here the unskilled group was slower by a slight difference of .05 second. In considering the range of scores for each group, the unskilled varied widely, while the skilled were clustered more closely around the mean. Within the skilled group, differences were found to occur according to the type of activity. Tennis showed faster reaction time than did the more stationary sports of golf and archery. The mean hand reaction times of the three sports were tennis .2415 second, archery .2509 second, and golf .2626 second. It was concluded, "a girl with fast reaction time of the arms does not necessarily have fast reaction time of legs, and vice versa." Further testing using a seven-week instructional period as a training period revealed no significant differences in reaction time scores.

Thomas K. Cureton[115] conducted an experiment to procure the Vertical Jump times of champion athletes. Total body reaction time was measured by means of the Illinois Reaction Timer. This apparatus included an electric time clock recording device, a stimulus unit, and a response unit which measured reaction time. The response unit, an aluminum platform, was placed on the floor. The subject stood on the platform. Upon perceiving the stimulus he jumped vertically and high enough to move both feet off the platform, thereby stopping the timing

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[115]Cureton, op. cit., pp. 94-102.

device. The mean reaction time to a visual stimulus for 150 subjects from the general population of college students at the University of Illinois was .350 second. The rank order and mean reaction time to a visual stimulus of three groups of champions are as follows: (1) fifteen track and field stars, .274 second, (2) fifteen Danish gymnasts, .320 second, and (3) twenty-three United States Olympic diving and swimming champions, .321 second. Cureton demonstrated that athletes in general have faster reaction times in this test than do nonathletes. Although the swimmers and divers were the slowest reactors of the athletic group, they were faster than the nonathletes. Conclusions were drawn from this study which confirm Keller's results; namely, all sports do not require the same degree of quickness of body movement, and proficiency in athletes is related to fast body movement. Comparisons were also made of the United States Olympic swimmers and divers with five other groups. These six groups ranked as follows in mean reaction time to a visual stimulus: (1) thirty women physical education majors, .268 second, (2) thirteen male track and field stars, .274 second, (3) thirty-seven male physical education majors, .290 second, (4) one hundred women non-physical education majors, .316 second, (5) twenty Olympic swimmers and divers, .321 second, (6) eighty male non-physical education majors, .390 second. Although no conclusions were drawn from these data, it is interesting to note that the women physical education majors demonstrated the fastest reaction time of these six groups. Of the group of non-physical education majors, the women again demonstrated faster reaction times than the men. It should be noted in this study that total body weight affected the speed of the response and, therefore, colored the resulting data.

Movement Time

Although Bowen and Stone assert a short reaction time is a natural prerequisite for a quick start,[116] in recent years a distinction in literature and testing has been made between reaction time and movement time. Through investigation, the concept that these two measures are highly correlated has been disputed and disproven.[117,118,119,120,121]

A component of the physiological process of reaction time is the muscular response with all its phases. It is probable that the muscular response which terminates reaction time is the foremost process in movement time. Muscle fibers are made to do one thing only--contract; and under normal conditions, the skeletal muscles depend entirely upon the nerve impulse for their activities.[122] Impulses travel from the spinal cord to the muscle fibers. At the muscle there is a brief latent period

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[116]Bowen and Stone, op. cit., p. 300.

[117]Franklin M. Henry, "Independence of Reaction and Movement Times and Equivalence of Sensory Motivators of Faster Response," The Research Quarterly, XXIII (March, 1952), p. 43.

[118]A. T. Slater-Hammel, "Reaction Time and Speed of Movement," Psychological Abstracts, XXVIII (July, 1954), p. 510.

[119]Miles, op. cit., p. 12.

[120]Lawrence Rarick, "An Analysis of the Speed Factor in Simple Athletic Activities," The Research Quarterly, VIII (December, 1937), p. 103.

[121]Franklin M. Henry, and Irving R. Trafton, "The Velocity Curve of Sprint Running," The Research Quarterly, XXII (December, 1951), p. 419.

[122]Perry D. Strausbaugh, and Bernal R. Weimer, Elements of Biology, (New York: John Wiley and Sons, Inc., 1944), p. 182.

which is followed by contraction of the muscle.[123] During the latent period, the muscle is overcoming the inertia of the part to which it is attached and chemical changes are being made.[124] It is generally agreed that co-contraction is the response of the antagonistic muscle in a simple voluntary movement.[125] Optimum speed of movement is partially affected by the maximum rate of muscle contraction and the maximum rate of innervation. The human arm needs approximately .04 second to develop maximum muscle tension.[126] McCloy[127] states that differences in speed of movement may be due to two factors: viscosity in the sarcoplasm of the muscular tissue or in leverage in the attachment of the muscles.

Related Studies of Movement Time

Henry and Trafton[128] used twenty-five male physical education majors in a study to discover the extent to which the time of reaction can determine differences in the time of a measured sprint. Defining

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[123]Katherine F. Wells, Kinesiology (Philadelphia: W. B. Saunders Company, 1950), p. 84.

[124]Scott, loc. cit.

[125]R. C. Davis, "The Pattern of Muscular Action in Simple Voluntary Movement," Journal of Experimental Psychology, XXXI (November, 1942), p. 348.

[126]S. S. Stevens (ed.), Handbook of Experimental Psychology (New York: John Wiley and Sons, Inc., 1951), p. 1324.

[127]Charles H. McCloy, "The Measurement of Speed in Motor Performance," Psychometrika, V (September, 1940), p. 174.

[128]Henry and Trafton, op. cit., pp. 409-421.

reaction time as the time between the start signal and the beginning of pressure on the starting blocks, the mean reaction time for the first fifty-yard run was .133 second, and for the second run, .131 second. A low correlation of .14 second was found between reaction time and fifty-yard run times. A conclusion was that "fast reactors" are not "fast runners." "Contrary to popular belief, individual differences in the reaction time function can be neglected except for very short distances, perhaps ten of fifteen yards at the most."

Shelby[129] divided total reaction time into two phases, hesitation time and movement time. Hesitation time consisted of the interval between the stimulus and the beginning of the muscular response. This would be true reaction time. She concluded that reaction time tests for small muscles were more reliable than those for larger muscles. Through partial correlations, hesitation and movement times were identified as independent factors in both the small and large muscle tests. The correlation of each of these factors with a motor ability criterion was more significant than their intercorrelation.

Slater-Hammel[130] investigated the relationship of reaction time to speed of movement. The subjects were twenty-five male physical education students. Measurements of reaction time of a visual stimulus and speed of arm movement over a 120-degree arc were obtained.

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[129]Wellesley College Studies in Hygiene and Physical Education, "Neuromuscular Function and Development," The Research Quarterly Supplement, IX (March, 1938), pp. 37-48.

[130]Slater-Hammel, "Reaction Time and Speed of Movement," loc. cit.

The mean reaction time of the group was .244 second; the mean movement time was .238 second. Correlations between the two measures were not statistically significant, ranging from -.07 to .17. Results indicated that reaction time is independent of and cannot be used to predict speed of movement.

In an attempt to prove reaction time and speed of movement function as independent factors, Henry[131] measured 100 college men on two different types of apparatus. The ball snatch apparatus consisted of reaction key, visual stimulus, and a tennis ball suspended by a strong twelve inches forward and upward from the reaction key. The action consisted of moving the hand from the reaction key to the tennis ball, pulling it down. In the treadle press apparatus the subject moved his hand from the reaction key forward five and one-half inches to press a treadle. Two chronoscopes were used, one measured reaction time and the other total time. Movement time was computed by subtracting reaction time from total time. Ball snatch mean measures were .193 second for reaction time, and .121 second for movement time. Those for the treadle press were .216 second, mean reaction time, and .089 second mean movement time. From these two independent experiments, Henry demonstrated there was no correlation between reaction time and speed of movement. He concluded the two measures functioned independently.

In charging from the football stance, Miles[132] measured eighty-seven football players and found the average "charging" time of the

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[131]Henry, "Independence of Reaction and Movement Times and Equivalence of Sensory Motivators of Faster Response," op. cit., pp. 43-53.

[132]Miles, op. cit., pp. 5-14.

group to be .389 second. In this experiment, the entire body had to be moved. Miles concluded that a faster-than-average response to a simple reaction time test does not determine if an individual will be above average in football "charging."

Stevens[133] identified three factors which underlie individual differences in fine motor skills. The most important factor was the pattern of the movements involved in a certain motor act. Of moderate significance was the sense employed, and of slight importance was the musculature employed.

Rarick,[134] in an attempt to isolate any common elements associated with speed of muscular movement, used fifty-one male subjects possessing a high degree of athletic ability. Three elements were investigated: muscle thickening latency, simple reaction time, and running velocity. Records of muscle thickening latency were obtained by means of photographing the string of a Cambridge galivanometer used in connection with an electrocardiograph. Running velocity was measured over a ten-yard course by timing the start and the finish. Action current electrodes on the reacting muscle were used to obtain reaction time measures. An insignificant correlation was found between velocity of movement and reaction time, also between velocity and muscle thickening latency. It was concluded that muscle thickening latency is not a factor influencing the speed of muscle movement. The viscosity of the muscle appears to be the chief factor limiting speed of muscle movement.

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[133]Stevens, <u>op</u>. <u>cit</u>., pp. 1341-1345.

[134]Rarick, <u>op</u>. <u>cit</u>., pp. 89-105.

"Normal individuals with a high degree of motor ability or skill and an average amount of strength cannot increase their speed of muscular performance to any appreciable extent."

Pierson[135] conducted a study with the purpose of investigating the differences between fencers and nonfencers with relation to various measures. These included speed of arm movement, finger-press reaction time, and movement-reaction time. Twenty-five male fencers and the same number of nonfencers were tested in this study. In measuring arm movement time, the subject was instructed to hit a target placed eleven inches directly in front of him as fast as possible any time after hearing a "ready" buzzer. Finger-press reaction time was determined by instructing the subject to depress a telegraph key with his fingers upon receiving a visual stimulus. Movement-reaction time was measured as the time elapsing between the introduction of a visual stimulus and the subject's response by moving the dominant hand forward eleven inches. Pierson found in administering numerous trials that numbers twenty through forty occurred on a plateau. He therefore used these twenty trials in computing the mean for each subject. The mean movement time for the fencers was .137 second, for the nonfencers, .170 second. Finger-press mean reaction times for the fencers and nonfencers were .217 and .230 second respectively. Mean movement-reaction time for the fencers was .370 second, while the same measure for the nonfencers was

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[135]William Russell Pierson, "A Comparison of Fencers and Nonfencers by Certain Psychomotor, Space Perception, and Anthropometric Measures," (unpublished Master's thesis, Michigan State College, East Lansing, 1953), pp. 1-99.

.417 second. The results of these psychomotor tests showed a significant difference existed between the fencers and nonfencers in speed of arm movement and movement-reaction time. However, fencers and nonfencers did not differ significantly in finger-press reaction time. Pierson also concluded, "There is no correlation in either fencers or nonfencers for speed of arm movement and reaction time, speed of arm movement and arm length, or reaction time and arm length."

Summary

The literature has indicated that varsity athletes, both men and women, are faster than nonathletes in speed of movement and reaction time measures. Faster reaction time of the arm and hand, leg, and total body has been demonstrated by the athletes.

Cureton[136] and Keller[137] in independent studies found that all sports do not require the same degree of body movement and that proficiency in athletics is related to fast body movement. These conclusions were derived from reaction time measures. It is debatable whether faster reaction time responses can be elicited through training.

For many years reaction time and speed of movement were thought to be highly correlated measures, but recent studies have shown these two measures to be uncorrelated and entirely independent. Rarick[138] found that movement time of a normal, highly skilled individual could not be increased to any appreciable degree.

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[136]Cureton, loc. cit.

[137]Keller, op. cit., pp. 146-155.

[138]Rarick, loc. cit.

CHAPTER III

EXPERIMENTAL METHOD

Apparatus

For the reaction time and movement time tests, the apparatus consisted of a response unit, stimulus unit, recording unit, and a stimulus-producing unit. This apparatus was similar to that used by William R. Pierson in his study of fencers.[1]

The response unit. This unit, mounted on a glass assembly, consisted of a reaction key, electronic eye with accompanying light beam, and a card target. Reaction time and movement time were measured with this unit. The reaction key was a standard telegraph key set to .05 inch and mounted at the front of the unit. The electronic eye with accompanying light beam was mounted directly behind and at a distance of eleven inches from the center of the reaction key. A five by eight white card serving as the target was placed two inches behind the light beam of the electronic eye and approximately thirteen inches from the center of the reaction key. This total response unit was mounted on the top of a standard office desk.

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[1]William Russell Pierson, "A Comparison of Fencers and Nonfencers by Certain Psychomotor, Space Perception, and Anthropometric Measures," (unpublished Master's thesis, Michigan State College, East Lansing, 1953), pp. 11-16.

The stimulus unit. One yellow lamp was used as the visual stimulus. It was placed directly behind and on the same plane as the response unit. The light stimulus was directly in front of the subject at approximately waist level. A preparatory set buzzer, the auditory stimulus, was placed at a distance of approximately five feet from the response unit.

The recording unit. The recording unit consisted of a chronoscope and a standard electric time clock. Both were calibrated in .01 second units. Reaction time was recorded by the electric time clock which was actuated on the presentation of the visual stimulus and stopped upon the release of the reaction key. Holding down the reaction key closed the circuit, which was broken when the key was released. Movement time was recorded by the chronoscope, which was activated upon the release of the reaction key and stopped when the light beam of the electronic eye was broken.

The stimulus-producing unit. This unit consisted of two switches which were combined and held in the operator's left hand. One switch incited the visual stimulus while the second switch incited the preparatory set buzzer. Placement of this unit made its operation inaudible to the subjects.

Subjects

Data were collected at Michigan State University from 122 volunteer subjects. These subjects constituted two groups, the athletes and the nonathletes. The nonathletic group was comprised of seventy-five women, of whom thirty-two were enrolled in a beginning tennis class, seventeen in a beginning fencing class, and twenty-six in a beginning swimming class. Of the forty-seven women in the athletic group, eight were varsity tennis players, twelve were varsity swimmers, twenty were field hockey players, and seven were fencers. The subjects ranged in age from seventeen to twenty-six years. The average age of the non-athletes was nineteen years, while the average age of the athletes was nineteen and one-third years. All subjects maintained a freshman, sophomore, junior, or senior class status.

The reaction time and movement time tests were administered during regularly scheduled class sessions during the last three weeks of the spring term of 1956. All data were obtained between the hours of 9 a.m. and 4 p.m. Tests were conducted in the Women's Gymnasium at Michigan State University. The apparatus was installed in a large room. Physical aspects of the room included one entrance door, various desks and chairs, electric lighting, windows lining two walls, and ample floor space. Opportunities for external distractions were as controlled as possible and similar for all subjects. The stimulus and response units were placed on a standard office desk seven feet from the recording and stimulus-producing units. Arrangement of the apparatus made it possible to place the subject within full view of the operator at all times.

Procedure

Each subject was tested individually. To facilitate the process, the subject and operator were locked within the testing room.

The subject was requested to fill out a short personal data questionnaire.[2] Assuming a comfortable position at the desk, facing the front of the stimulus and response units, the subject was given verbal instructions which emphasized the "muscular response."[3] The starting position was standardized by directing each subject to place the middle fingers of her dominant hand on the reaction key, holding it down, and to place her hand and arm to the shoulder in a straight line with the reaction key and target. To insure the proper preparatory set, an electric buzzer was used to present an auditory signal prior to the presentation of the visual stimulus. A short interval interceded the different stimuli. On appearance of the visual stimulus, the subject was instructed to move her hand from the reaction key directly forward toward the target and through the beam of the electronic eye. This action constituted one complete trial. A careful demonstration of the desired response followed the verbal instruction.

Thirty-five consecutive reaction time measures and thirty-five movement time measures were obtained from each subject. No rest periods were taken between trials. The time interval or foreperiod between the auditory signal and the visual stimulus was either one, two, three, or four seconds, as recommended.[4] The sequence in which these intervals were presented between trials was randomly selected and the same for

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[2]Appendix A.

[3]Charles S. Myers, A Text-Book of Experimental Psychology (third edition; New York: Longmans, Green and Co., 1926), p. 125.

[4]Floyd L. Ruch, Psychology and Life (third edition; Chicago: Scott, Foresman and Company, 1948), p. 466.

each subject. Complete testing procedures lasted a maximum of ten minutes for each subject. The data were recorded by the operator on the subject's questionnaire card.

Statistical Methods Employed

Arithmetic means were computed for movement and reaction time scores of each subject, using the last twenty trials as recommended. The difference in means for reaction and movement time between athletes and nonathletes was tested for significance by using the critical ratio.

Within the athletic group, analyses of variance with corresponding F test of significance were used to determine if the four sport groups were from a homogeneous or heterogeneous population. Rank-difference coefficients of correlation were computed for each sport to measure the degree of association between reaction and movement time rank and coach-assigned ability rank.

For nonathletes, analyses of variance by letter grade were computed for each sport. An additional computation, the Student small sample "t", was used to test the hypothesis that a significant difference in the means of reaction and movement time during and after menstruation was nonexistent. Product-moment coefficients of correlation were computed to determine the relationship between reaction and movement time.

CHAPTER IV

RESULTS

Athletes and Nonathletes

To allow for practice scores to be excluded, and to simplify statistical computations from the raw data, the last twenty trials of each subject were used to compute the individual mean.[1] Averaging the forty-seven athletes' scores produced a mean reaction time of 0.2482 seconds, while the seventy-five nonathletes' mean reaction time was 0.2735 seconds. That the difference between the athletes and non-athletes mean reaction time was highly significant, was revealed by a critical ratio of 5.04. (P = less than 0.01.) The hypothesis that this difference can be attributed to chance is thus rejected. Similar results were found regarding mean movement times. The athletes showed a mean movement time of 0.2746 seconds, and the nonathletes, 0.2979 seconds. The significance of the difference in the means was demonstrated by a critical ratio of 4.85. (P = less than 0.01.) The differences between the mean reaction and movement times of the two groups were 0.0253 and 0.0233 seconds respectively.

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[1]William Russell Pierson, "A Comparison of Fencers and Nonfencers by Certain Psychomotor, Space Perception, and Anthropometric Measures," (unpublished Master's thesis, Michigan State College, East Lansing, 1953), p. 87.

Burley[2] and Hubbard[3] found reaction time of male athletes faster than nonathletes. Beise and Peaseley's[4] study dealing with reaction time of skilled and unskilled women showed similar results. Pierson[5] discovered a significant difference between male fencers and nonfencers in speed of movement. A difference in reaction time means was shown although it was not significant. The results of this study would tend to support the findings of these investigators. It should be noted, however, that reaction time comparisons between men and women have never been attempted.

From the writer's observations, it appeared that the motivation factor influenced the responses of the athletes to a greater degree than those of the nonathletes. Fast reaction time was based upon the instantaneous perception of the visual stimulus, whereas movement time response followed and was an extension of the reaction time response. It is possible, therefore, and more logical to assume that motivation affected reaction time to a greater extent than movement time. On the other hand, it is feasible that athletes excell in speed of reaction because of an unknown innate quality which may or may not be motivation.

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[2]L. R. Burley, "A Study of the Reaction Time of Physically Trained Men," The Research Quarterly, XV (October, 1944), pp. 232-239.

[3]Alfred W. Hubbard, "Peripheral Perception and Reaction Time," (Chicago: American Association of Health, Physical Education, and Recreation Research Section, 1956), pp. 1-6. (Mimeographed.)

[4]Dorothy Beise, and Virginia Peaseley, "The Relation of Reaction Time, Speed, and Agility of Big Muscle Groups to Certain Sports Skills," The Research Quarterly, VIII (March, 1937), pp. 133-142.

[5]Pierson, op. cit., pp. 1-99.

Another possibility suggests athletes' excellence can be attributed to training. There is evidence to support this hypothesis, as there is evidence to repudiate it.

The movement time results confirmed the research findings of Pierson.[6] The motivation factor may have operated to a lesser degree in these results.

Athletes

Reaction time. Within the athletic group, analysis of variance with corresponding F = score of only 1.327 indicated that the tennis, fencing, swimming, and field hockey groups were from a homogeneous population in so far as reaction time was concerned. The mean reaction time scores for the four sports were tennis 0.2356, fencing 0.2404, field hockey 0.2505, and swimming 0.2572. Results of the analysis of variance are shown in Table I, page 35.

Although no significant differences among the four sports were observed, the resulting mean reaction time scores indicated a trend which would confirm the findings of Cureton and Beise and Peaseley. Cureton[7] found swimmers, as compared to various champion athletes, demonstrated slowest total body reaction time; whereas Beise and Peaseley[8] observed tennis players as the fastest reactors when compared with

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[6] Ibid.

[7] Thomas K. Cureton, Physical Fitness of Champion Athletes (Urbana: The University of Illinois Press, 1951), pp. 94-102.

[8] Beise and Peaseley, loc. cit.

TABLE I

ANALYSIS OF VARIANCE OF REACTION TIMES
OF 47 ATHLETES IN 4 SPORTS
GROUPS OF VARIOUS SIZES

Source of variation	Degrees of freedom	Sum of squares	Mean square
Total	46	.03330	
Between sports means	3	.00282	.000940
Within sport	43	.03048	.000708

F = 940/708 = 1.327, not significant for 3 and 43 df at the 0.05 level.

TABLE II

ANALYSIS OF VARIANCE OF MOVEMENT TIMES
OF 47 ATHLETES IN 4 SPORTS
GROUPS OF VARIOUS SIZES

Source of variation	Degrees of freedom	Sum of squares	Mean square
Total	46	.0087	
Between sports means	3	.0046	.00153
Within sport	43	.0041	.00010

F = 153/10 = 15.3, significant for 3 and 43 df at the 0.01 level.

archers and golfers. Of the four sports tested in this study, it should be noted that swimming is the sport that varies widely from the other three.

The results of the rank-difference coefficients of correlation showed that no significant relationship existed between any of the ranked individual reaction time scores and their assigned ability rank within the sport. The resulting rho coefficients are shown in Table III, page 37.

Movement time. In disagreement with the reaction time results by sport, an F = score of 15.3 indicated that the four sports groups were not from the same population and the difference in means was significant at the one per cent level of confidence. The mean movement time of the four sports were field hockey 0.2669, fencing 0.2752, tennis 0.2757, and swimming 0.2895. The analysis of variance is shown in Table II, page 35.

It appears that the type and amount of physical activity is related to speed of movement. Field hockey, as compared with fencing, tennis, and swimming, is a continuous running game involving constant change of pace. The tennis and fencing sports tend to be "start and stop" type of activities. In contrast, swimming conditions require entirely different types of movement. The training period involved for most varsity sports evidently had little effect upon the results, as evidenced by the fact that only in one sport--tennis--were the athletes actively engaged in competition or training during the testing period of three weeks. The further possibility exists that the athletes comprising the

TABLE III

MOVEMENT AND REACTION TIME RANK-DIFFERENCE CORRELATIONS OF ATHLETES IN 4 SPORT GROUPS; MEANS OF SPORTS

Sport	N	Mean MT	Mean RT	MT rho*	RT rho*
Tennis	8	.2757	.2356	-.0952	.3095
Swimming	12	.2695	.2572	-.4340	-.0909
Fencing	7	.2752	.2404	.5358	-.3541
Field Hockey	20	.2649	.2305	.2357	.2781

*None of these values are significant at the 0.05 level other three groups were individually engaged in other sports activities aside from varsity competition. Rarick[9] concluded that speed of movement possessed by an individual cannot be increased to any appreciable extent. This would assume that the quality is innate. The four rank-difference coefficients of correlation between ranked movement time scores and assigned ability ranks within tennis, swimming, fencing, and field hockey groups were not significant. The rho for each sport is shown in Table III, page 37.

The results of both movement time and reaction time rank-difference correlations indicated that individual scores and ability were not correlated. These results may have been affected by women who were highly proficient in other sports activities, but ranked as to ability in only one. It is a frequent occurrence to find a woman athlete proficient in various sports, which enables her to compete the year around.

Nonathletes

Reaction time. The F= ratio in the analysis of variance by letter grade for each sport course was not significant. In computing the data, letter grades affected by student absences were excluded. This necessitated the use of a smaller number of subjects within the swimming group. The mean scores for each letter grade by course are shown in Table V, page 40. The F= scores for tennis, swimming, and fencing are indicated in Table IV, page 39. Within each of the three sports,

[9]Lawrence Rarick, "An Analysis of the Speed Factor in Simple Athletic Activities," The Research Quarterly, XXIII (December, 1951), pp. 89-105.

TABLE IV

ANALYSIS OF VARIANCE OF REACTION AND MOVEMENT TIMES
OF NONATHLETES IN VARIOUS LETTER GRADE GROUPS

Groups compared	Number of subjects	Source of variation	Degrees of freedom	Sum of squares	Mean square	F = score
Tennis Reaction time	32	Total	31	.015266		
		Between letter grade means	2*	.000399	.0001995	
		Within letter grade	29	.014867	.0005126	
Tennis Movement time	32	Total	31	.015911		
		Between letter grade means	2*	.001366	.000683	1.361
		Within letter grade	29	.014545	.000501	
Swimming Reaction time	25	Total	24	.022358		
		Between letter grade means	2*	.000113	.000056	
		Within letter grade	22	.022245	.001011	
Swimming Movement time	25	Total	24	.022954		
		Between letter grade means	2*	.000705	.000353	
		Within letter grade	22	.022249	.001011	
Fencing Reaction time	17	Total	16	.015393		
		Between letter grade means	1*	.000809	.000809	
		Within letter grade	15	.014584	.000972	
Fencing Movement time	17	Total	16	.014232		
		Between letter grade means	1*	.000440	.000440	
		Within letter grade	15	.013792	.000919	

*Generally grade groups of A, B, and C; hence, 2 df except in fencing where all were A and B; hence, 1 df.

TABLE V

COMPARISON OF MEAN REACTION AND MOVEMENT TIMES OF NONATHLETES RECEIVING VARIOUS LETTER GRADES

Sports	Measurement	Course Grade A	B	C
Tennis	Reaction Time	.2673	.2594	.2661
Tennis	Movement Time	.2891(32)*	.3059	.2979
Fencing	Reaction Time		.2702	.2872
Fencing	Movement Time	(17)	.2956	.2950
Swimming	Reaction Time	.2636 (25)	.2[illegible]86	.2813
Swimming	Movement Time	.3009	.2686	.3039

*Number of subjects are shown in parenthesis.

there was no evidence that indicated a trend toward the "A" students being faster than the "B," the "B" faster than the "C," or the "C" faster than the "D" or "F" students. The mean scores varied among letter grade groups, but no trends were observed.

Movement time. The movement time and reaction time data were similarly computed. Again the letter grade groups for tennis, fencing, and swimming constituted random samples from a homogeneous population. That the letter grade group means of each sport did not differ significantly among themselves was indicated by the F= scores in Table IV, page 39. The letter grade means by course are presented in Table V, page 40.

These reaction and movement time results would be expected to occur under conditions not affected by chance sampling. In dealing with women, letter grades are often based upon measures other than performance, skill, or innate ability. The interest of the student enrolled in an activity class of the type tested plays a large role in determining her final grade, as well as affecting her performance and skill within the class. It is natural to assume that letter grades would vary to a greater degree than reaction time or movement time, due to their subjectivity. In contrast, it is not illogical to assume that the interest factor would also operate when reaction and movement times were tested. Again this motivation factor possibly affected both the letter grades and the test scores, only one, or neither.

Menstruation

An additional computation was made to determine if menstruation affected reaction and movement time scores. The Student small sample technique was applied to the difference between the means of fourteen paired observations. The difference between the means when menstruating and not menstruating was not significant for either reaction time or movement time as demonstrated by "t" values of .377 and .214 respectively. Both values were entered with thirteen degrees of freedom. The movement time mean when menstruating was 0.2825 seconds; when not menstruating the same measure was 0.2799 seconds. The reaction time means were similar, 0.2506 when menstruating and 0.2464 when not menstruating.

Faster mean movement and reaction time responses were elicited when the group was not menstruating. These results may show a trend, but it is also probable that these faster responses were the results of practice. Throughout the testing procedure, if menstruation was observed on the first test, the subject was retested after this period. The non-menstrual data were collected from the second test.

Correlation of Reaction Time with Movement Time

To determine the relationship between individual reaction times and movement times, product-moment coefficients of correlation were computed for the athletes and nonathletes. The resulting correlation coefficients for the athletes and nonathletes were 0.267 (P= between 0.05 and 0.01), and 0.251 (P= 0.05) respectively. Although both correlations between these two functions were very low, they were statistically significant.

In independent studies, Henry and Trafton,[10] Henry,[11] Pierson,[12] and Slater-Hammel[13] found reaction time and speed of movement to be uncorrelated and entirely independent functions. The slight indication of correlation found in this study would tend to contradict the findings of the above investigators. It should be pointed out that the studies mentioned above were conducted using male subjects; therefore, the possibility exists that sex differences were operating in this study.

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[10]Franklin M. Henry, and Irving R. Trafton, "The Velocity Curve of Sprint Running," The Research Quarterly, XXII (December, 1951), pp. 409-421.

[11]Franklin M. Henry, "Independence of Reaction and Movement Times and Equivalence of Sensory Motivators of Faster Response," The Research Quarterly, XXIII (March, 1952), pp. 43-53.

[12]Pierson, loc. cit.

[13]A. T. Slater-Hammel, "Reaction Time and Speed of Movement," Psychological Abstracts, XXVIII (July, 1954), p. 510.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

The reaction time and movement time of forty-seven women athletes and seventy-five women nonathletes were measured on an electronic apparatus. The resulting data were statistically analyzed.

The athletes were further studied by comparing the reaction time and movement time scores of four sport groups: eight tennis players, seven fencers, twelve swimmers, and twenty field hockey players which comprised the total group. Also, within each sport group, the women were ranked by ability and these data compared to similar ranked reaction and movement time measures.

Reaction and movement time scores and letter grades achieved by the nonathletes in three instructional courses, tennis, swimming, and fencing, were also compared.

The effect of menstruation on reaction time and movement time measures was determined from comparison of fourteen paired observations. Also, the relationship between reaction and movement time was determined.

Conclusions

From the statistical analysis of the data, the following conclusions were drawn:

1. Women athletes are significantly faster than women nonathletes in speed of arm movement.

2. Women athletes are significantly faster than women nonathletes in finger reaction time.

3. In comparing a small number of cases, menstruation has no measurable effect on speed of movement or speed of reaction.

4. Reaction time is not correlated with coach-assigned ability position within tennis, swimming, fencing, or field hockey.

5. Movement time is not correlated with coach-assigned ability position within tennis, swimming, fencing, or field hockey.

6. Within the athletic group, tennis players, swimmers, fencers, and field hockey players do not differ significantly in reaction time measures.

7. Within the athletic group, tennis players, swimmers, fencers, and field hockey players differ significantly in speed of movement. They ranked as follows: field hockey, fencing, tennis, and swimming.

8. Nonathletes' reaction time in tennis, swimming, and fencing is unrelated to achievement as measured by letter grade.

9. Nonathletes' movement time in tennis, swimming, and fencing is unrelated to achievement as measured by letter grade.

10. Within the athletic group, a significant correlation exists between reaction time and movement time.

11. Within the nonathletic group, a significant correlation exists between reaction time and movement time.

Recommendations

1. A study should be conducted to ascertain the effect of training on the reaction and movement times of women.

2. A study should be designed to discover the effects of menstruation on reaction time and movement time.

3. Reaction time and movement time measures of men and women should be compared.

4. Champion women athletes should be tested in relation to reaction and movement time.

5. A study of total body reaction and movement times of women should be conducted.

6. Sports activities requiring varying degrees of physical activity should be compared.

7. The results of this research should be verified by a similar study.

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APPENDIX A

1. Subject Questionnaire Card

RT	MT	RT	MT

Name ______________________ Date __________

Age ______ Ht. ______ Wt. ______ Student No. ______

Major Field ______________________

Repeating this class? ______________________

Previous high school participation in sports other than a required class? Explain on the reverse side.

College participation in sports other than a required class?

Intramurals ______________________ Years ______

Varsity ______________________ Years ______

Other organized competition? Explain on the reverse side?

Hours of sleep last night? ______________________

Menstruating at present? ______________________

Any illness recently? (last few days) __________

Reaction-Movement Time

APPENDIX B

1. Raw Scores of Athletes

2. Raw Scores of Nonathletes

TABLE VI

RAW SCORES OF ATHLETES

Sport	Subject	RT	MT	Sport	Subject	RT	MT
Fencing	1	.239	.253	Field Hockey	1	.273	.256
	2	.202	.273		2	.265	.274
	3	.264	.293		3	.243	.248
	4	.268	.260		4	.247	.253
	5	.200	.280		5	.244	.296
	6	.292	.304		6	.238	.226
	7	.218	.264		7	.264	.236
					8	.256	.238
Swimming	1	.248	.274		9	.228	.261
	2	.256	.298		10	.226	.264
	3	.231	.298		11	.326	.314
	4	.252	.286		12	.296	.256
	5	.282	.295		13	.220	.250
	6	.248	.254		14	.283	.280
	7	.264	.264		15	.254	.271
	8	.297	.292		16	.239	.268
	9	.252	.292		17	.214	.240
	10	.268	.354		18	.202	.262
	11	.271	.278		19	.234	.325
	12	.218	.290		20	.258	.280
Tennis	1	.218	.254				
	2	.244	.234				
	3	.224	.308				
	4	.219	.298				
	5	.239	.256				
	6	.228	.268				
	7	.257	.279				
	8	.256	.309				

TABLE VII

RAW SCORES OF NONATHLETES

Sport	Subject	RT	MT	Sport	Subject	RT	MT
Tennis	1	.258	.296	Fencing	6	.244	.276
	2	.266	.291		7	.303	.328
	3	.296	.314		8	.276	.356
	4	.266	.308		9	.306	.292
	5	.280	.292		10	.296	.278
	6	.274	.291		11	.270	.306
	7	.260	.350		12	.316	.283
	8	.217	.312		13	.248	.288
	9	.252	.296		14	.318	.298
	10	.264	.332		15	.270	.254
	11	.264	.286		16	.252	.291
	12	.254	.270		17	.258	.266
	13	.316	.348				
	14	.238	.260	Swimming	1	.235	.257
	15	.250	.262		2	.262	.294
	16	.258	.296		3	.326	.282
	17	.267	.288		4	.261	.322
	18	.234	.330		5	.308	.270
	19	.239	.294		6	.261	.303
	20	.272	.278		7	.273	.320
	21	.243	.274		8	.335	.290
	22	.248	.274		9	.282	.303
	23	.273	.304		10	.267	.315
	24	.262	.296		11	.277	.301
	25	.292	.308		12	.318	.296
	26	.228	.268		13	.245	.264
	27	.266	.306		14	.300	.292
	28	.258	.304		15	.260	.310
	29	.313	.318		16	.342	.298
	30	.258	.302		17	.262	.302
	31	.274	.326		18	.276	.278
	32	.266	.265		19	.294	.278
					20	.316	.304
Fencing	1	.270	.264		21	.263	.268
	2	.246	.265		22	.290	.288
	3	.344	.295		23	.256	.358
	4	.300	.361		24	.350	.404
	5	.247	.302		25	.250	.293
					26	.218	.271