7-1935

A Study in Comparison of Foot and Hand Reaction Time of Women Athletes and Non-Athletes

Helen Anna Lengyel

A STUDY

IN

COMPARISON OF FOOT AND HAND REACTION TIME OF WOMEN ATHLETES AND NON-ATHLETES

20

A THESIS

Submitted in Partial Fulfillment of the

Requirements for the Degree of

Master of Arts (in Psychology)

By

HELEN ANNA LENGYEL

B.A., University of Maine, 1927

Graduate Study

University of Maine

Orono

July, 1935

TABLE OF CONTENTS

LIST OF TABLES

SUPPLEMENTS

A STUDY IN COMPARISON OF FOOT AND HAND REACTION TIME OF WOMEN ATHLETES AND NON-ATHLETES

I

Preface

This study is based upon experiments carried out by the writer with the assistance of fourteen undergraduate women students at the University of Maine for the purpose of studying:

1. The relationship between the reaction time of the foot start or crouching start as in running events, and the voluntary reaction of the hand to a given stimulus.

2. The constancy of this relationship in the individual and in the group.

3. The central tendency and variability of the reaction times of the athletes in comparison with the non-athletes.

4. And the extent to which learning affects this reaction time and the variability.

It was originally planned to use for this experiment sixteen undergraduate girls, eight in the athletic group and eight in the non-athletic group. However, unforseen circumstances lowered this number in the non-athletic group to six, then to five, thus making the total subjects of the experiment fourteen and later thirteen.

These girls were selected at random from all classes and classified according to their participation or non-participation in extra curricular physical activities. Since the University of

Maine Department of Physical Education does not offer track athletics for women, and none of the girls had been coached previously, the subjects had no knowledge of the accepted methods used in starting. Their general physical condition based on their medical and physical examinations upon entering college falls within the A and B group in comparison to C and D which are the lowest in this grading. Age varies from seventeen to twenty-one, the mean being nineteen years and six months. Height varies from four feet two inches to five feet eight, the mean being five feet two and one-fourth inches. Weights are from $104\frac{3}{4}$ to 187 pounds, and the mean weight is 130 pounds, 10 ounces. Lung capacity varies from 170 to 240 cubic inches in the case of athletes, and 175 to 208 in the case of non-athletes. The group's mean lung capacity is 200 cubic inches.

The subjects according to college classes are:

3 Seniors
2 Juniors
4 Sophomores
5 Freshmen

Up to the time of the experiment their range in academic grades in all subjects was from 1.23 to 2.64 with the mean grade of 2.13 for the group. Of these the athletic group was slightly higher.

Most subjects tested were at the top of their classes in extra-curricular activities. Some carried as many as five, six, seven, and eight activities respectively, while only two, among the non-athletic group, did not take any part in extra-curricular activities. Table No. I on the following page summarizes this information for each individual and for the entire group.

Table No. I
Summary of Information Concerning Subjects

Athelete	Age	Height (in.)	Weight (lbs.)	Lung Capacity (cu. in.)	Medical Grade	Blood Test Haemoglobin	Year in College	Grade Aver.	Extra-Curricular Activities	Activity for which Remuneration was made	Athelete
1	20- 8 mo.	63.75	127	210	A	80%	Sen.	2.63	4	1	1
2	18-11	63.75	116.9	193	B	90%	Soph	1.77	6	1	2
3	19- 3	60.7	104.12	170	A	80%	Jun.	2.25	4	1	3
4	21- 8	65.3	116.	200	B	80%	Sen.	2.61	4	-	4
5	18- 9	66.2	137	235	A	90%	Fresh	2.00	5	3	5
6	19-11	67.7	138.3	230	A	90%	Jun.	1.85	2	1	6
7	18-11	60.4	116	215	B	85%	Soph	2.26	7	1	7
8	19-10	66.1	187	240	B	80%	Fresh	1.75	1	-	8
Mean	19- 8	64.25	129.3	211.62				2.14	4.1	2	Mean
Non-Ath.											Non-Ath.
1	20- 4	66.5	123.4	196	B	70%	Soph	2.08	8	-	1
2	18-11	62.25	153.8	175	A	85%	Fresh	1.23	0	-	2
3	18- 9	63.62	122	208	B	60%	Fresh	2.13	1	-	3
4	18	62.74	151.3	180	B	90%	Fresh	2.55	0	1	4
5	20- 4	60.5	128.8	175	A	85%	Soph	2.41	2	2	5
6	20- 3	58.2	105.8	175	B	75%	Sen.	2.41	4	1	6
Mean	19- 4	62.25	131.7	184.8				2.13	2.6	.66	Mean
Group Mean	19- 6	63.25	130.10	200				2.135	3.35	1.33	Group Mean

Acknowledgments are gratefully made to Dr. Charles A. Dickinson for his kind and valuable suggestions in regard to the subject offered and for methods in the experiment proper; to Dr. Edward N. Brush for his suggestions and guidance in tabulating the data, and to the fourteen women students who so generously gave their time and subjected themselves to the experiment.

CHAPTER II

Literature

Reaction time is that interval in a motor performance during which the external stimulus is received by the sensory receptor and acted upon by the affected member of the body part (end organ) thus producing movement.

The program of speed of reaction itself is old, and earlier experimentation was directed to the exact measurement of a definite type of reaction. This consisted in a simple measurement of the response of the hand to a definite stimulus such as light or sound. From the various reaction time experiments, beginning with Wúndt and still being carried on, has been developed the general law that the time of the reaction varies inversely with the intensity of the stimulus. Another significant fact evolves: the time of reaction differs from one individual to another. These individual differences appear to be sheer speed differences. According to Griffith:

> Reaction time is due in part to the inertia of the nervous system and in part to the time it takes for a nervous impulse to travel from one part of the system to another. Other things being equal, the more complex the path to be traversed in the nervous system, the longer the reaction time.[1]

Ach[2] states that the essential factor in determining the difference

---

[1]Griffith, C.R., Psychology of Athletics. Chapter IX, p. 153. New York: Charles Scribner and Son, 1929.

[2]Quoted from Henmon, Archives of Psychology. No. 30, p. 30.

in reaction time in different individuals is the "observer's" attitude toward the intention to react in his relation to the stimulus or to the movement. According to Dodge,[1] though, this intention is affected not only by shortening or lengthening the stimulus, but by fatigue, and inhibition, and this in turn may be affected by environment, interaction, and a number of other factors. Evans[2] claims that distraction increases the reaction time in both trained and untrained subjects and apparently is never overcome. Furthermore, some investigators[3] hesitate to make a definite statement as to just which is the real reaction time in the crouch start position since the body is making four contacts with the ground in the "get set" position, and the contact is broken for a right handed individual first with the left hand, then the right hand, right foot and then left foot.

If reaction time is affected not only by the strength and duration of the stimulus, but attention, emotion and intellect, will science ever be able to control it so it can, within reason, predict what will happen under given conditions?

What makes some automobile drivers sometimes do the right thing in their control of wheel and brakes, and at other times

---

[1] Dodge, R., Human Variability. Yale University: Institute of Human Relations, 1931.

[2] Evans, T. E., "The Effects of Distraction on Reaction Time." Archives of Psychology. No. 37.

[3] Tuttle, W. W. and Bresnabau, G., "An Apparatus Measuring Starting Time in Foot Races." Research Quarterly. IV:2, (May, 1933).

experience sad results because the turning of the wheel or stepping on the brake was "just a fraction of a second" too late? Repetition decreases reaction time, but Professor James,[1] and later Meumann[2] a long time ago pointed out that there is no transfer of training from one activity to another except in training of closely related functions and then only to a small degree. It is hardly probable that drivers of automobiles would deliberately train themselves in such reactions.

Various studies on intelligence tests bring out individual differences in speed. These tests in the earlier studies utilized strict time limits. While there is time limit in the later studies, it tends to be more liberal. Thorndike[3] suggested an analysis of ability into level, range, and speed. Garrett's[4] experiments bring to light the fact of an optimal speed for each individual. For example, accuracy of judgment is related to quickness in making the judgment. Bernstein[5] concludes against the "speed" factor independent of intelligence, meaning that the individual who is fast in one operation will not necessarily be fast in another. The opposite

---

[1]Pillsbury, W. B., Education as the Psychologist Sees It. P. 290.

[2]Meumann, Psychology of Learning. Pp. 347-364.

[3]Thorndike, "The Effect of Practice in the Case of Purely Intellectual Function." American Journal of Psychology. XIX:374. (1908).

[4]Garrett, Henry E., "Study of the Relation of Accuracy to Speed." Archives of Psychology. No. 56.

[5]Bernstein, E., "Quickness and Intelligence." British Journal of Psychology. Monograph Supplement. No. 7, (1934).

opinion is held by Farnsworth, Seashore, and Tinker[1] who failed to find any relationship between simple speed processes and intelligence test scores.

Lanier in his studies, "Interrelations of Speed of Reaction Measurements," concludes:

> The amount of correlation between measurement of speed of reaction tends to vary somewhat directly with the similarity in the postural and affector mechanisms involved in any pair of reactions correlated. Such results are unintelligible on the basis of view that an individual possesses a constant grade of neural conductivity which operates uniformly to determine speed in all types of activities. Such results are perhaps expected on the hypothesis that speed in a given act depends upon the integration of nerve impulses from the higher motor centers which may be differentially affected by variation of posture, in the source and nature of the stimulus, in the effector organ involved and in the pattern of response required in the situation. A type of neural organization which would function rapidly in one situation might well operate slowly in another type of activity, in which the rhythms of discharge from the several higher motor centers presented greater 'difficulty' with respect to the physiological resolution occurring in the excitation of the lower motor centers directly controlling the act.[2]

An almost unlimited number of scientific studies have been made in recent years by students of psychology and physiology on speeding up, controlling and measuring reaction time which are related to the present investigation. These studies have been especially stimulated since track activities have become more popular.

---

[1] Farnsworth, P. R., Seashore, R. H., and Tinker, M. S., "Speed in Simple and Serial Action as Related to Performance in Certain Intelligence Tests." Journal of Genetic Psychology. (1927). Pp. 537-551.

[2] Lanier, L. H., "Interrelations of Speed of Reaction Measurements." Journal of Experimental Psychology. (1934). Pp. 371-399.

A large number of these studies is concerned only with one phase of reaction time, namely, reduction of the time element involved in the different phases of reaction. To be able to correct and eliminate unnecessary movements by producing in the athlete a mental and nervous set, which will stimulate his efforts toward this end, is the ambition of all athletic trainers. In this phase of experimentation the efforts are being directed toward the improvement of the mental and physical coordination of the track "start" so that less time in this phase will affect the total activity. To this end various instruments and pieces of apparatus have been set up in order to measure more accurately the response movements.

H. Nakamura[1] made a study on reaction time of track runners in which he found that varying the time interval between the calling of the "get set" and the firing of the gun caused a variation of the reaction time. He approached the problem from three different angles:

1. The study of the simple reaction time by measuring the time elapsing between the sound of a hammer and the release of a key by the left index finger.

2. A study of starting reaction time as influenced by the length of time elapsing between the command, "get set," and the firing of the starting gun.

---

[1]Nakamura, H., "An Experimental Study of Reaction Time." Japanese Journal of Psychology. III:11, (1928), pp. 231-262. Translated by Hugh Chan and W. W. Tuttle. Published by University of Iowa as a Studies Supplement to the Research Quarterly of the American Physical Education Association.

3. A study of the starting time of a subject as in (2) but when there was a competitor as in an actual race.

In addition to the above problems the following factors were recognized but were not included in the experiment:

a. The effect of the fluctuations of attention on reaction time.

b. The effect of fatigue on reaction time.

In order to record the instant that the gun was fired the trigger was equipped with an electrical contact from battery current, which started a chronoscope. The hands of the subject rested on these contacts which stopped the chronoscope when the hands were lifted from the ground.

The most important techniques involved in the experiment were the shooting of the gun and the reading of the chronoscope. The experimental racing track was arranged so as to duplicate actual racing track conditions. The chronoscope was inside and was connected by wires to the gun trigger and to the contacts on which the subject's hands rested. In order to eliminate the element of fatigue each subject was given five minutes rest after each reading.

Ten subjects were used and ten readings for each subject of which the average and average differences were taken. In comparing the simple reaction time with that of the starting time Nakamura found that the first was always faster. The smallest percent difference was 3.57 and the largest 73.76. The mean percent difference was 35.08.

Nakamura claims that the difference in the time elements involved in comparing the two above tests was due to the facts:

1. In the starting time the entire body must be moved while in the simple reaction time only the finger is raised. Lanier stated this same point in more technical language. It is restated here for emphasis:

> .....A type of neural organization which would function rapidly in one situation might well operate slowly in another type of activity, in which the rhythms of discharge from the several higher motor centers presented greater 'difficulty' with respect to the physiological resolution occurring in the excitation of the lower motor centers directly controlling the act.[1]

2. Since the simple reaction time depends on a hammer for its stimulus and the starting reaction time on the firing of the gun, there must be some variation of the two to the strength of the stimuli. The individual variations, that is, the individual differences - some being motor and others sensory responders - were probably due to the habit of reaction. This distinction has been made by Griffith.[2]

Nakamura's most important finding in connection with this study was the optimum time between the "get set" signal and firing the gun. When the mean variations were considered, he found that these were at their lowest point at 1.5 seconds. In one second the attention

---

[1]Lanier, L. H., "Interrelations of Speed of Reaction Measurements." Journal of Experimental Psychology. (1934), pp. 371-398.

[2]Griffith, C. R., Psychology of Athletics. P. 156. New York: Charles Scribner and Son, 1928.

was not at its height; in two seconds the attention was fluctuating. Furthermore, the mean variation showed that the responses were more consistent when the time interval of 1.5 seconds was used.

In his third experiment, the influence of competition on starting reaction time, he alternated the subject, first recording his starting reaction time, then after a little rest repeating the experiment with a competitor running beside the subject. The data show that five out of ten subjects who ran with competitors showed decrease in reaction time, and the five remaining subjects increased their time. However, for the group the competitive starting reaction time was 2.99 percent faster than the individual starting reaction time.

W. R. Miles'[1] experimentation with timing devices for determining the reaction time of athletes was confined to football men. He found that if a man is quicker than the average in lifting his finger in response to a pre-arranged signal, he probably will not be slowest in football charging, but he may be slower than the average - thus disproving the common assumption that speed in one physical activity is proof of speed in another. He also made a study of the correlation of reaction and coordination speed with age in adults[2] and found that the twelve adult subjects (average age 79 years)

---

[1]Miles, W. R., "Studies on Physical Exertion." Research Quarterly. Vol. II, (1931), pp. 5-13.

[2]Miles, W. R., "Correlation of Reaction and Coordination Speed with Age in Adults." American Journal of Psychology. 1931. Vol. 43, pp. 377-391.

averaged 29-30 percent slower than the general mean for the group as a whole on the same test (mean age 48). One fourth of the oldest subjects were, however, as quick or quicker than the average for the total group. There is a better retention for preferred hand dexterity than of non-preferred hand facility in the very old.

H. V. Gaskill[1] found that the simple reaction time is slower when the stimulus occurs at the beginning of breath inspiration than when given during the inspiration or expiration.

M. F. Washburn, K. Keller, K. B. New, and A. M. Parshall[2] made a study of the relation of reaction time to temperament. They found the tendency for extraverts was to make a quicker reaction than introverts to noise stimuli.

B. R. Philips[3] in his studies on reaction time of children aged nine to sixteen years found that 1. Boys' reaction time was generally quicker than girls', especially to sound; 2. Girls' reaction to light, however, is quicker than boys'; 3. Above ten years all reaction is retarded except to sound when warning is given; 4. This stage is followed by a speeding up of reaction after eleven years; 5. A rather rapid rise for girls occurs after

---

[1]Gaskill, H. V., "The Relation of Reaction Time to Phase of Breathing." Journal of Experimental Psychology. (1928). 11:364-69.

[2]Washburn, M. F., Keller, K., New, K. B., Parshall, A. M., "Experiments on the Relation of Reaction Time to Temperamental Differences." American Journal of Psychology. (January, 1929), 41:112-17.

[3]Philips, B. R., "Reaction Time of Children Nine to Sixteen Years." American Journal of Psychology. (July, 1934), XLVI:3, pp. 379-396.

fifteen, probably due to a period of retardation for girls just before this period, because of adolescence, as boys do not show such tendency; 6. For the group of older children a definite speeding up of reaction time occurs. In spite of this, girls, however, show a definite slowing up of reaction time. This difference is probably due to the greater activity of boys in their play; 7. When fatigue is compared with practice the former is more apparent. He further finds that there is no correlation between mental age and reaction time, but certain innate abilities such as intelligence and memory improve with age, also that some motor abilities develop even when there has been no training; hence, maturation is a factor in learning.

There is a study of motor reaction of athletes and non-athletes by Marvin Steen of the University of Wisconsin, referred to by Husband,[1] which seems to prove that athletes stand high in certain types of reaction as evinced in his "Pursuit Rotor" test which calls for an eye-hand coordination. Track men were poorest except in a "serial discrimination test." Crew men seem to stand lowest in the scale, because their task does not demand dexterity.

Westerlund and W. W. Tuttle experimented on the running events in track and reaction time and found that the mean reaction of a group of champions, men holding national records, is definitely shorter than that of any group studied regardless of the distance run.

---

[1]Husband, Applied Psychology. Chapter XXV, pp. 591-606. New York: Harper and Brothers.

> Men who are trained to run short distances respond faster than those who specialize in middle distances, while the long distance group responded slower than any of the others.[1]

They selected twenty-two university track men in training. This group included three champions, four short distance men, eight middle distance men and seven distance men. They tested each athlete three different times in seventy-five yard runs recording the best time as their record. In the laboratory the test consisted of responding to a light stimulus by pressing a key. After fifty practice tryouts, fifty responses were taken on each, for a period of ten days, making a total of five hundred tests. Findings are:

The mean reaction time for the champion group is .121 seconds, with a range of .118 to .124 seconds.

For the short distance group, up to 440 yards, the mean is .131 seconds, range .130 to .132 seconds.

For the middle group, including one-half mile, the mean is .149 seconds, range .134 to .156.

For the distance group, including two miles, the mean is .169 seconds, range .155 to .187 seconds.

When the mean reaction time of the champions is compared with the mean of the other groups, it is evident that they responded

---

[1]Westerlund and Tuttle, W. W., "The Relationship Between Running Events in Track and Reaction Time." Research Quarterly. II:3, (October, 1931), pp. 95-100.

definitely faster. When individual means are compared, the data show that the slowest responding champion is .006 seconds faster than the fastest responding subject in any of the other groups.

The coefficient of correlation is .863 between the reaction time and the time record of the seventy-five yards for the whole group. This clearly bears out their conclusion that there is a high degree of relationship between speed in running seventy-five yards and reaction time.

Since Westerlund found a significant relationship between voluntary response as measured by reaction time and running events. Ruth Lautenbach and W. W. Tuttle[1] experimented further to find out "if there was any similar relationship between involuntary response as measured by reflex time and the same event." In this experiment they found that "there is a direct relationship between the reflex time of sprinters and the distance of the race for which they are specially trained. The short distance man has the shortest and the long distance man the longest reflex time."

The technique used for measuring the reflex time of the knee jerk was similar to that of other investigators, such as L. E. Tavis and C. W. Young, in this same field. It consists of a round nosed hammer connected to a dry cell, a signal magnet and a brass

---

[1] Lautenbach, R. and Tuttle, W. W., "The Relationship Between Reflex Time and Running Events in Track." Research Quarterly. (October, 1932), III:3, pp. 138-143.

strip. The brass strip is placed over the patellar tendon and held in place by elastic bands. Stimulation is delivered by means of the hammer which strikes the tendon indirectly (over the brass strip). The impact elicits the knee jerk and at the same time closes the signal magnet circuit thus marking the time of the stimulation.

The subject is seated in a chair so that his legs are free to swing. A kymograph registers the beginning of the response through a string running from the heel of the subject. When the foot moves forward, the stylus is pulled down indicating the time on the kymograph. This apparatus is to some extent similar to the one the present investigator used for reaction time measurement.

Lautenbach used for subjects the same group of twenty men who were used in the experiment by Westerlund. In fact she used his data for this further experiment eliminating one man from each of the first two groups.

She found that the mean <u>reflex</u> time for the champion group, two men, is .1008, the range from .0927 to .1089 seconds. For the short distance group of three men the mean reflex time is .0965 seconds and the range .0851 to .1039 seconds. For the middle distance group of eight men the mean reflex time is .1221 seconds with a range of .1026 to .1365 seconds. The distance group of seven men show a mean reaction time of .1345 seconds with a range of .1004 to .1621 seconds.

This experimenter does not attempt statistical treatment of the data other than the probable error of the means for the individual cases because of lack of a greater number of highly trained subjects.

According to her findings there seems to be a definite relationship between the reflex time of the subjects studied and the distance for which they were specialized, and very little difference between the reflex times in the first two groups, namely, the champion and short distance; but she found that in reaction time the champions were faster. Miss Lautenbach offers as an explanation of this point, the fact that reaction time is a voluntary response while reflex response is involuntary. Thus, due to the nature of the neural mechanisms involved, the former is more readily reduced by training than the latter. Griffith[1] claims that practice does not reduce reaction time, but by eliminating superfluous muscle movement, the response path becomes more direct.

The coefficient of correlation between running speed and reflex time was found to be .815. To determine these data the figures from the entire group of twenty men were used. It is interesting to note that the r .815 is very close to what Westerlund found in reaction time and speed, his r being .863. However, neither of these investigators mentions the possible effects of

---

[1]Griffith, C. R., Psychology of Athletics. P. 155. New York: Charles Scribner and Son.

practice upon these reaction times.

Lautenbach's investigation does not appear to be entirely reliable because of the small number of subjects in two groups. Mean variations for individuals as well as the group are entirely omitted, and the probable errors for the group means are not given because of the small number of cases.

It seems to have been difficult for all the experimenters mentioned to obtain a large enough number of subjects. The reason, perhaps, as is the case in the present experiment, is that they were testing college groups who are too fully occupied with extra curricular activities to make them reliable subjects, and the time given to the experiments does not permit of a thorough testing. Lanier[1] makes a statement in regard to discrepancies in experimental results as being due to unreliable data, differences of the range of processes studied, experimental errors, and the differences in the homogeneity of the subjects used.

To date there has been very little study on reaction time for women. B. R. Philips[2] in his studies of reaction time for children aged nine to sixteen has compared adolescent girls to adolescent boys and found that girls' reaction time drops just before puberty, and increases just after puberty, but his conclusions

---

[1]Lanier, L. H., "Interrelations of Speed of Reaction Measurements." Journal of Experimental Psychology. (1934), pp. 371-398.

[2]Philips, B. R., "Reaction Time of Children Nine to Sixteen Years." American Journal of Psychology. (July, 1934), XLVI:3, pp. 379-396.

are mostly hypothetical, drawn up only on comparisons with boys of the same age. Furthermore, there is no study made to find if there are differences of reaction time between girl athletes and non-athletes. Kuhrt Wieneke[1] has made a study of boys in "A Comparison of Certain Physical Developments of Freshmen Athletes and Non-Athletes." His experiment was based only on anthropometric measurements, and his selection of men athletes and non-athletes was based on participation or non-participation in freshman athletics.* Therefore, the present study is somewhat unique since it is concerned with women dividing them, nominally, at least, into athletes and non-athletes. The writer recognizes, however, that there may be other and possibly better divisions of these groups which probably would facilitate a more accurate study.

---

[1]Wieneke, K., "Comparison of Certain Physical Developments of Freshmen Athletes and Non-Athletes." American Research Quarterly. (May, 1932), III:2.

* This same decision is made in the Studies of the Carnegie Foundation at Columbia University in 1927.

CHAPTER III

The Problem

The subjects tested reported every day at a definite time and were suitably dressed for physical activities. The testing took place in the University of Maine Alumni Gymnasium balcony track from March 15 to the middle of May, 1932, a period of about two months. The total number of tests made was: crouching start reaction 922, and hand reaction 924. The average number of tests per girl is 70.9 for the first and 71 for the second reaction. The range for the entire group is 30 to 103 tests for the crouch and 31 to 117 for the hand. The cause of this difference is that three of the non-athletes discontinued experimentation at an early date, and three others did considerably less than the average number of performances.

For the foot start the average number of tests a day given each girl is 8.2, the range being from six to twelve tests. Strong effort was made by the experimenter to keep the number of the hand reaction tests within the same range.

Experiment:

The foot start reaction experiment consisted of having the subject assume the regulation crouching start position, placing both feet against the starting block. Her rear foot pressed against the electric contact point on the block, which registered on the kymograph when, after the stimulus was given, the contact was made by the releasing of the key as the foot moved forward. Her two hands placed before her on the ground aided her in the push-off.

Directions were given by the operator before every performance in order to get the subject mentally as well as physically in the "set" position.

The directions consisted of the following words which were given as a formal command, not read, with proper fluctuation of voice:

> This track is twenty-five yards long. You are to run it in the shortest possible time in which you are able.
>
> The record of your time, as to speed, depends on the way in which you "get off," so it is important that every part of your body, every muscle in your body, be set for the signal indicating the moment when you are to go.
>
> At the words "on your mark!" get into a firm but comfortable position.
>
> At the words "get set" stretch your body in order to move your weight further forward, keep your eyes straight ahead down the lane. Control in this position is important. Do your best.
>
> The signal to go will be the clicking of the switch key. Immediately when this sound occurs, you're to start running. Push hard from your fingers and forward foot to enable you to get away more quickly. Run your course in a straight line never slacking your speed till you round the corner. Do your best - run your fastest.

After these directions the subject was allowed to get on her "mark." The starting stimulus to which she responded was the slamming of the switch key by the operator which registered the beginning of the stimulus. The forward motion of her foot indicated the response on the kymograph in one-fifth of seconds.

Between each of these tests, from six to twelve, a few seconds elapsed in order to prepare the subject for her new trial. After that, the subject was tested for hand reaction. In these tests the operator was again careful to develop a proper mental "set" for good reaction as was attempted in the crouching start by giving instructions regularly before each test.

The "get set" position consisted of the subject's placing her right hand on a key which rested on the table. Her feet were slightly apart and her body slightly crouched. From her standing position the subject was unable to observe the kymograph or notice the movements of the operator in preparation for the signal. The kymograph record gave the time elapsing between the slamming of the switch key, as the stimulus, and the lifting of the hand from the key.

This procedure while in the main quite satisfactory had some drawbacks. Since this experiment was carried on in the gymnasium balcony, the subject's attention was at times distracted by sounds below. This probably is the reason that some reaction times were exceptionally long, for experiments have proved that two stimuli simultaneously given delay reaction because of the choice the subject has to make in order to respond. Because of the crowded room situation, which demanded that the entire set-up be taken apart and stored after every experiment, some of the records were spoiled for further study. The space, however, was the best available at the time the experiment was carried out.

Apparatus:

For the experiment, a starting block made under the supervision of Dr. Charles Dickinson of the University of Maine was used. In order to keep it steady, it was placed on the floor against the wall. It consisted of three projected toe rests, one in the center for the rear foot, and one on each side so the subject could use either foot. The electric contact point was attached to its rear toe rest. This was connected by electric wire to four No. 6 dry cell ignition batteries which in turn were connected with a triple fork signal magnet.

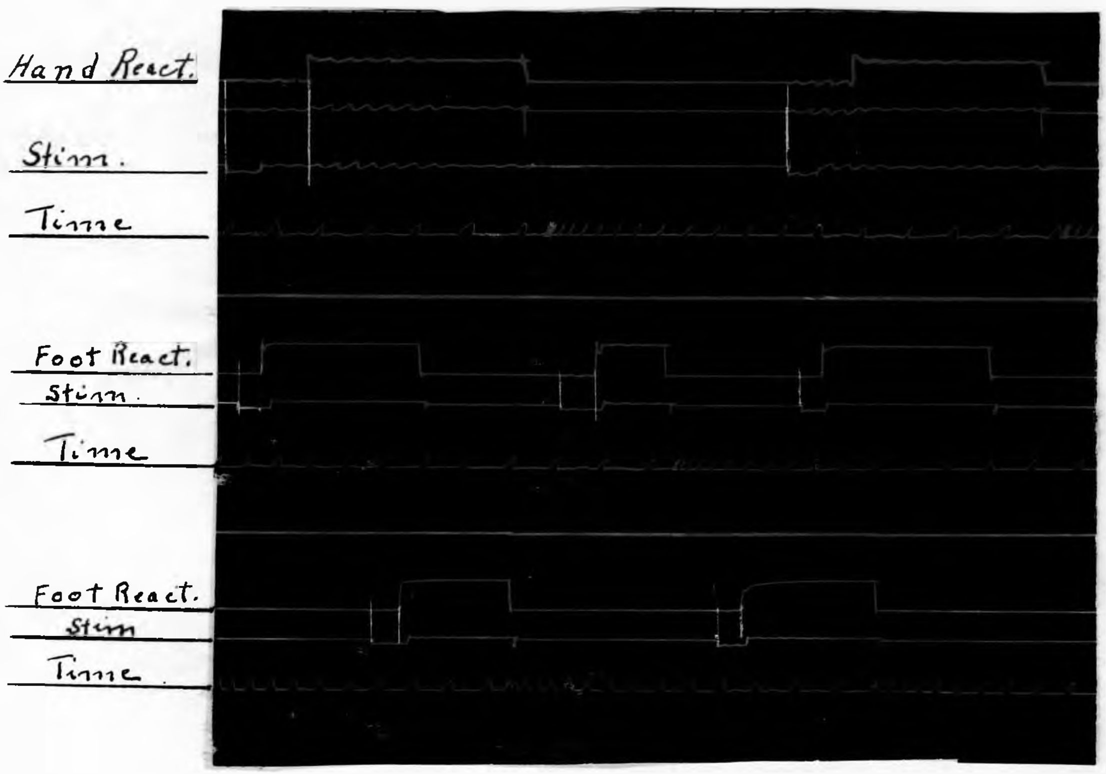
The stimulus was given by the slamming of a switch key which in turn was connected with the middle fork of the signal magnet, so that when the circuit was made by closing the switch key, it registered on the kymograph as the stimulus. As soon as the foot, which in the "get set" position was pressing against the contact point of the toe block, was removed, it registered with the first signal magnet on the kymograph as the response. A Jacquet's Cronomometer Timer* was adjusted beneath the signal magnet in such a way that while the kymograph was slowly revolving it registered the time in one-fifth of a second vibrations.

---

* A Ludwig Kymograph used is an extending type purchased from C. H. Stoclting, No. 22211.

Jackquet's Cronomometer Timer purchased from C. H. Stoclting, No. 20232.

The key for the hand reaction was set up in the same way as the contact point for foot reaction, and was connected with the first fork of the signal magnet.



Photograph of Reaction Time Apparatus.

CHAPTER IV

Results of Experiment

<u>The Learning Process:</u>

The mean reaction time of the fourteen subjects tested for the first fifteen crouch tests is .419 of a second as against that of the athletic group of eight .443, and of the non-athletic group of six .395. Further comparison shows that in the last fifteen foot reactions for the group of fourteen the mean is .345. Of this, the group of athletes shows an average of .372 and the group of non-athletes .318.

For the hand start, which corresponds to Titchner's[1] conception of simple reaction time, the mean reaction on the basis of the first fifteen tests for the group was found to be .153, for the athletes .165, and for the non-athletes .14. During the last fifteen tests of this series the mean was .143, .143 and .14 respectively. These differences are too small to be of significance, but the result seems to show that in both test series the non-athletic group had a shorter reaction than the athletic which is not entirely overcome even with practice. The fact that the mean for both hand reactions for non-athletes is .14, however, seems to indicate that this type will probably reach its maximum of improvement in a shorter time or fewer trials. The athletes, however, may through longer

---

[1]Titchner, E. B., <u>Experimental Psychology</u>. Vol. I, pp. 117-119. New York: McMillan Company.

practice be capable of reducing the time element beyond that of the non-athletic type.[1]

The mean reaction time for thirteen subjects on the total number of tests (800) was .377 for the first and .153 for the second series. The athletic group in this tabulation, too, showed a slower reaction, .381 and .162 for the two series of tests as compared with the non-athletes' .371 and .139.

The individual learning process was further studied by means of graphs[1] in which the first fifteen trials of each individual were contrasted with the last fifteen. During this period approximately two months' time elapsed, and individuals had from thirty to one hundred trials in each series. Since at the beginning of these tests none of the subjects selected had any training in track activities at the University, the figures for the first fifteen trials in all individuals show a definite variability.

During these experiments there was no attempt made to "coach" the subjects in speed. Instructions for getting on the starting block and of pushing off after the given stimulus were merely given in the standard way as the object of these experiments was to measure reaction time.

The reaction time range for the group as tabulated from the first twenty-five tests and last twenty-five tests of each series

---

[1] See Table II following page.
[2] See supplement of graphs

Table No. II
Averages for the First Fifteen
and Last Fifteen Foot and Hand Reactions

Trials	Group First 15 Foot Reactions	Group Last 15 Foot Reactions	Group First 15 Hand Reactions	Group Last 15 Hand Reactions	Athletes First 15 Foot Reactions	Athletes Last 15 Foot Reactions	Athletes First 15 Hand Reactions	Athletes Last 15 Hand Reactions	Non-Athletes First 15 Foot Reactions	Non-Athletes Last 15 Foot Reactions	Non-Athletes First 15 Hand Reactions	Non-Athletes Last 15 Hand Reactions
1	.415	.37	.17	.145	.435	.39	.175	.16	.39	.35	.155	.125
2	.365	.37	.16	.13	.36	.39	.16	.135	.40	.32	.16	.135
3	.42	.325	.15	.14	.435	.38	.155	.145	.42	.24	.155	.14
4	.38	.365	.145	.165	.39	.39	.15	.16	.37	.325	.145	.12
5	.38	.37	.15	.155	.395	.415	.16	.14	.39	.29	.14	.165
6	.43	.345	.145	.15	.45	.37	.165	.145	.405	.31	.115	.115
7	.425	.34	.15	.15	.45	.38	.18	.14	.395	.285	.13	.145
8	.405	.335	.165	.14	.41	.34	.185	.135	.40	.32	.13	.14
9	.405	.355	.155	.155	.435	.39	.185	.14	.375	.285	.11	.165
10	.395	.33	.15	.135	.40	.34	.165	.135	.375	.33	.13	.135
11	.42	.32	.16	.14	.435	.35	.18	.15	.395	.27	.14	.135
12	.48	.34	.145	.135	.435	.315	.135	.155	.455	.36	.145	.125
13	.425	.365	.155	.13	.455	.355	.19	.145	.41	.38	.145	.10
14	.37	.345	.165	.145	.375	.355	.165	.14	.365	.33	.14	.145
15	.395	.37	.14	.14	.40	.38	.15	.155	.38	.38	.15	.13
Mean	.419	.345	.153	.143	.443	.372	.165	.143	.395	.318	.14	.14

shows that among the athletic group No. 4 had the widest range, that is, .10 to .48, the range being .38, while among the non-athletic group No. 1 had the widest, .06 to .30, the range being .24. In the first case no theory is being advanced regarding this slowness of reaction which occurred only once among her fifty tests, but in the second case No. 1 non-athlete's medical examination showed slight hyperthyroidism which probably was the cause of her extremely active nervous temperament manifested in her spasmodically varied extra curricular activities, and probably her reaction time shows this type of mental set. The mean range of the athletic group for the first twenty-five crouch tests is .19 and the non-athletic group .14 for the corresponding performances. The last twenty-five crouch reaction tests show for the athletes a mean range of only .085 while for the non-athletes it is .135. The mean range on the first twenty-five hand reaction tests for the athletic group is .05 and for the last twenty-five it is .047. and .06 and .06 for non-athletes. This seems to illustrate clearly the laws affecting learning pointed out by Warren and Carmichael:

> The Law of Facilitation: As the newly acquired path is strengthened the new response tends to proceed more rapidly.
>
> Law of Elimination or Accuracy: As the new connections improve, there are fewer useless and erroneous movements; the response becomes more precise and more accurate.[1]

---

[1]Warren and Carmichael, Elements of Human Psychology. Pp. 185-200. Houghten Mifflin and Company, 1930.

In contrasting the above findings with the individual records of the athletic group for the first fifteen tests[1] it is obvious that the range of the reaction times has decreased in all but two individual cases during the last tests. These two are Nos. 3 and 5. On the other hand, among the non-athletes only Nos. 1 and 4 show improvement. For the second series of tests among the athletes we found improvement among all but Nos. 5 and 8 while in the non-athletic group only No. 4 shows much improvement.

The range for the last twenty-five crouch trials dropped for No. 1, athlete, from .21 to .07, for No. 2 from .22 to .09, for No. 4, .38 to .10, for No. 6, .15 to .10, for No. 7, .12 to .07 and for No. 8, .18 to .03. Among the non-athletes in this same test the decrease is marked by No. 1 who lowered the range from .24 to .15 and No. 4 who lowered it from .25 to .16. It thus appears that while reaction time seems longer for athletes than non-athletes, the average range of the former shows a definite concentration in comparison with the latter.[2]

Method of Studying Fatigue

The first four tests of each day was compared with the last four of the same day. The individual curves show more marked changes than the curves for the group. In the comparison there seems to be

---

[1]See Table II, p. 29.

[2]Support for this observation will be found in the graphs on the first and last fifteen trials for the athlete and non-athlete groups on pp. X-XIII also on Table III, following page.

Table No. III
Reaction Time Range of Individual Subjects

thlete	Foot Reaction First 25 Tests	Foot Reaction Last 25 Tests	Foot Reaction Range Diff. in first Test	Difference on Last Test	Hand Reaction First 25 Tests	Hand Reaction Last 25 Tests	Diff. on First R.H.	Diff. on Last R.H.	Improvement in [redacted] Reaction R.	Improvement in Hand Re-action R.
1	.10 - .31	.13 - .20	.21	.07	.06 - .12	.06 - .10	.06	.04		
2	.12 - .34	.12 - .21	.22	.09	.06 - .13	.05 -. .10	.07	.05		
3	.10 - .26	.15 - .30	.16	.15	.05 - .11	.07 - .11	.06	.04		
4	.10 - .48	.16 - .26	.38	.10	.06 - .10	.05 - .10	.04	.05		
5	.10 - .23	.13 - .23	.13	.10	.06 - .10	.04 - .10	.04	.06		
6	.11 - .26	.10 - .20	.15	.10	.07 - .11	.05 - .10	.05	.05		
7	.20 - .32	.20 - .27	.12	.07	.04 - .10	.05 - .09	.06	.04		
8	.16 - .34	.19 - .22	.18	.03	.07 - .10	.05 - .10	.03	.05		
m Range fference			.19+	.085			.05	.047	.105	.004
-Ath.										
1	.06 - .30	.08 - .23	.24	.15	.06 - .10	.05 - .12	.04	.07		
2	.15 - .25	.15 - .23	.10	.08	.05 - .09	.04 - .10	.04	.06		
3	.16 - .30	.07 - .25	.14	.18	.04 - .10	.05 - .10	.06	.05		
4	.13 - .38	.14 - .30	.25	.16	.05 - .12	.05 - .10	.07	.05		
5	.15 - .24	.06 - .20	.09	.14	.05 - .10	.04 - .10	.05	.06		
6	.14 - .30	.13 - .24	.16	.11	.06 - .10	.05 - .12	.04	.07		
m Range ference			.16+	.135			.06	.06	.025	No Im

Showing the range of reaction time on the first twenty-five tests in comparison with the last twenty-five.

a contrast between the first and last tests. In so far as the range is concerned it seems to be less varied in the last test of the crouch start. Among the athletes only Nos. 1 and 7 do not show fatigue traces (increase) on the foot reaction time; and among the non-athletes only No. 5 shows no fatigue. In the hand reaction athletes 1, 2, 5, 6, 7, and 8 show no fatigue while only 1, 2, and 3 of the non-athletes show no fatigue.

Observation of the curves for the two groups further shows that athletes do not fatigue as easily as non-athletes, that is, their fatigue curve while rising slightly seems to maintain an almost steady, even line through the last four trials. Among the non-athletes this curve shows a wider range. This, however, cannot be proved conclusively from these tests as the total number of tests each day, six to twelve, is probably not sufficient in either case to show marked degree of fatigue. See Table No. IV.[1]

Table No. IV
Fatigue Trends Based on the First Four and Last Four Readings of Each Day for the Two Tests

Tests	First Foot Reaction			Last Foot Reaction			First Hand Reaction			Last Hand Reaction		
	Aver. of Group	Aver. of Ath.	Aver. of Non-Ath.	Aver. of Group	Aver. of Ath.	Aver. of Non-Ath.	Aver. of Group	Aver. of Ath.	Aver. of Non-Ath.	Aver. of Group	Aver. of Ath.	Aver. of Non-Ath.
1	.38	.39	.37	.39	.42	.375	.155	.17	.135	.15	.155	.14
2	.40	.415	.385	.385	.385	.385	.14	.155	.135	.155	.155	.145
3	.395	.385	.36	.395	.41	.38	.14	.16	.135	.15	.165	.13
4	.36	.385	.325	.41	.42	.395	.155	.16	.145	.165	.16	.165

[1]See also graphs on pp. XIII-XV in supplement.

Comparisons of Variability

Comparisons on the measurements of variability were also made of the first twenty-five and last twenty-five reactions. Unfortunately, the data of this study are only complete for the athletic group, and for as many of the non-athletic group as have a sufficient number of tests to allow of a comparison.

On the comparison of the measurement of variability[1] to establish the individual and group reaction time as it deviates from the mean or arithmetic average, it was found that on the first twenty-five foot reaction tests for the athletes the mean variation ranges from .030 to .114, the average of these being .063. For the second twenty-five foot tests the mean variation ranges from .026 to .053, the mean is .043 and the difference between these averages is .02. For the group on the first twenty-five reaction tests the mean variation ranges from .030 to .114 with an average of .065. On the last twenty-five foot reactions the mean variation ranges from .026 to .07. The average mean variation is .045 and the difference between the averages is .02.

Comparing the second series of tests, namely, the hand reaction time, it was found that the range of mean variation for athletes' hand reaction on the first twenty-five tests is from .021 to .032. The average is .026. On the second twenty-five tests the mean variation range is .021 to .028, and the average is .023. The

[1]Data for these findings are shown in tables V and VI on the following page.

Table No. V
Comparisons on the Measurement of Variability

Subject	Foot reaction mean for first 25 tests.	Mean Variation Range.	Foot reaction mean for last 25 tests.	Mean Variation Range.	Difference of Mean Variation.	Hand reaction mean for first 25 tests.	Mean Variation Range.	Hand reaction mean for last 25 tests.	Mean Variation Range.	Difference of Mean Variation.
Athlete										
1	.425	.084	.367	.048	.036	.178	.023	.145	.028	.005
2	.40	.038	.334	.042	.04	.166	.028	.154	.027	.001
3	.397	.030	.398	.033	.03	.186	.025	.174	.03	.005
4	.369	.114	.362	.043	.071	.142	.028			
5	.365	.045	.335	.050	-.005	.173	.027	.137	.021	.006
6	.428	.063	.329	.040	.023	.167	.032	.144	.024	.008
7	.52	.070	.49	.053	.017	.145	.024	.147	.026	.002
8	.405	.061	.394	.026	.035	.17	.021	.15	.028	.007
Non-Ath.										
1	.308	.104				.158	.035			
2	.348	.038				.121	.034			
3	.408	.055	.296	.070	.015	.157	.031	.165	.031	.00
4	.459	.093				.133	.044			
5	.376	.056				.145	.032			
Group	.40	.065	.356	.045	.02	.154	.029	.15	.024	.005
Athlete	.41	.063	.376	.043	.02	.165	.026	.131	.023	.003
Non-Ath.	.38	.058	.296	.070	.12	.143	.035	.165	.031	.004

Contrasting the first twenty-five and last twenty-five tests. Showing mean, mean variation and difference of mean variation for athletes, non-athletes and the group.

Table No. VI

	Average of M.V. first 25 Foot Reaction	Average of M.V. last 25 Foot Reaction	Difference of M.V. Aver. for Crouch Tests	Average of M.V. first 25 Hand Reaction	Average of M.V. last 25 Hand Reaction	Difference of M.V. Average for Hand Reaction Tests
Athlete	.063	.043	.0	.026	.023	.003
Non-Athlete	.058	.070		.035	.031	.004
Group	.065	.045	.0	.029	.024	.005

Showing average mean variation and average mean variation differences for the three groups.

difference between these averages is .003. The range of mean variation for the whole group is from .21 to .044, and the mean variation is .029 on the first twenty-five tests; and the last twenty-five hand reactions show mean variations of from .021 to .031 differing from the average of the first tests by .005.

In order to determine the relationship between speed of the foot reaction and speed of hand or simple reaction on the total number of tests (800) the product moment method of computing correlation coefficient was used. This was found to be .546±.028. The standard deviation, σy, for the hand reaction is .036, σx, for the foot reaction is .099. These findings indicate two definite trends: 1, that there is a fair correlation between these two types of reaction as indicated by r and σr; 2, that while the mean difference between the foot and hand reaction is .224, roughly there is about 1/3 as great a variability in the hand reaction as in the foot reaction for the entire group tested. Furthermore, correlations when taken on fifty tests of each series by the Spearman rank order correlation method, P shows that for the group of thirteen subjects it is .46±.22. For the athletes P is .52±.027, and for the non-athletes P is .29±.07. Thus, according to these findings the athletic group has a higher correlation than the non-athletic by .29. However, in these findings we must take into consideration the smallness of the groups studied, especially the non-athletic group which in this test consisted of only five subjects.

CHAPTER V

Discussion

Findings concerning the learning processes in these studies correspond to the findings of previous investigators on simple and starting reaction time. Nakamura[1] in a similar experiment on men athletes found that the mean of the foot start was .182, decidedly slower than the mean for the hand start, .132, both for individuals and for the group. He, however, used ten trained athletes for his experiments. Westerlund and Tuttle's[2] investigation shows a mean reaction time of .169 on the foot start for long distance track men and .121 for the champion track men. Both these studies indicate definitely that learning tends to reduce reaction time. This, the present, experiment shows for the group a mean reaction time of .377 on the foot start and .153 for the hand start. But, is this reaction time always slower in women? The trend of previous studies made seems to indicate that women's reaction time is somewhat slower than that of men.[3] This being so, the findings of the present experiment

---

[1]Nakamura, H., "An Experimental Study of Reaction Time." Japanese Journal of Psychology. III:11, (1928), pp. 231-262. Translated by Hugh Chan and W. W. Tuttle. Published by University of Iowa as a studies supplement to the Research Quarterly of the American Physical Education Association.

[2]Westerlund and Tuttle, W. W., "The Relationship Between Running Events in Track and Reaction Time." Research Quarterly. II:3, (October, 1931), pp. 95-100.

[3]Thompson, H. B., Mental Traits of Sex. University of Chicago Press, 1903.

when compared with Nakamura and Westerlund[1] are a confirmation of the preceding statement. Since there are only a few data available for untrained women's simple and starting reaction time, the findings of this study need more intensive experimentation in order to validate them. Furthermore, it is necessary to have a more accurate classification of athletic and non-athletic types which in this experiment were not clearly defined. What are the characteristics necessary to classify women into these two groups aside from participation in athletics, is in my opinion worthy of further study.

The effect of the learning process upon the range of response times for both individuals and groups as found in this experiment correspond to statements on learning made by psychologists. The present experiment in comparing the averages of the first twenty-five tests with those of the last twenty-five tests for the individuals, athletes and non-athletes, shows that the range is narrowed from .19 to .085 in the case of athletes and from .16 to .135 in the case of the non-athletes. The mean range for both groups is .065. Warren and Carmichael[2] and later Griffith[3] claim in substance that what speeds up reaction time during the learning

---

[1] Refer to footnotes 1 and 2, preceding page (37)

[2] Warren and Carmichael, Elements of Human Psychology. Pp. 185-200. Houghten Mifflin and Company, 1930.

[3] Griffith, C. R., Psychology of Athletics. P. 155. New York: Charles Scribner and Son.

process is, that with practice there are fewer useless and erroneous movements, and the response tend to proceed more rapidly along the neural path.

Findings on the relation of <u>reaction time to fatigue</u> show that there is a definite tendency to fatigue in both groups of subjects. This is more evident in the foot reaction. Fatigue curves in the last four foot reaction tests show a more even, steady climb while in the last four hand reaction tests, they have more variability; also fatigue is less noticeable in the athletic group than in the non-athletic. However, in this experiment the amount of fatigue shown is insignificant, due probably to the too small number of experiments each day to cause an appreciable amount of fatigue, or as some psychologists state; while fatigue tends to increase reaction time, the purely physiological reactions are least affected. Reactions involving "mental factors" are most affected. Thus fatigue in an athlete shows to a greater extent in the way of strategy and mental alertness.[1]

Findings on the <u>comparison of variability</u> show that the athletes tend to be less variable than the group as a whole in both tests. The findings on the non-athletes are not given because of their insufficient number.

Lanier[2] in comparing the variability of thirteen subjects'

---

[1]Griffith, C. R., Psychology of Athletics. P. 162. New York: Charles Scribner and Son.

[2]Lanier, L. H., "Interrelations of Speed and Reaction Measurements." <u>Journal of Experimental Psychology</u>. Pp. 371-399, (1934).

serial reaction time with the serial activity time of thirty-four subjects arrived at the conclusion that the serial reaction time group was more variable than the serial activity test group. His study is somewhat similar to the present experiment in so far as Lanier, too, tested simple reaction time, visual, auditory, and tactual, with some other activities: stylus tapping, Minnesota speed movements, naming colors and naming names of colors, etc. Lanier's study is different from the present experiment in that it compares two different groups whose different homogeneity probably affected the result. The importance of his study to the present is only in its indication that the variability of reaction time is probably different with a different stimulus.

Findings on the <u>relationship of the hand and foot reaction</u> in the present study are in the main supported by other studies made. Lautenbach[1] found that the r between speed in running and reflex time of twenty athletes was .815. Westerlund's[2] findings on twenty-two athletes who were tested for speed in running and reaction time was r .862. Both these experimentations show a fairly high correlation but somewhat unreliable because of the small number tested.

---

[1] Lautenbach, R. and Tuttle, W. W., "The Relationship Between Reflex Time and Running Events in Track." <u>Research Quarterly.</u> III:3, pp. 138-143. (October, 1932).

[2] Westerlund, J. H. and Tuttle, W. W., "The Relationship Between Running Events in Track and Reaction Time." <u>Research Quarterly.</u> II:3, pp. 95-100. (October, 1931).

Lanier found that the correlation between the three types of simple reaction measurements, auditory versus visual $.78 \pm .041$, auditory versus tactual $.64 \pm .046$, visual versus tactual $.76 \pm .50$, is fairly high.

The correlation of the present experiment for the entire group is $.546 \pm .028$, but perhaps the most important finding shown in this study is that when the rank order correlation method is used, the P for the group is $.46 \pm .22$, for the athletes P $.52 \pm .027$, and for the non-athletes P $.29 \pm .07$, indicating that the athletic group has a higher P than the non-athletic.

These findings may imply in general that the athletes while slower in reaction time as a whole seem to have a better integration of motor skills, due probably to transfer of training from other similar muscular activities by which the neural path has been strengthened, thereby decreasing variability. The greater relationship between hand and foot reaction would suggest that even in aspects of reactions which have not been specifically learned, the learning acquired in similar activities might improve or quicken the functioning far beyond those attainable by uninstructed repetition.

CHAPTER VI

Summary and Conclusion

The data presented in this investigation justify the following summary:

1. There is a direct relationship between the reaction time of the foot start of girl athletes and non-athletes and the simple reaction time of the hand as indicated by the r of $.546 \pm .028$.

2. The athletic group has a higher correlation than the non-athletic group.

3. The athletic group shows on both tests a slower reaction time than the non-athletic group. Their mean reaction time shows a difference of .051 in the first test and .006 in the second of the series.

4. The learning process show a negligible difference in the two groups studied when comparisons of the first fifteen tests are made with the last fifteen in each series. It does, however, show that while there is less variability among the athletes than the non-athletes as a group, certain individuals in both groups show an extreme range of variability.

5. Fatigue in both groups is more pronounced after the foot reaction than after the hand reaction, and slightly less noticeable in the athletic group than in the non-athletic. How-

ever, these findings being slight do not affect appreciably the mean of the reaction time.

From the data of these studies the experimenter does not claim more than a tentative conclusion believing that the small number of the subjects studied does not warrant a final conclusion, but that the study of certain phases of reaction time warrants a further study in the reaction time of women athletes and non-athletes, in order to clear up the problem and to determine further whether there are actual differences between these types and between the sexes.

BIBLIOGRAPHY

1. Beck, L.F., "Relation of Speed of Reaction to Intelligence." American Journal of Psychology. 44:793-95, (October 1932).

2. Bovard, John F., Cozens, Frederick W., Tests and Measurements in Physical Education. Philadelphia: W. B. Saunders Company, 1930.

3. Brace, David Kingsley, Measuring Motor Ability. New York: Barnes and Company, 1927.

4. Bresnabau, George, "Study of Movement Pattern in Starting the Race from the Crouch Position." University of Iowa Studies in Physical Education, No. I. Pp. 1-11. Ann Arbor, Michigan: American Physical Education Association, 1934.

5. Chan, S. K., "Reaction Keys and a New Technique for Reading Reaction." American Journal of Psychology. 41:469-73, (1929)

6. "College Athletics and Scholarship." Carnegie Foundation for the Advancement of Teaching. Part III. Twenty-second Annual Report, 1927. Pp. 49-65

7. Dodge, R., Conditions and Consequences of Human Variability. Yale University: Institute of Human Relations, 1931.

8. Evans, T. E., "The Effects of Distraction upon Reaction Time." Archives of Psychology. Volume 17, (1927).

9. Felker, A., "A Study of the Respiratory Habits of Sprinters in Starting a Race." University of Iowa Studies in Physical Education, No. I. Pp. 20-26. Ann Arbor, Michigan: American Physical Education Association, 1934.

10. Gaskill, H.V., "Relation of Reaction Time to Phase of Breathing." Journal of Experimental Psychology. 11:364-69, (October 1928).

11. Griffith, C. R., Psychology and Athletics. Charles Scribner's Sons, New York. 1929.

12. Hausmann, M. F., "New Apparatus for Measuring Choice and Decision." Journal of Experimental Psychology. 15:218-25, (April 1932).

13. Hayden, T. C., and Walker, S.A., "A Comparison of the Starting Time of Runners Using Holes in the Track and Starting Blocks." Research Quarterly. IV:2, pp. 117-23, (May 1933).

14. Hill, Archibald, V., Muscular Activity. Baltimore: William and Wilkins Company, 1926, for the John Hopkins University.

15. Hull, Clark L., Aptitude Testing. Yonkers on Hudson, N.Y.: World Book Company, 1928.

16. Husband, Richard W., Applied Psychology. New York: Harper and Brothers.

17. Johnson, H. M., "Reaction Time Measurements." Psychological Bulletin. 1923.

18. Kelley, Truman L., Interpretation of Educational Measurements. Yonkers on Hudson, N. Y.: World Book Company, 1927.

19. Lanier, Lyle H., "Interrelations of Speed and Reaction Measurements." Journal of Experimental Psycnology. Pp.. 371-99, (1934).

20. Lanier, Lyle H., "Twenty-eighth Annual Meeting of the Southern Society for Phylosoohy and Psychology." American Journal of Psychology. P. 531, (1933).

21. Lautenbach, R. and Tuttle, W. W., "The Relationship Between Reflex Time and Running Events in Track." Research Quarterly. III:3, pp. 138-143, (October 1932).

22. Lemmon, V. W., "The Relation of Reaction Time to Measures of Intelligence, Memory and Learning." Archives of Psychology. No. 94, (November 1927).

23. Lemmon, V. W., "The Relation of Reaction Time to Sensations of Intelligence, Memory and Learning." Archives of Psychology. No. 94, (1928).

24. Miles, W. R., "Correlation of Reaction and Coordination Speed with Age in Adults." American Journal of Psychology. 43:377-91, (1931).

25. Miles, W. R., "Studies on Physical Exertion: II. Individual and Group Reaction Time in Football Charging." Research Quarterly. II:5-13, (1931).

26. Nakamura, H., "An Experimental Study of Reaction Time in Running a Race." Japanese Journal of Psychology. III:11, pp. 231-62, (1928). Translated by Hugh Chan and W. W. Tuttle, University of Iowa.

27. Palmer, Irene, Tests and Measurements. New York: A. S. Barnes and Company, 1932.

28. Philips, B. R., "Reaction Time of Children." American Journal of Psychology. XLVI:3, pp. 379-96, (July 1934).

29. Pilsburry, W. B., Education as the Psychologist Sees It. New York: McMillen Company, 1926.

30. Rounds, G. H., "Is the Latent Time in the Archilles Tendon Reflex a Criterion of Speed in Mental Reactions?" Archives of Psychology. No. 95, (1928).

31. Rugg, Harold, Primer of Graphics and Statistics for Teachers. Boston: Houghton Mifflin Company, 1925.

32. Seward, G. H., "Recognition Time as a Measure of Confidence." Archives of Psychology. No. 99, (1928).

33. Spearman, C., The Abilities of Men, Their Nature and Measurement. New York: McMillan Company, 1927.

34. Starch, Daniel, Educational Psychology. New York: McMillan Company, 1929.

35. Thorndike, E. L. "Variability of an Individual in Repetition of the Same Task." Journal of Experimental Psychology. (1923).

36. Titchner, E. B., Experimental Psychology. Volume I. New York: McMillan Company, 1901.

37. Tuttle, W. W., "Studies in the Start of the Sprint." Research Quarterly. IV:2, (May 1933).

38. Tuttle, W. W. and Bresnabau, S. T., "The Apparatus for Measuring Starting Time in Foot Races." Research Quarterly. IV:2, pp. 110-116, (May 1933).

39. Walker, G. A. and Hayden, T. C., "Optimum Time for Holding a Sprinter Between the 'Set' and the Stimulus." Research Quarterly. IV:2, pp. 124-30, (May 1933).

40. Warren, Howard C. and Carmichael, L., Elements of Human Psychology. Boston: Houghton Mifflin Company, 1930.

41. Washburn, M. F., Keeler, K., New, K. B., Parshall, F. M., "Experiments on the Relation of Reaction Time, Cube Fluctuations, and Mirror Drawing to Temperamental Differences." American Journal of Psychology. 41:112-17, (1929).

42. Wechsler, David, "The Measurement of Emotional Reactions, Researches on the Psychogalvanic Reflex." Archives of Psychology. No. 76, (1925)

43. Westerlund, J. H. and Tuttle, W. W., "The Relationship Between Running Events in Track and Reaction Time." Research Quarterly. II:3, pp. 95-100, (October 1931).

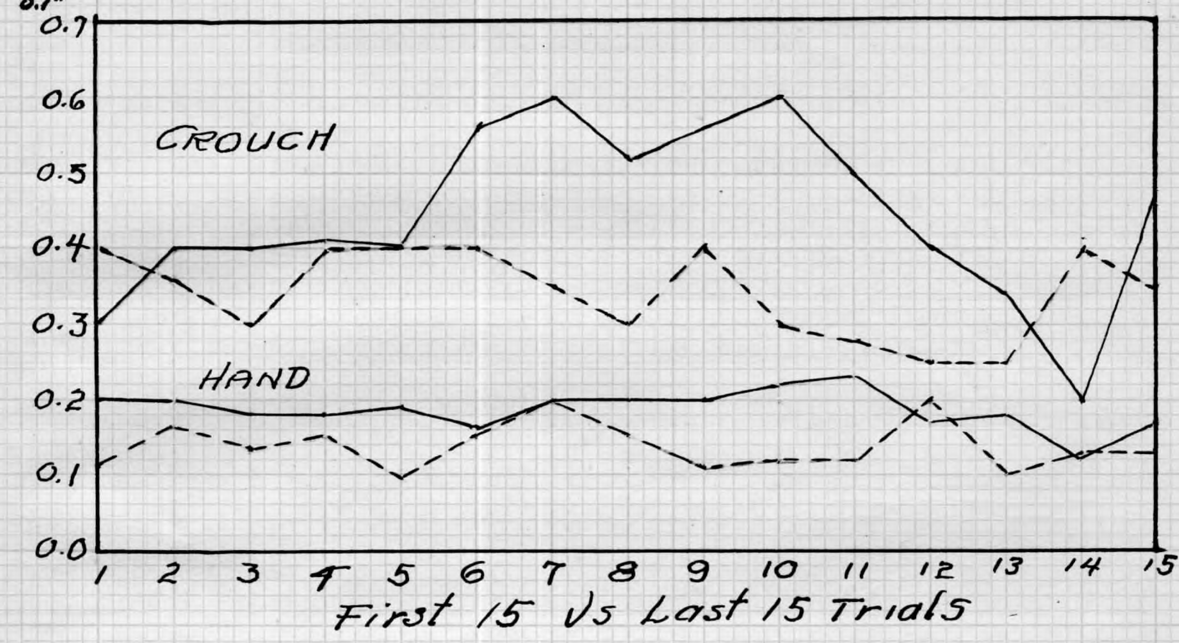
44. Whipple, Guy M., Manual of Mental and Physical Tests--Part I. Baltimore: Warwick and York Inc., 1914.

45. Wieneke, Kuhrt, "Comparison of Certain Physical Developments of Freshmen Athletes and Non-Athletes." American Research Quarterly. III:2, (May 1932).

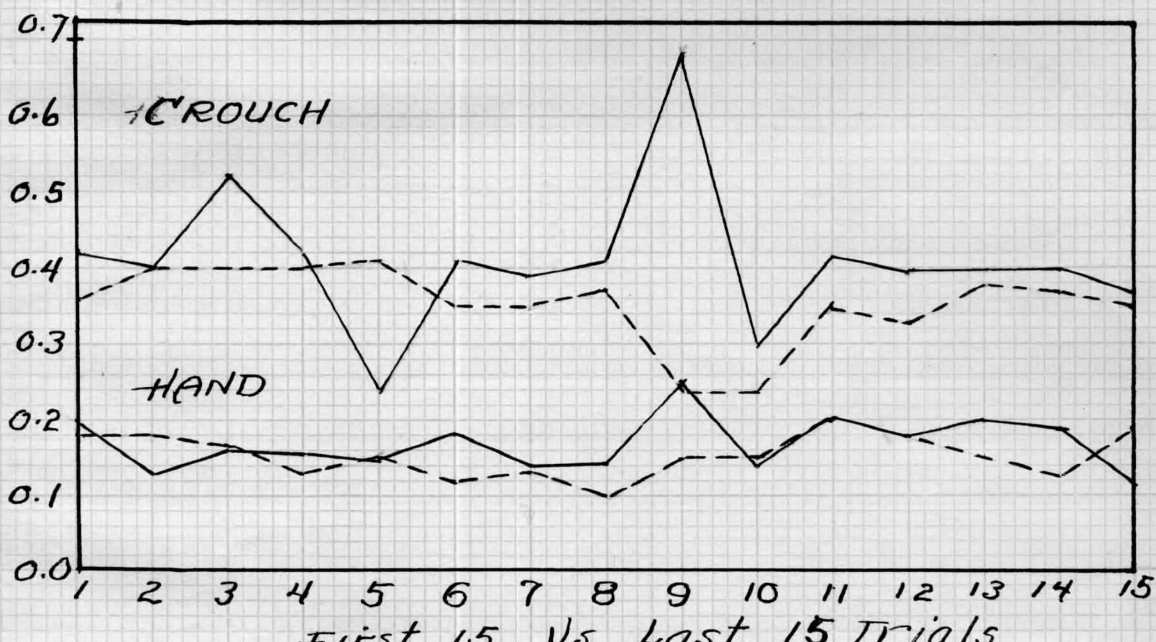
46. Wingate Memorial Lectures. Culkins, Editor. New York: Wingate Memorial Foundation.

47. Wundt, W. M., Grundzuge Der Physiologishen Psychologie. Volume 3, pp. 388-451. Leipzig. Translated by W. Engelman. (1903).

No. 1 ~ ATHLETE



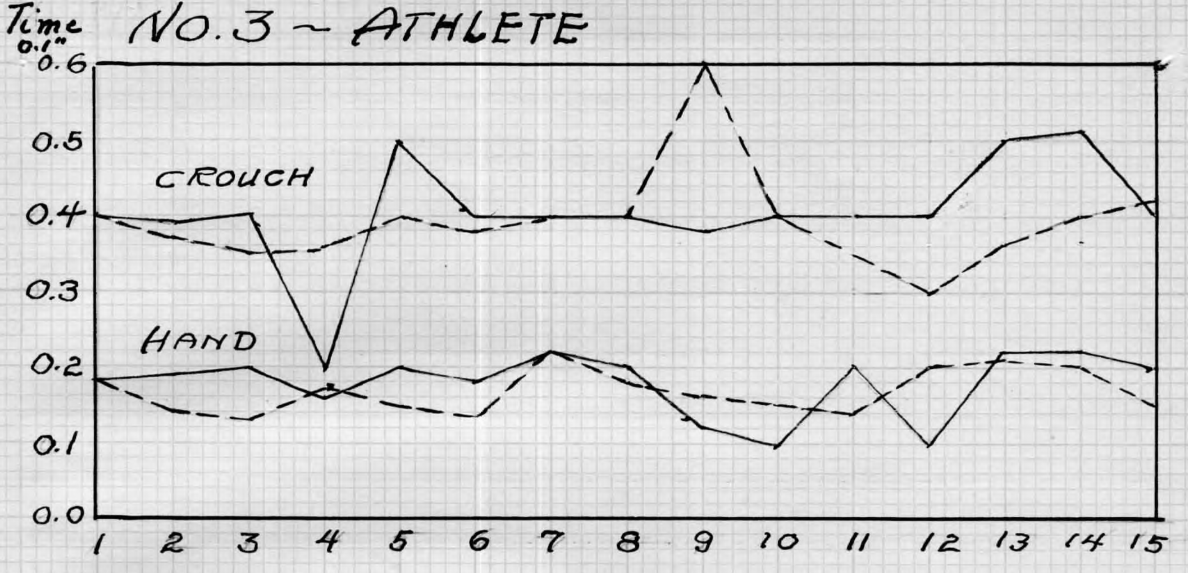
No. 2 ~ ATHLETE



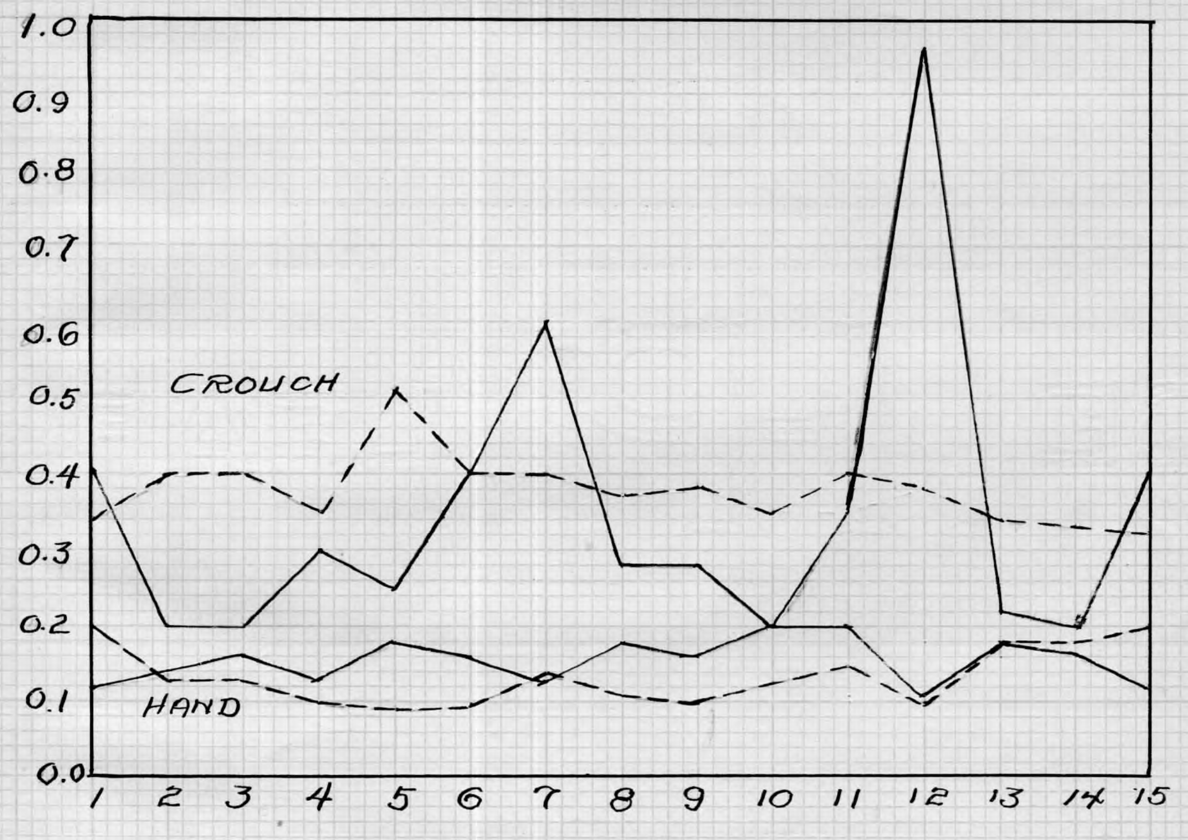
First Indicated by ———

Last Indicated by - - - -

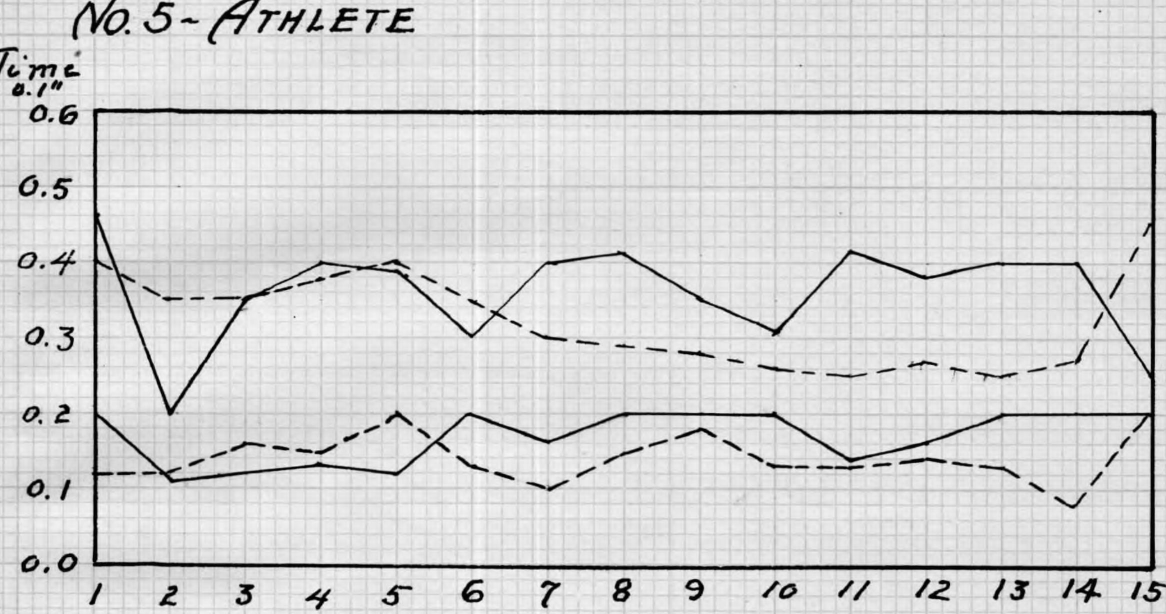
NO. 3 ~ ATHLETE

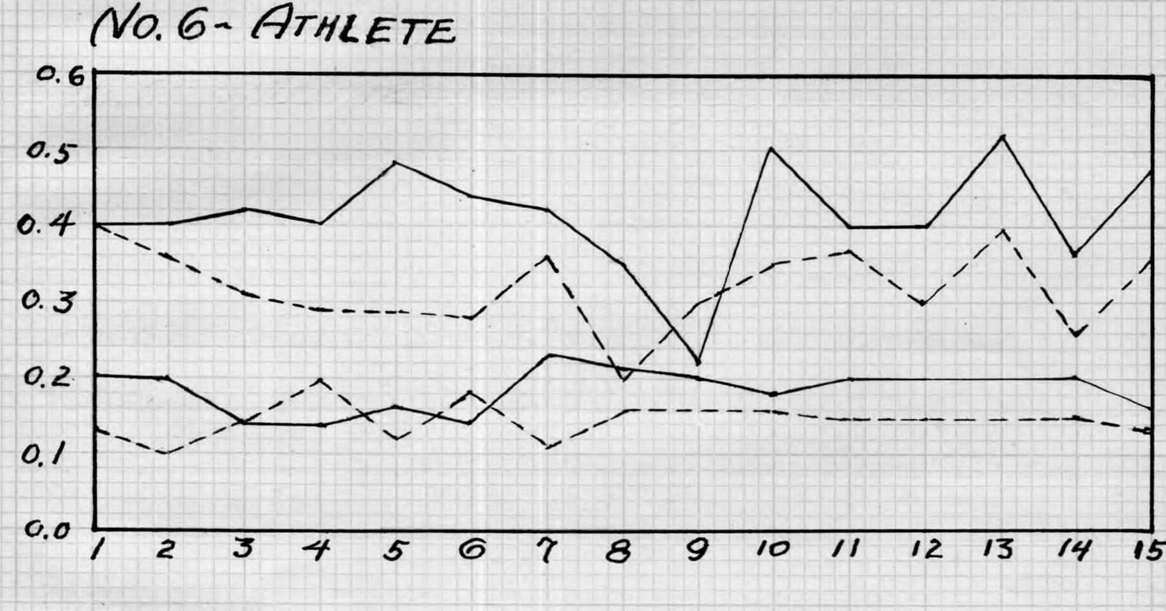


NO. 4 ~ ATHLETE



First 15-Trials Vs Last 15
First Indicated by ——
Last Indicated by - - - -





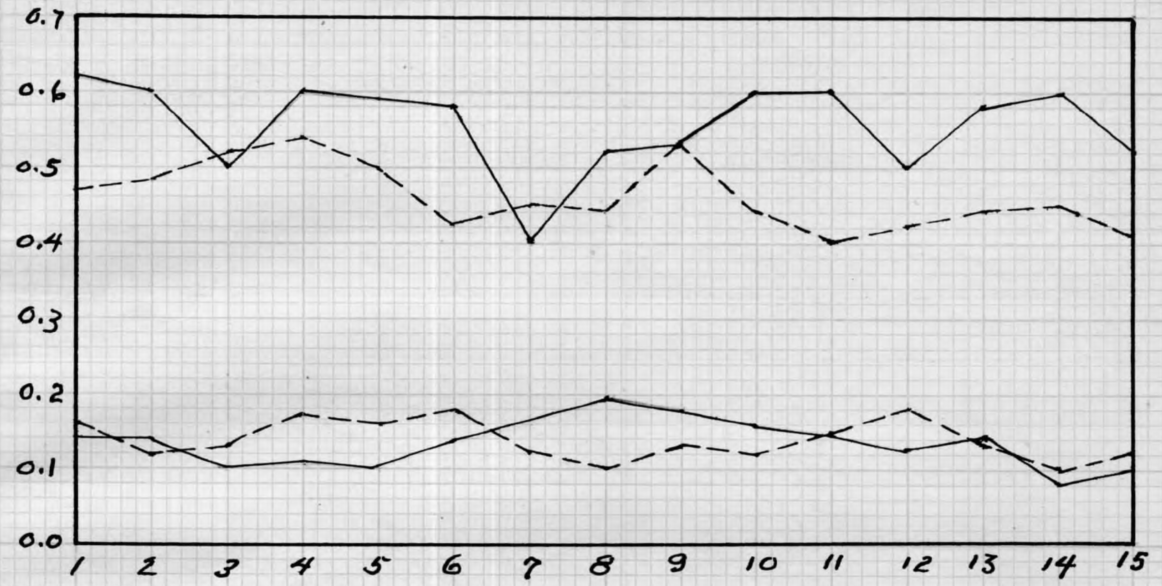
Above - Foot Reaction, First 15 Vs Last 15 Trials

Below - Hand Reaction, First 15 Vs Last 15 Trials

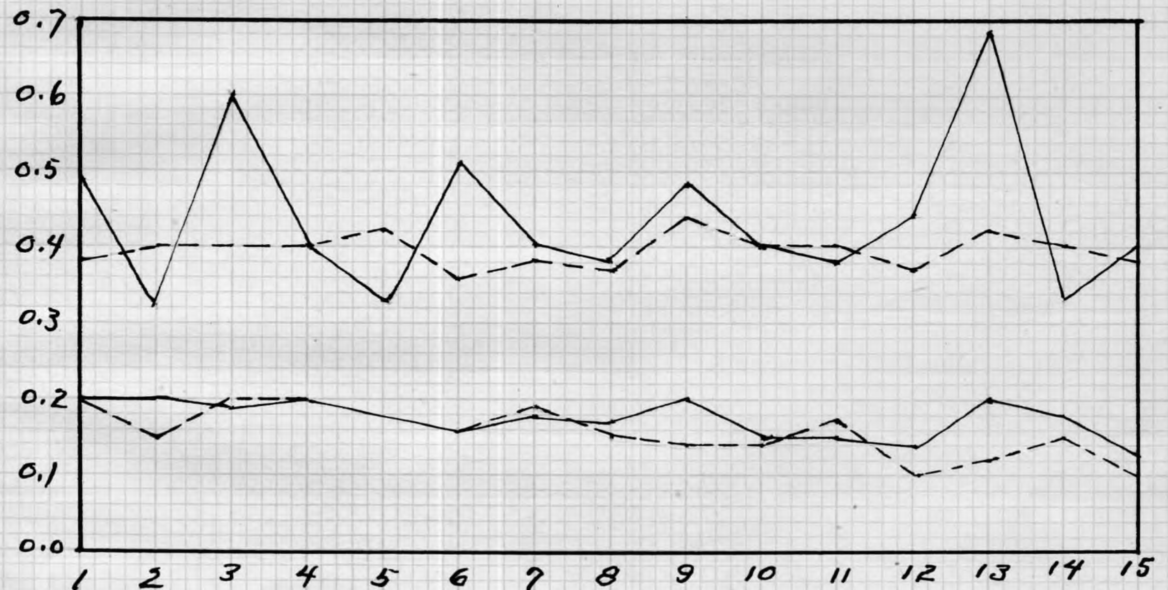
First Indicated by ——

Last Indicated by - - - -

Time 0.1" No. 7 ~ ATHLETE



No. 8 ~ ATHLETE



ABOVE ~ Foot Reaction, First Vs Last Trials

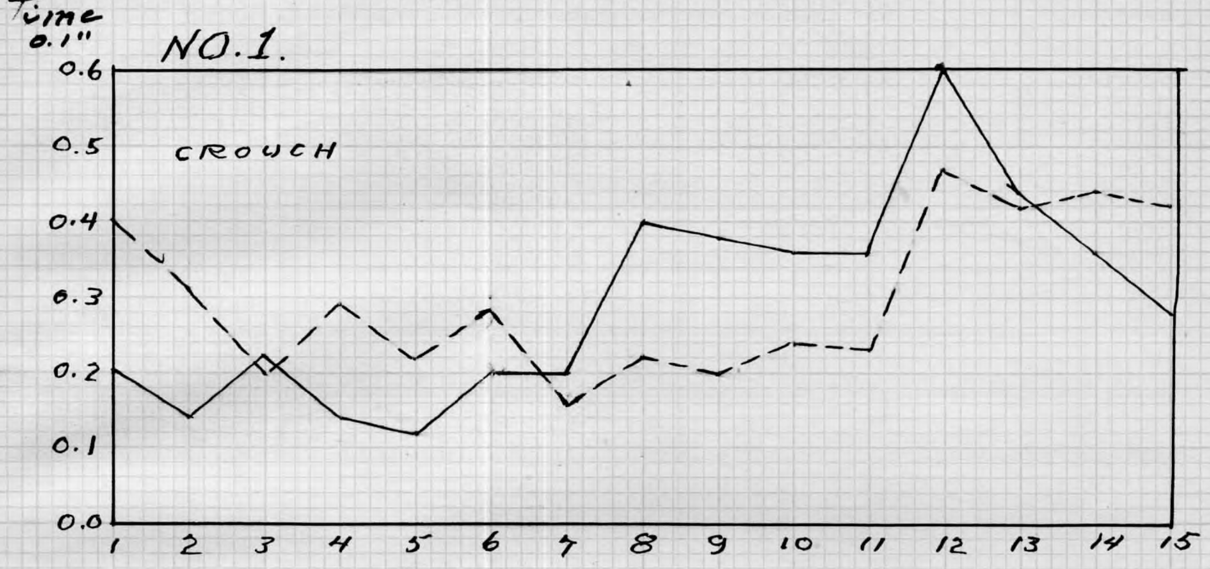
BELOW ~ Hand Reaction, First 15 Vs Last 15 Trials

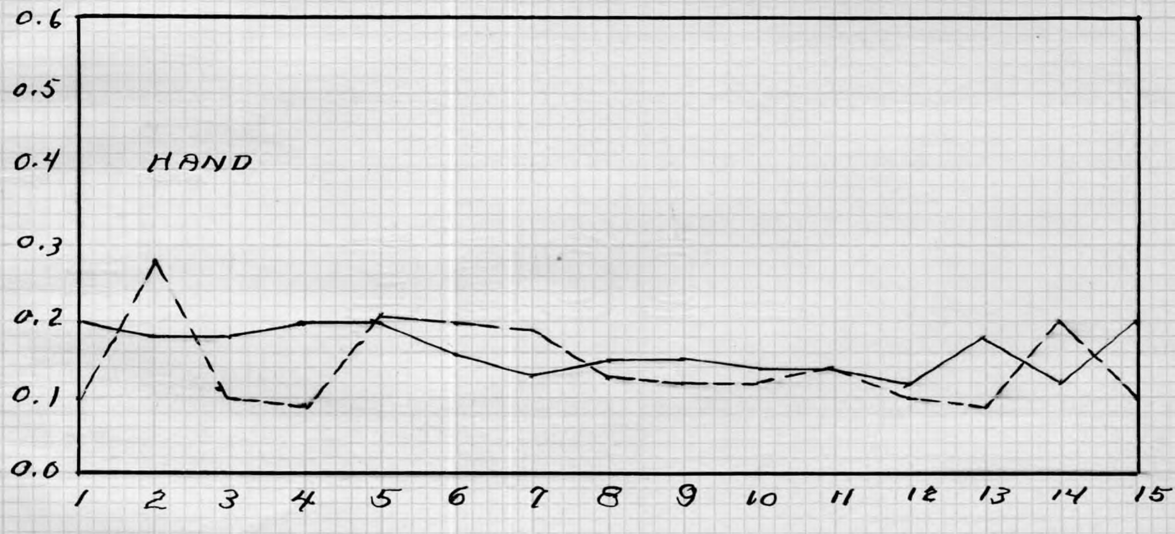
First indicated by ——

Last indicated by - - - -

NON-ATHLETE

FOOT REACTION





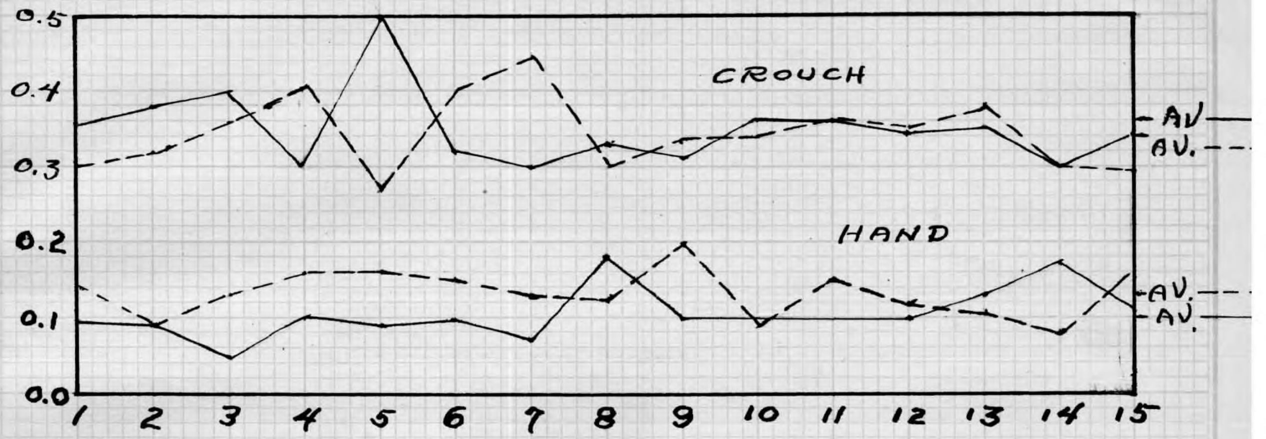
First 15 Vs Last 15 Trials

First Indicated by ——

Last Indicated by - - - -

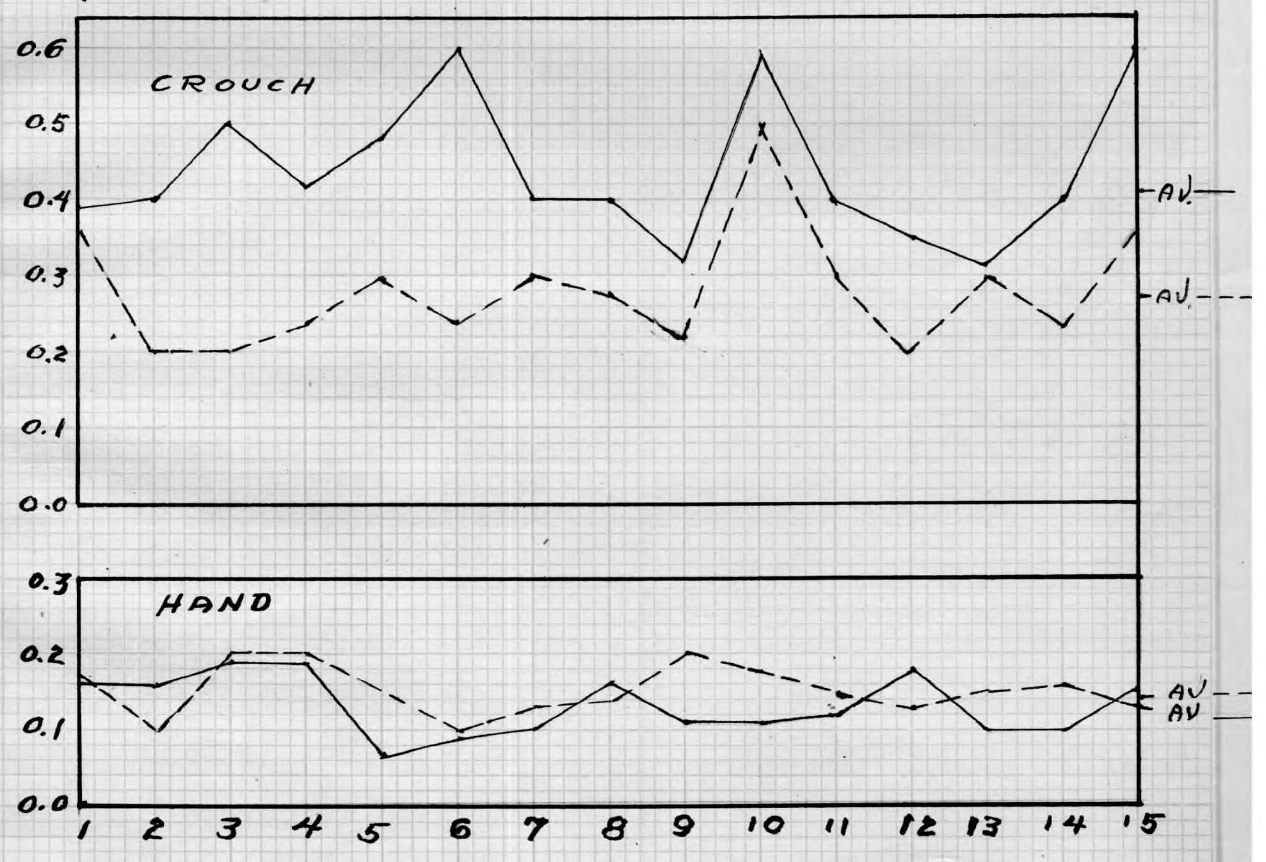
NON-ATHLETE
FOOT REACTION

Time 0.1"
No. 2 NA

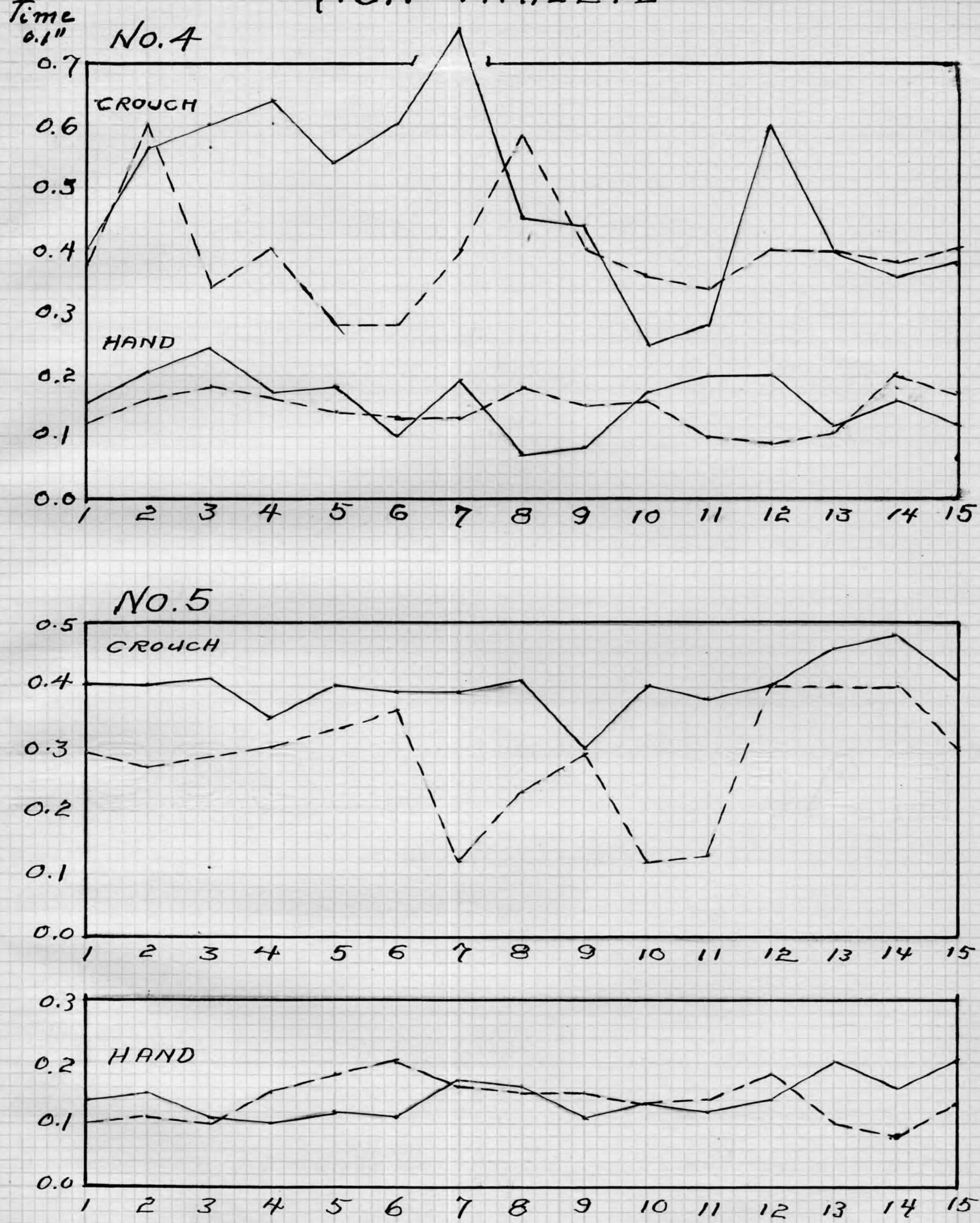


First 15 Vs Last 15 Trials
First Indicated by, ——
Last Indicated by - - -

No. 3 NA



NON-ATHLETE



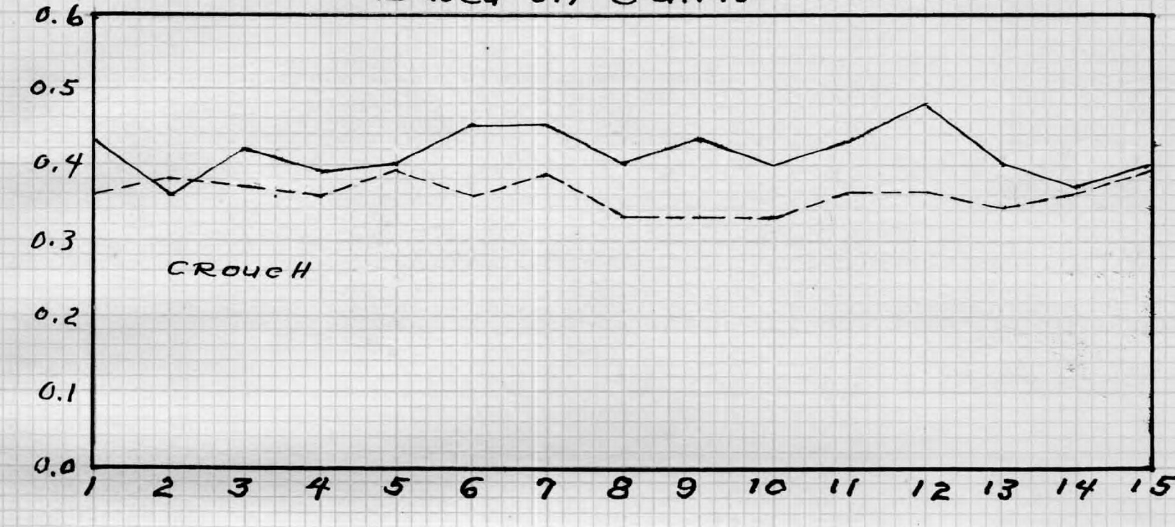
First 15 Vs Last 15 Trials
First Indicated by ———
Last Indicated by - - - -

ATHLETES

FOOT REACTIONS

Time 0.1"

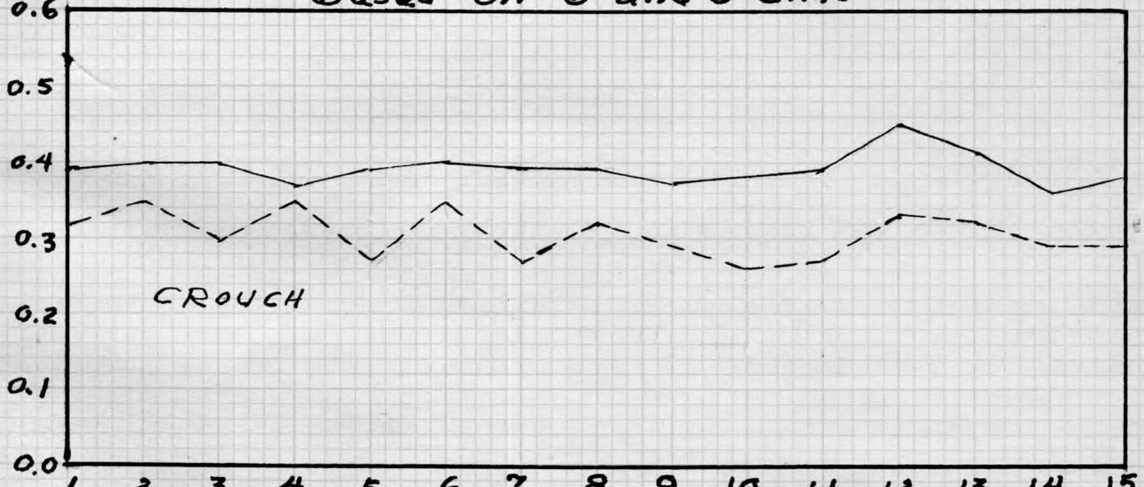
Based on 8 Girls



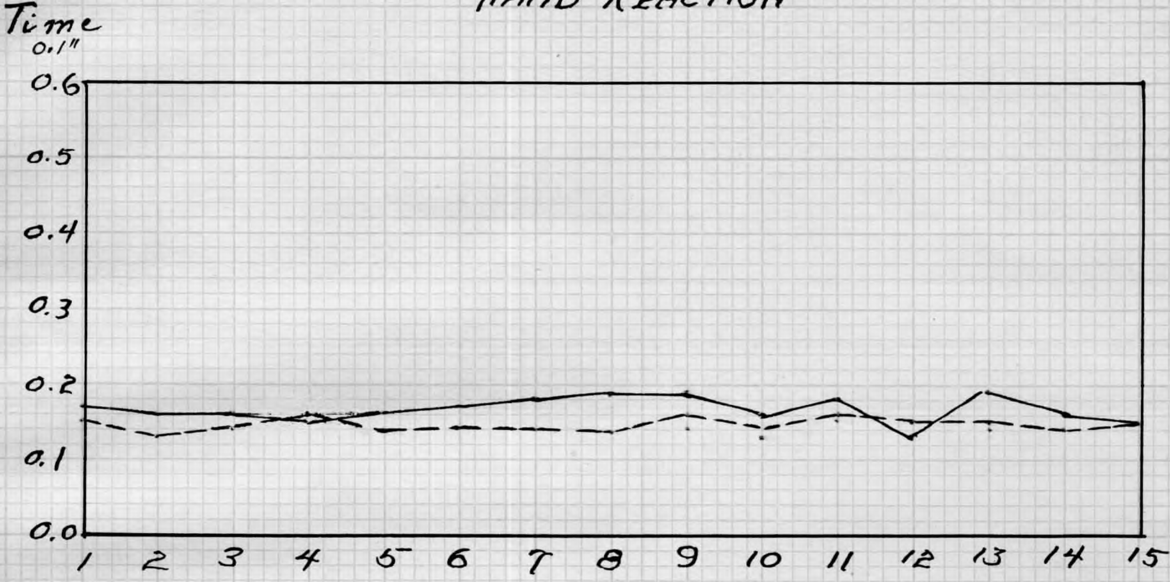
First 15 and Last 15 Trials
First Indicated By ——
Last Indicated By - - - -

NON-ATHLETES

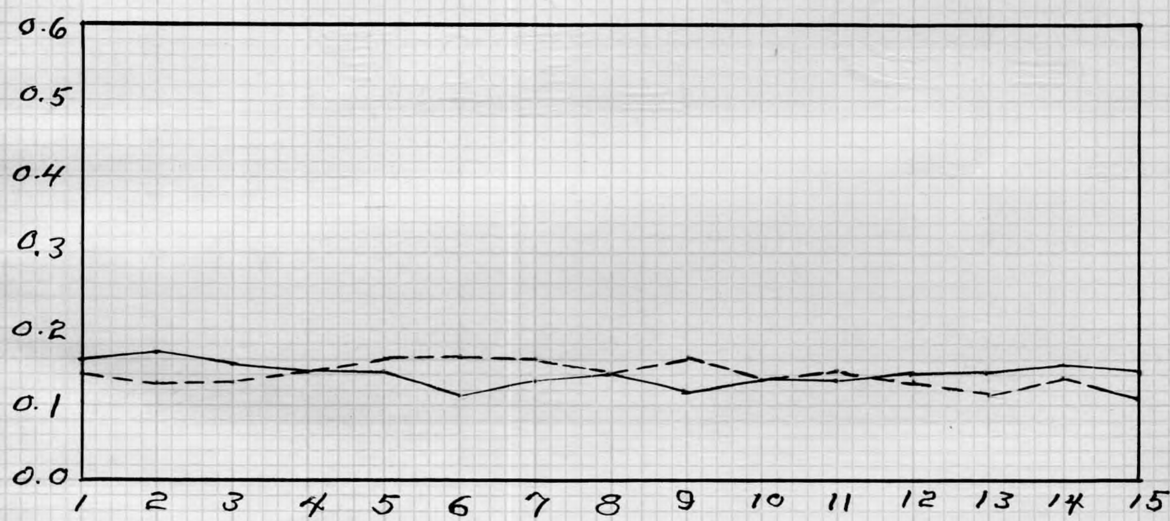
Based on 6 and 5 Girls



ATHLETES
HAND REACTION



NON - ATHLETES
HAND REACTION

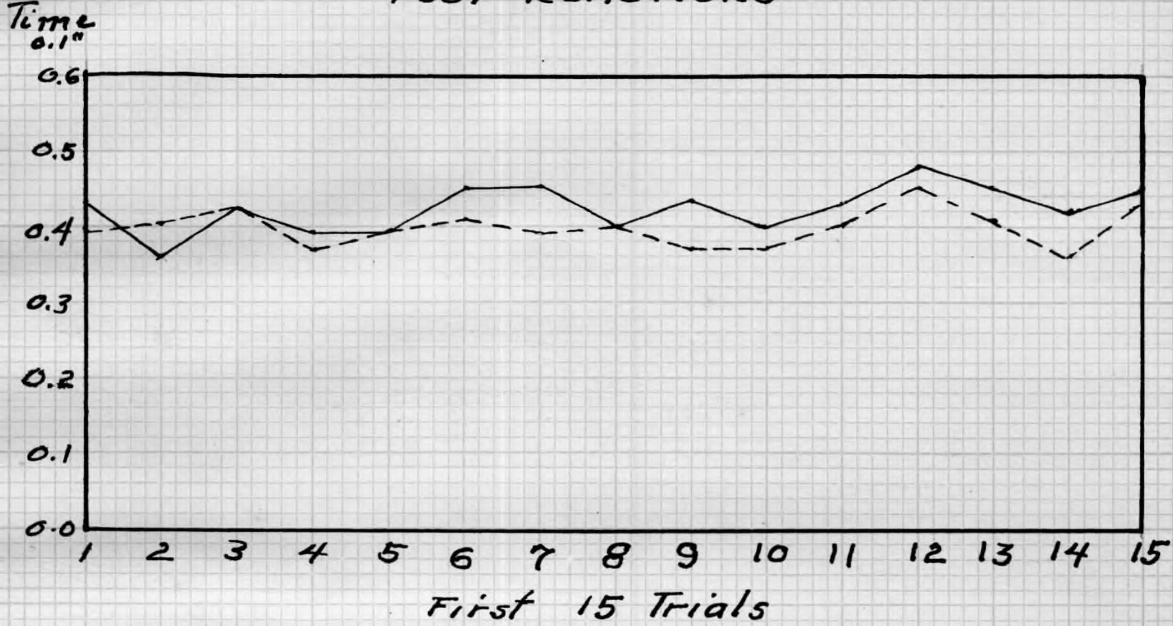


First 15 Vs Last 15 Trials

First Indicated by ———
Last Indicated by - - - -

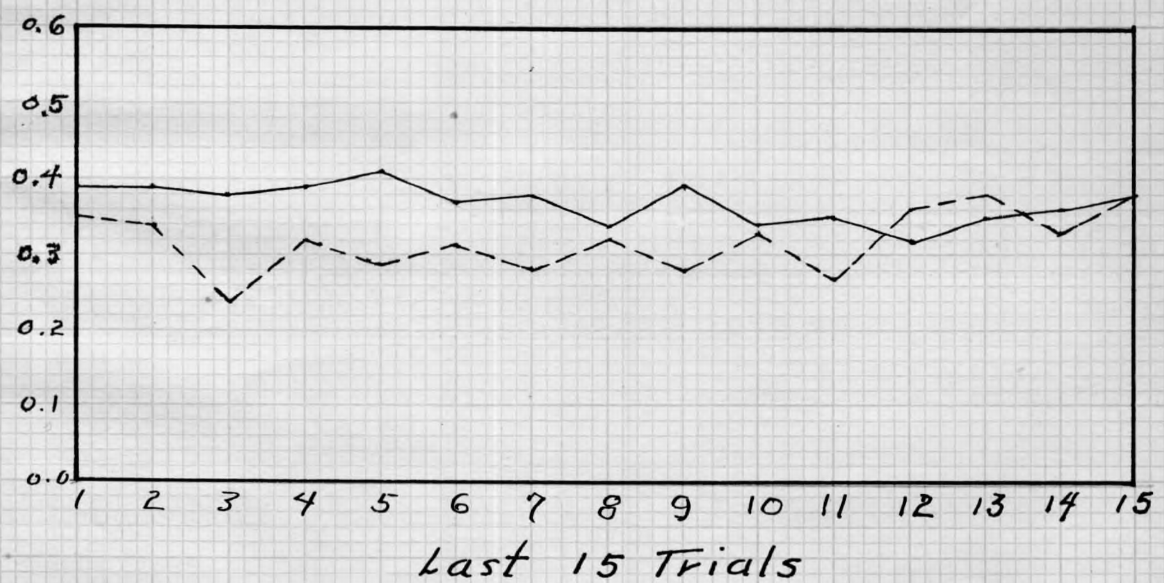
ATHLETE Vs NON-ATHLETE

FOOT REACTIONS



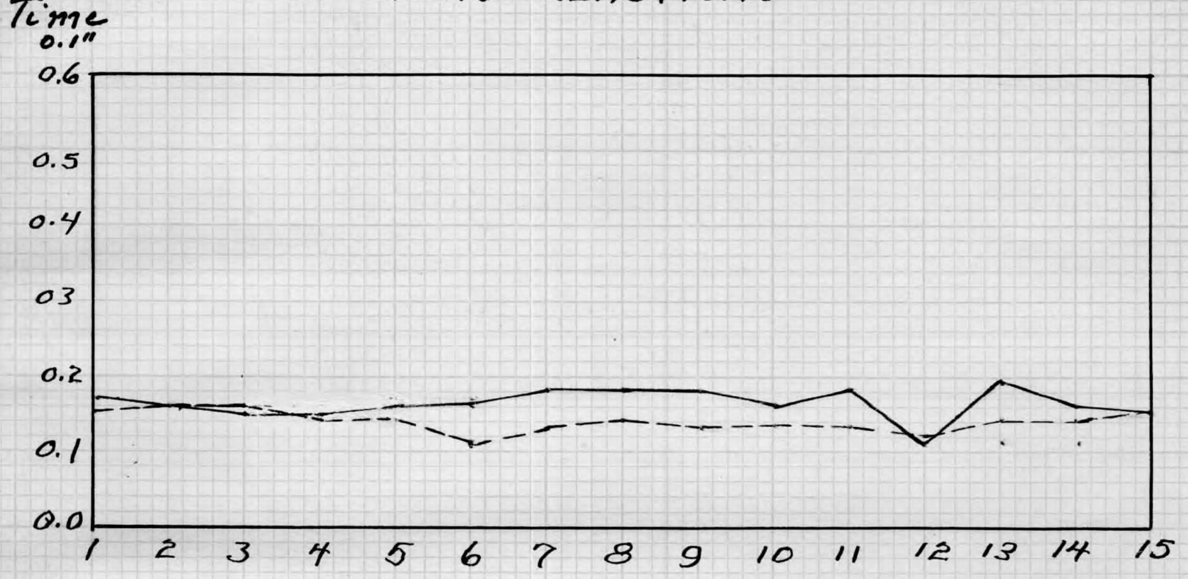
ATHLETE Indicated by ——— (8)

NON-ATHLETE Indicated by - - - - (6)

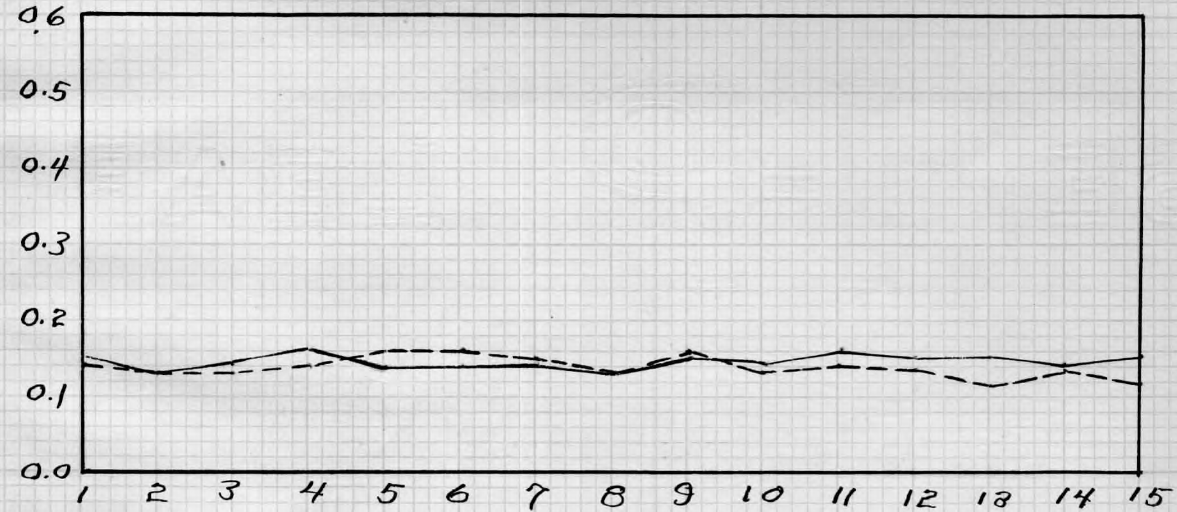


ATHLETES Vs NON-ATHLETES

HAND REACTIONS



FIRST 15 TRIALS

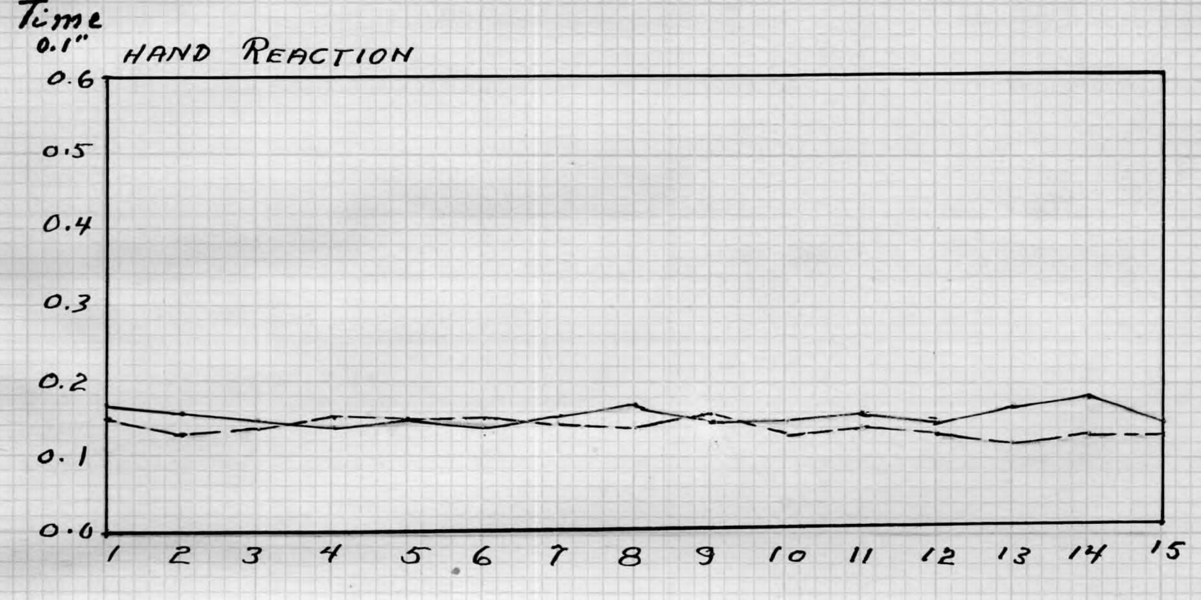


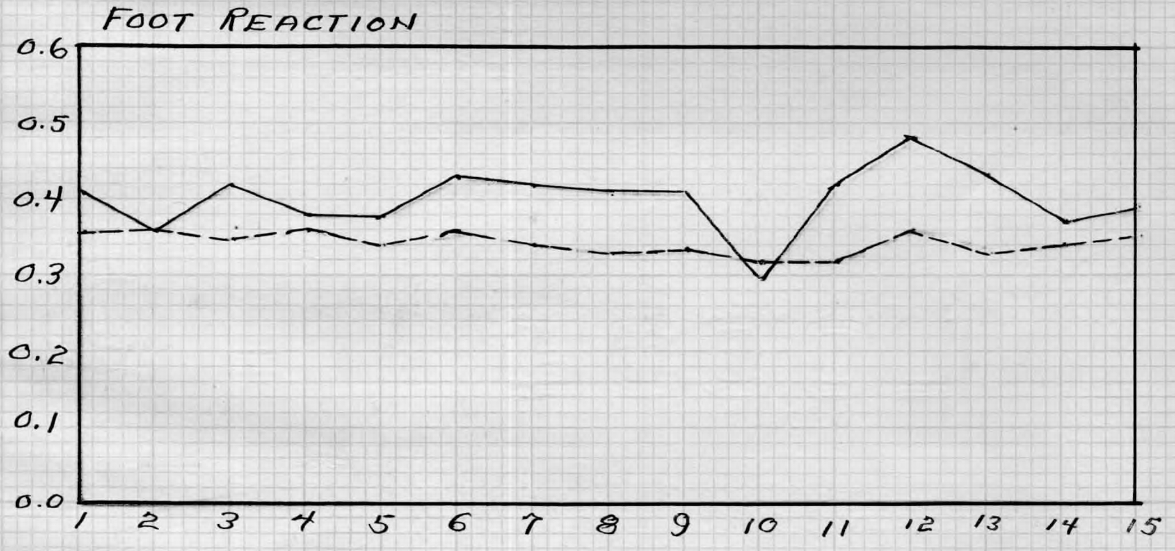
LAST 15 TRIALS

ATHLETES Indicated by ———

NON ATHLETES Indicated by - - - -

GROUP



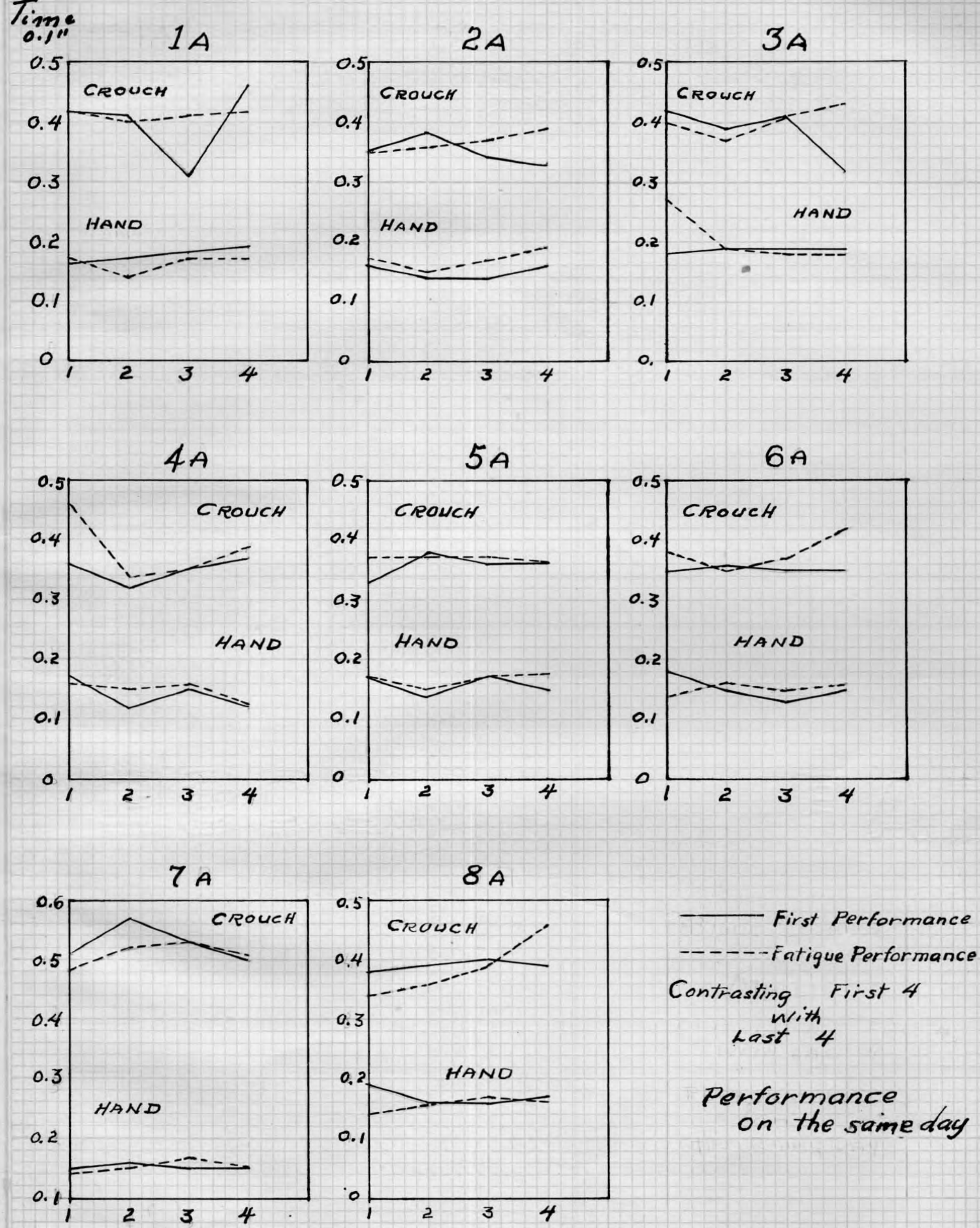


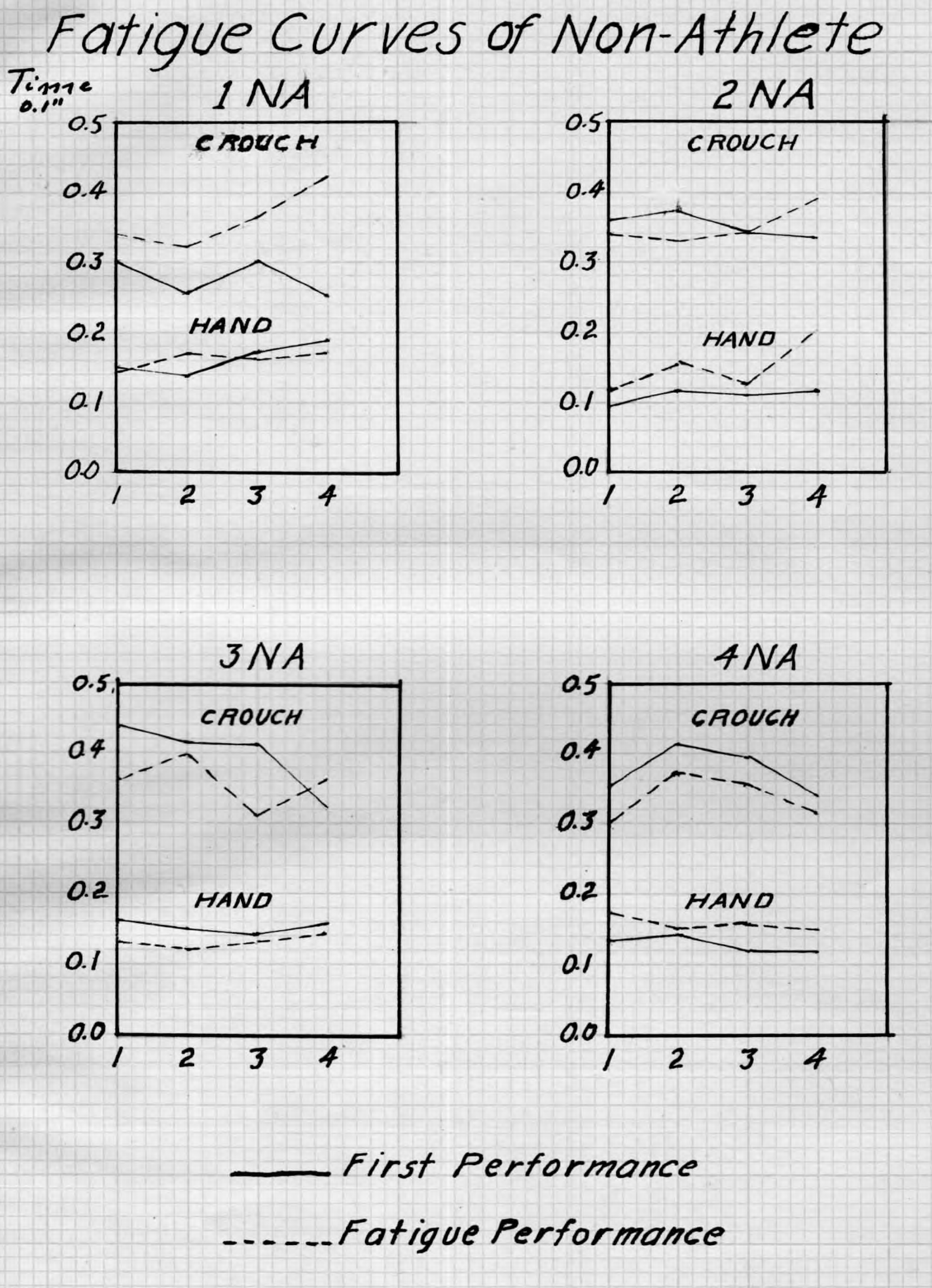
FIRST 15 TRIALS Vs LAST 15 TRIALS

First Indicated by ———

Last Indicated by - - - -

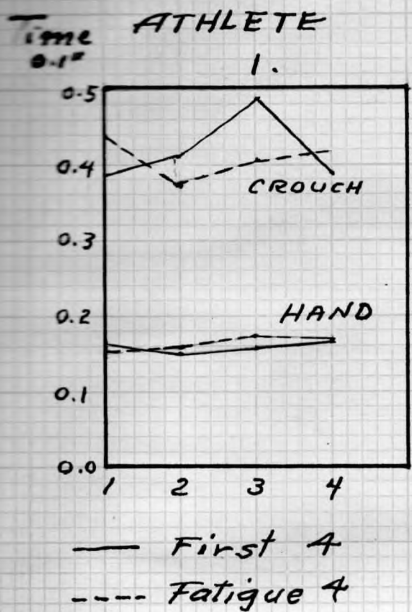
FATIGUE CURVES OF ATHLETES

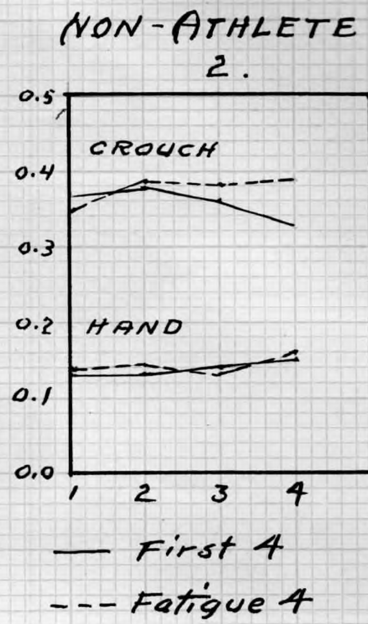


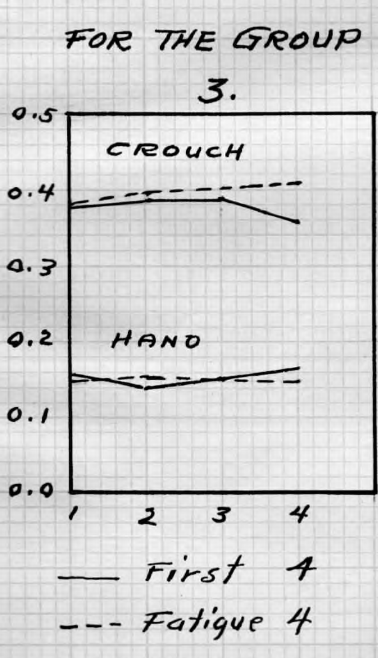


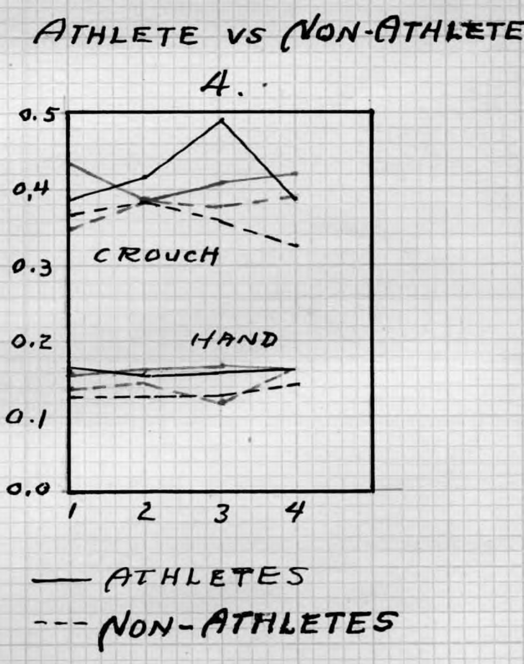
Fatigue Curves of Non-Athlete
Time 0.1"
1 NA
2 NA
3 NA
4 NA
CROUCH
HAND
0.0
0.1
0.2
0.3
0.4
0.5
1
2
3
4
First Performance
Fatigue Performance

X


Time 0.1"
ATHLETE
1.
0.5
0.4
0.3
0.2
0.1
0.0
CROUCH
HAND
1
2
3
4
— First 4
---- Fatigue 4


NON-ATHLETE
2.
0.5
0.4
0.3
0.2
0.1
0.0
CROUCH
HAND
1
2
3
4
— First 4
--- Fatigue 4


FOR THE GROUP
3.
0.5
0.4
0.3
0.2
0.1
0.0
CROUCH
HAND
1
2
3
4
— First 4
--- Fatigue 4


ATHLETE VS NON-ATHLETE
4.
0.5
0.4
0.3
0.2
0.1
0.0
CROUCH
HAND
1
2
3
4
— ATHLETES
--- NON-ATHLETES