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Date June 23, 1970

AN ELECTROMYOGRAPHICAL ANALYSIS OF SPRINT STARTING FROM VARIABLE WIDTH BLOCKS

by

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A professional paper submitted to the Graduate Faculty in partial fulfillment of the requirements for the degree

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ABSTRACT

The general problem of this study was to determine what effect variable width starting blocks would have on the muscles involved in sprint starting. This was determined by electromyographical analysis. It was hypothesized that by providing wider foot placement at the start, the muscles would be placed in a more efficient position for maximum contraction, resulting in a more effective start.

Four experienced subjects were used, with each subject taking nine starts from each of the various widths. Horizontal block spacings of 4, 9, 15, and 20 cm were used. Three muscles were studied, the gastrocnemius, vastus medialis, and semitendinosis. Three contractions of each muscle were recorded at each of the various widths. Recordings were made on an E & M Physiograph with the use of surface electrodes and a telemetry transmitter and receiver. Each subject was classified according to the longitudinal block spacing they selected, as well as their lever length to determine if this had any effect.

The data was processed by a computer and the findings were as follows:

1. Gastrocnemius contractions were significantly better at 15 cm than at 4 cm.
2. Vastus medialis contractions were greater at 15 and 20 cm than at 4 cm.
3. Semitendinosis contractions were greater at 20 cm than at 9 cm.
4. Gastrocnemius contractions were greater for subjects using a 25 cm longitudinal spacing.
5. Semitendinosis contractions were greater at 4, 9, and 20 cm for subjects using a 25 cm longitudinal spacing.
6. Gastrocnemius contractions at 15 cm were greater for subjects having short levers.
7. Semitendinosis contractions at 4 cm were also greater for those having short levers.

Conclusions drawn from this study were that 15 cm appeared to be the most desirable width. 4 cm was found to be the least effective. 20 cm was found to be more effective than 4 cm, but less effective than 9 and 15 cm widths. The semitendinosis appears to be in a better position when a shorter longitudinal spacing is used. Wider foot placement appears to put all the muscles studied in a better position for contraction.

CHAPTER I

INTRODUCTION

Several new discoveries have been developed in the area of athletics in the past few years. Those individuals involved with such sports as track and field are always looking for new ideas and means of improving their performances.

PROBLEM

The general problem of this study was to myographically analyze selected muscles involved in the sprint start using variable width blocks. Specifically, this study attempted to find if wider foot placement at the start would position the selected muscles involved in a more advantageous manner for maximum contraction.

Related Questions:

A. Are the effects identical for sprinters with different length levers?

B. Are the effects identical at different longitudinal block spacings?

DEFINITIONS

A. Sprint start - The crouched starting position used in the dash events.

B. Horizontal spacing - Width between the blocks, perpendicular to the long axis of the starter's body.

C. Longitudinal spacing - Width between the blocks, perpendicular to the transverse axis of the starter's body.

D. Standard starting position - Starting from blocks with a 4 cm (1½ inch) horizontal spacing.

E. Wide starting position - Starting from blocks with varied widths of either 9 cm (3½ inches), 15 cm (6 inches), or 20 cm (8 inches).

F. Selected muscles - The gastrocnemius, vastus medialis, and semitendinosis were studied.

G. Lever length - The individual differences among the subjects in bone length of the lower extremities which might influence muscle position and contraction at different widths.

DELIMITATIONS

This study was delimited to a myographical analysis of the differences in effectiveness or amplitude of muscular contraction. Only selected muscles involved in sprint starting were studied. Only four block widths were used.

JUSTIFICATION OF STUDY

PROJECT JUSTIFICATION

According to Doherty, there has always been a desire to improve form and methods in all areas of athletics. He feels that the sprint events are such a major part of track and field, that a strong nucleus

of sprinters can easily be the key to a winning track team. One of the most important aspects in good sprinting is the start. It must be perfected in order to put the athlete in the most effective position and get him moving in the shortest possible time.[1] It is hoped that this study may improve the knowledge and performances of those involved in track and field. A survey of literature revealed no published reports of experiments dealing with varied foot width in sprint starting.

Electromyography is a relatively new field, particularly in the areas of athletics and physical education. As stated by LaFratta,

> The contributions this new technique of study has made in analyzing patterns of voluntary muscle movement can hardly be duplicated. With it we can furnish objective findings which are not available from any other source as well as confirm clinical opinions.[2]

HYPOTHESIS

It was hypothesized that the narrow placement of the feet as used in the standard starting position due to the construction of present starting blocks is an unnatural position. It was further hypothesized that by enabling the feet to be placed further apart, the athlete would be able to obtain better balance and a more powerful thrust from the start. Since the start would originate from a broader base and the

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[1]J. Kenneth Doherty, Modern Track and Field (Englewood Cliffs: Prentice-Hall, Inc., 1963), pp. 47-119.

[2]Carl W. LaFratta M.D., "An Appraisal of the More Popular Methods of Electrodiagnostic Testing", Journal of the Southern Medical Association, 57:6, (June 1964), pp. 649-654.

levers and the muscles acting on them would be at a more direct angle, the resulting force should be greater and come from a more advantageous position.

CHAPTER II

REVIEW OF LITERATURE

ELECTROMYOGRAPHY

There are two general methods of taking an electromyography. The first consists of thrusting a needle into the belly of the muscle and the other of larger electrodes placed on the skin over the appropriate muscle. By this second method, we can measure voluntary response. Electromyography has made it possible to differentiate motor unit contractions from individual fiber activity. The action potential measured on the skin represents the combined potential of many individual fibers and motor units. Under isometric conditions, the electrical output closely parallels the tension developed by the muscle.[3]

Houtz and Fischer performed tests to find the part played by different muscles used in pedaling a bicycle. They did an electromyographical analysis on three young women. These findings were to be used in developing better exercises for rehabilitation in clinics. They found:

1. During bicycling, the muscles contract in a pattern which is orderly and coordinated.

2. The pattern muscle activity is highly reproducible in each individual subject and among the three different subjects under test.

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[3]John F. Fulton M.D., A Textbook of Physiology (Philadelphia and London: W. B. Saunders Co., 1956), pp. 151-156.

3. Varying the height of the bicycle seat does not influence, in general, the timing of muscle activity, but the exercise is performed with less effort when the seat is high.

4. As the resistance to muscle action increases, electrical activity intensifies in each muscle and develops in other muscles. Exercise against no resistance evokes action potentials primarily in the muscles acting on the foot and ankle.

5. The bicycle is a useful therapeutic device for increasing the range of motion in the hip, knee, and ankle within certain limits. The ankle moves through its complete range of motion, while considerably less motion occurs in the knee, and still less in the hip.

6. Of the muscles studied, those most necessary for pedaling a stationary bicycle are the tensor fascia latae, sartorius, quadriceps femoris, and tibialis anterior as demonstrated by multiple lead electromyography.[4]

The fundamental principles of electrodiagnosis have been known for about a hundred years, but recent advances in electronics have made it possible to record a wide variety of information by electromyography. The contributions this new technique of study has made in analyzing patterns of voluntary muscle movement can hardly be duplicated. With it

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[4]S. J. Houtz R.P.T. and F. J. Fischer M.D., "An Analysis of Muscle Action and Joint Excursion During Exercise on a Stationary Bicycle", The Journal of Bone and Joint Surgery, 41-A:1, (January 1959), pp. 123-131.

we can furnish objective findings which are not available from any other source as well as confirm clinical opinions. Electromyography is still a new and vastly promising field.[5]

SPRINT STARTING

Kistler studied the total thrust on the front and back faces of the starting blocks in three types of start from the horizontal position: the bunched, medium, and elongated. The results showed:

1. Total pressure in the bunch start was three hundred forty-six pounds pressure.

2. Three hundred eighty-six pounds in the medium start.

3. Four hundred four pounds pressure in the elongated start.

4. The elongated start was suggested as the best starting position because it allowed for a more powerful thrust in the start than did the other forms of starting.[6]

Murray did a study on block placement in regard to the starting line. He found that the distance that the starting blocks should be placed from the starting line depends on the height and leg length of the individual. The type of block spacing used by the sprinter made no

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[5]Carl W. LaFratta M.D., "An Appraisal of the More Popular Methods of Electrodiagnostic Testing", Journal of the Southern Medical Association, 57:6, (June 1964), pp. 649-654.

[6]J. W. Kistler, "Study of the Distribution of the Force Exerted Upon the Blocks in Starting the Sprint from Various Starting Positions," Research Quarterly Supplement, March 1934, Vol. 5, pp. 33-35.

difference.[7]

Franklin Henry did a study on the patterns of force against each starting block by sprinters of different degrees of skill. He found:

1. The highest proportion of best runs and the smallest proportion of poorest runs result from starting with a 16-inch stance. A 21-inch stance is nearly as good.

2. An elongated stance of 26 inches results in greater velocity leaving the blocks, but the advantage is lost within the first 10 yards.

3. Use of the 11-inch bunch start results in clearing the blocks sooner, but with less velocity than that secured from medium stances, resulting in significantly slower time at 10 and 50 yards.

4. Reaction time is uninfluenced by block spacing and uncorrelated with speed in the sprints.

5. Leg length is not important in determining the best block spacing and is unrelated to 50 yard sprinting ability.

6. With block spacing held constant, speed in the sprint is significantly related to how closely the individual approaches the ideal start.

7. Although the rear leg develops considerably more force than

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[7]A. Murray, "Relationship Between Foot Placement and Speed in Sprint Starts", (unpublished Master's thesis, University of California 1947).

the front, the latter contributes twice as much to the block velocity because its impulse has a longer duration.[8]

Mortensen and Cooper found that the average good sprinter's rear leg exerts considerably more force on the blocks when starting than the front leg, but he applies the force from the front leg longer. However, with some of the top sprinters, such as Mel Patton, the above condition did not quite prevail. Patton exerted more force with his front foot as well as applied the force longer. It would seem from this study that the runner should attempt to get the rear foot into action against the ground as soon as possible.[9]

Sigerseth and Grinaker did further study on the foot spacing in the various starting positions. Their results showed:

1. Sprinters using the bunch start had the fastest time over 30 yards.

2. Subjects using the medium start had the best time over 10, 20 and 50 yards.[10]

Sprinters have been found to have a variety of body builds. Probably the ideal build for a sprinter would be that of a tall individ-

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[8]Franklin M. Henry, "Force-time Characteristics of the Sprint Start", The Research Quarterly, October 1952, 23:3, pp. 301-318.

[9]J. P. Mortensen and John M. Cooper, Track and Field for Coach and Athlete (Englewood Cliffs: Prentice-Hall, Inc., 1959), p. 19.

[10]P. O. Sigerseth and V. F. Grinaker, "Effect of Foot Spacing on Velocity in Sprints", Research Quarterly, March 1962, 33:1, p. 599.

ual, about six feet, having light bones, good musculature, especially in the thigh region, light musculature in the calf, and slender long feet. Jackson feels that as far as size of the sprinter is concerned, there have been all types. Size doesn't seem to matter at all.[11]

Top flight sprinters are seldom found who weigh less than 130 pounds or more than 170 pounds. They range in height from five feet seven inches to six feet three inches. The tall sprinter is characterized by long lower extremities, equipped with long powerful muscles. The short sprinter compensates for muscle length found in taller sprinters by possessing strong thick muscles. Since driving force is the chief prerequisite for good sprinting, it makes little difference whether it comes from long slender muscles or short thick muscles.[12]

A study by Dickinson in regard to physical measurements and foot spacing found:

1. The differences in sprinter's height, trunk, leg, and thigh length make exact measurement of various starts impossible.

2. The distance behind the starting line at which the blocks are placed, depends on the height of the individual regardless of the type of spacing used.

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[11]J. P. Mortensen and J. M. Cooper, Track and Field for Coach and Athlete (Englewood Cliffs: Prentice-Hall, Inc., 1959), pp. 16-17.

[12]Oliver Jackson, "The Sprints", Championship Track and Field, ed. Tom Ecker (Englewood Cliffs: Prentice-Hall, Inc., 1961), p. 4.

3. The distance of the rear block from the starting line was also found to vary with the height of the sprinter.

4. The front-back distance between the starting blocks varies only slightly among large and small individuals. Either the size of the foot or the length of the leg is the determining factor.[13]

Extreme lateral spacing of either holes or blocks causes the sprinter to leave the mark with a twisting motion. The distance suggested is approximately eight inches from center of heel to center of heel.[14]

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[13]G. T. Bresnahan and W. W. Tuttle, Track and Field Athletics, ed. Francis X. Cretzmeyer, Louis E. Alley and Charles M. Tipton (St. Louis: The C. V. Mosby Co., 1969), citing A. D. Dickinson, "The Effect of Foot Spacing on Starting Time and Speed in Sprinting and the Relation of Physical Measurement to Foot Spacing", Research Quarterly Supplement, March 1934, 5:1, p. 12.

[14]G. T. Bresnahan, W. W. Tuttle and F. X. Cretzmeyer, Track and Field Athletics (St. Louis: The C. V. Mosby Co., 1964), pp. 55-73.

CHAPTER III

METHOD AND PROCEDURE

SUBJECTS

Four varsity sprinters from the 1970 Montana State University track team were used for the experiment. All subjects were experienced athletes.

DATA COLLECTION

To analyze the varied width sprint starts, three electromyographs were taken from each of the muscles involved as the sprinter started from each width.

An E & M Physiograph was used to measure the intensity of muscle contractions as well as the time period through which the contraction had its effect. The physiograph represents the amplitude of contractions by the size of the variations made on the graph as the muscle impulses are recorded. The calibration was set at 2 cm for every recording, and the recording speed at .25 cm/sec. to insure accurate measurement of the duration of the contractions. The recordings were made on physiograph "six" recticurvelinear paper to facilitate easy measurement and comparison. E & M self-adhering surface electrodes were used. These are a pure silver disc electrode in a soft plastic cover with an attached three foot lead of strong lightweight wire terminating in a standard phone tip plug. The plastic cover provides a large self-contouring surface for adhesion and holds the electrode

from direct contact with the skin. This was connected to an E & M telemetry transmitter and the recordings were transmitted through an E & M telemetry receiver.

Starting blocks with an Arnett face were used since, according to Maughan, they are the most common type being used by sprinters today.[15]

Subjects wore cotton trunks, lightweight jerseys, and flat shoes without spikes since the study was conducted indoors.

Steps were taken to insure accurate measurement of the amplitude of the muscle contractions. A one millimeter grid superimposed on a transparent overlay was constructed so as to enable the myograph to be seen through the grid. A platform magnifying glass was then used to measure the amplitude in millimeters.

A pilot study was conducted to determine which muscles would be studied and at what widths. The pilot study was also used to determine what speed and calibration would be used. All recordings were made on the subjects forward leg. The leg placed in the block nearest the starting line and having the longest period of contraction.

Two sessions were conducted with each of the four athletes. Each subject completed a series of 18 starts during each testing session. The skin area where the electrodes were to be placed

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[15]Statement by Ralph Maughan, personal interview June 1969.

was shaven and thoroughly cleaned with 70 percent isopropyl alcohol before each recording session and electrode paste was applied to the electrodes to improve the conduction. The electrodes were then placed on the selected muscle and held in place with a Conoco Elasticfoam bandage.

The starting commands were used as follows:

1. come to your marks; the subject took his place in the blocks and the starter waited until he was completely motionless.
2. set; the subject assumed the set position.
3. go; the subjects were held in the set position between one and two seconds.

This was found to give the best response time in a study by Nicholson.[16]

DESIGN

A cross-over design was used, with the resulting relationships based on T-scores. The design is such that each subject ran nine times at each of two different block spacings on each day. These were as follows:

A. Six starts while recording the gastrocnemius at two dif-

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[16] J. P. Mortensen and J. M. Cooper, Track and Field for Coach and Athlete (Englewood Cliffs: Prentice-Hall, Inc., 1959), p. 18 citing S. R. Nicholson, "Study of the Factors Which Contribute to Decreasing the Starting Time of Trained Sprinters", (unpublished report, January 1952).

ferent block widths.

B. Six starts while recording the vastus medialis at two different block widths.

C. Six starts while recording the semitendinosis at two different block widths.

A different random sequence was followed by each subject on each testing day. Random sequences were as follows:

1. ABC	3. BCA	5. CBA
2. ACB	4. BAC	6. CAB

The subjects were given cardinal numbers for identification. The four block widths were identified as follows:

4 cm - one and one-half inches wide.

9 cm - three and one-half inches wide.

15 cm - six inches wide.

20 cm - eight inches wide.

Each subject selected the longitudinal spacing he desired, which remained constant and unchanged for all widths throughout the study.

Each athlete was classified according to the length of his levers. Two classifications were used as follows:

Class	Definition
S	short levers
L	long levers

This was to make it possible to determine if the length of the levers had any effect on the relationship between the various starting positions.

Each subject was also classified according to the longitudinal block spacing he used. Again, two classifications were used as follows:

Class	Definition
A	10 inch spread
B	13 inch spread

This was to make it possible to determine if the longitudinal spacing of the blocks had any effect on the relationship between the various starting positions.

CHAPTER IV

ANALYSIS OF DATA

The electromyographs were then analyzed to determine what relationships exist. There were a total of 144 starts recorded as follows:

36 from the 4 cm start.

36 from the 9 cm start.

36 from the 15 cm start.

36 from the 20 cm start.

The amplitude of each recording for each muscle at each starting width was then measured. This data was then processed by a Sigma 7 Computer at the Montana State University Computing Center to find the average amplitude for each muscle at each starting width. T-tests were run between each average for the three different muscles at each width to determine if any significant relationships exist. This data was again processed along with each subject's classifications and T-tests were run to determine if any significant relationships existed. Relationships were accepted or rejected at the five percent level of confidence.

The measurements taken from each recording are presented on the following tables. All measurements are in millimeters.

Table I presents the measurements taken from the gastrocnemius on three trials from each of the various widths.

TABLE I

GASTROCNEMIUS TRIALS

Subject	Groups AB	Groups SL	Starting Widths 4 cm	9 cm	15 cm	20 cm
			5.3	5.8	4.7	3.1
1	A	S	4.2	5.8	4.3	4.0
			5.4	4.5	4.3	5.1
			2.0	4.7	6.4	3.1
2	A	L	1.3	3.4	5.3	3.1
			1.2	3.3	6.5	2.8
			1.9	4.0	5.0	4.5
3	B	S	1.3	3.5	3.2	6.0
			1.5	4.0	5.0	6.0
			6.8	8.5	8.9	7.5
4	B	L	5.5	7.2	6.8	6.9
			6.8	7.1	9.0	9.1

Table II presents the measurements taken from the vastus medialis on three trials from each of the various widths.

TABLE II

VASTUS MEDIALIS TRIALS

Subject	Groups AB	Groups SL	Starting Widths 4 cm	9 cm	15 cm	20 cm
			6.0	5.5	5.1	5.0
1	A	S	4.0	4.3	6.0	6.2
			5.0	3.6	5.0	5.0
			5.0	8.5	10.0	7.0
2	A	L	5.8	10.0	9.4	6.2
			6.3	11.5	10.4	7.0
			8.3	9.0	6.6	6.9
3	B	S	6.0	9.1	10.0	9.7
			5.0	7.0	9.0	7.0
			2.5	4.0	7.0	4.8
4	B	L	2.2	5.0	9.0	7.9
			4.0	3.8	6.7	10.0

Table III presents the measurements taken from the semitendinosis on three trials from each of the various widths.

TABLE III

SEMITENDINOSIS TRIALS

Subject	Groups AB	Groups SL	Starting Widths 4 cm	9 cm	15 cm	20 cm
			4.0	13.5	12.6	3.8
1	A	S	6.0	12.5	13.5	3.5
			4.7	11.0	10.6	4.0
			7.0	10.1	6.5	3.8
2	A	L	8.2	6.8	6.7	4.0
			7.5	8.3	7.4	3.5
			7.5	7.6	6.2	8.8
3	B	S	7.0	6.5	6.4	8.5
			8.1	7.0	8.0	8.7
			8.8	6.8	6.5	9.6
4	B	L	14.1	9.2	9.0	10.0
			11.7	8.8	7.2	8.3

Figures I, II, and III are examples of the recordings made on each of the three muscles at each of the various widths.

Figure I Gastrocnemius

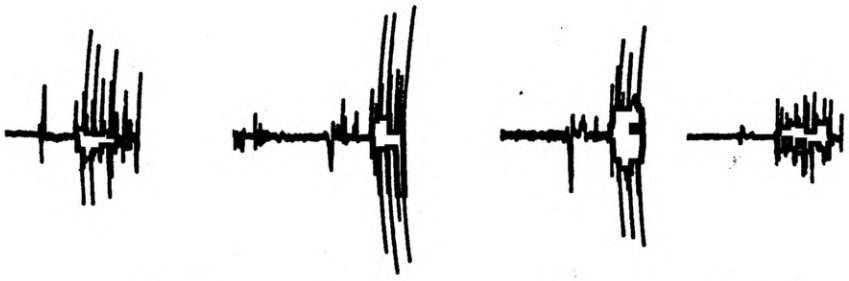


Figure II Vastus Medialis

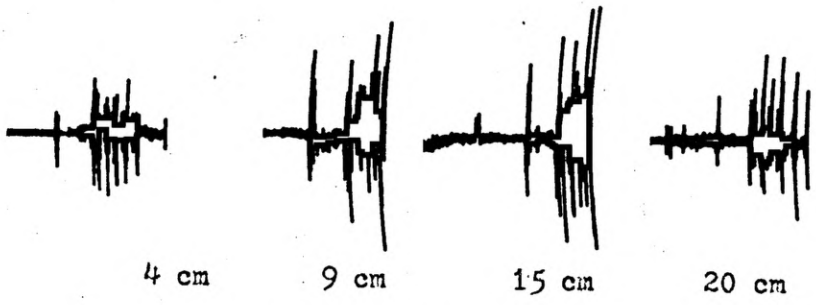


Figure III Semitendinosis

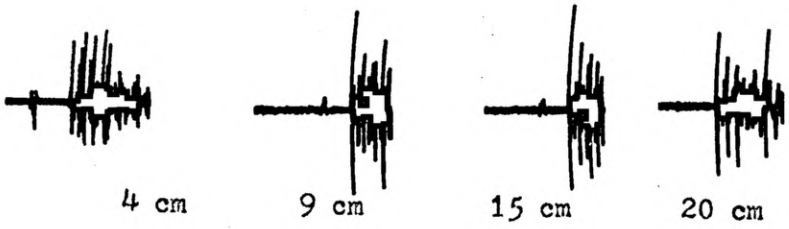


Illustration I is an oblique view of the variable width blocks set at 15 cm.

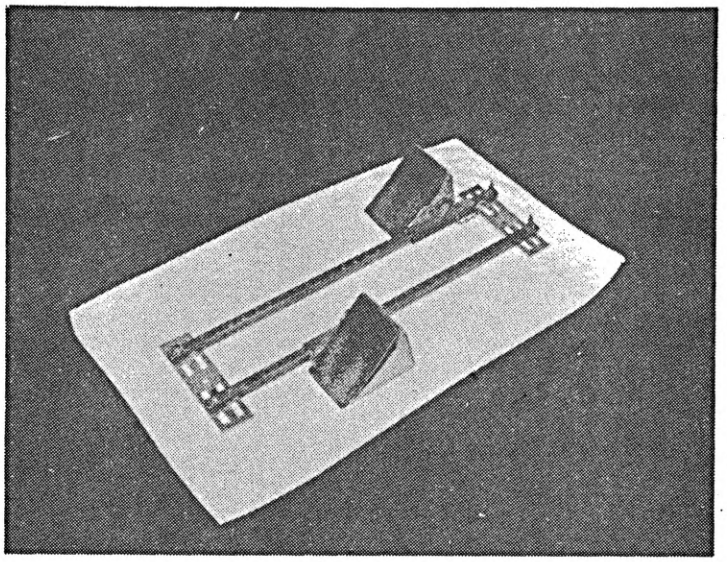


Illustration I

Illustration II is a frontal view of the variable width blocks set at 15 cm.

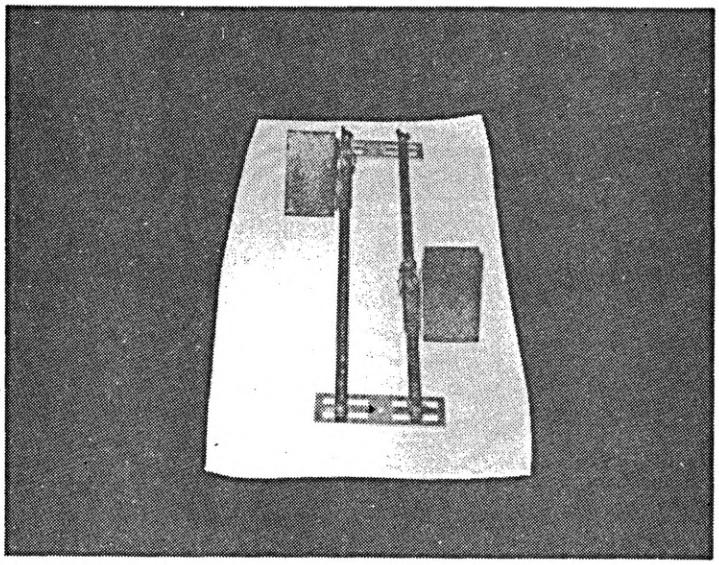


Illustration II

Illustration III is a lateral view of the variable width blocks set at 15 cm.

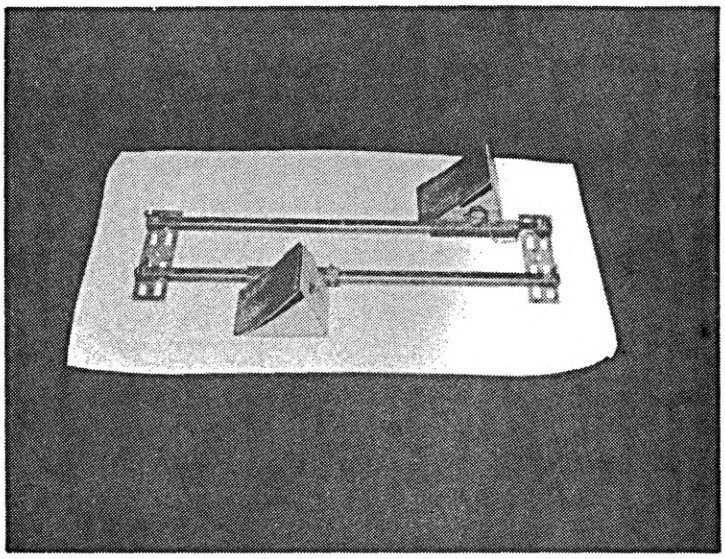


Illustration III

Illustration IV is a frontal view of the standard blocks with a 4 cm horizontal width.

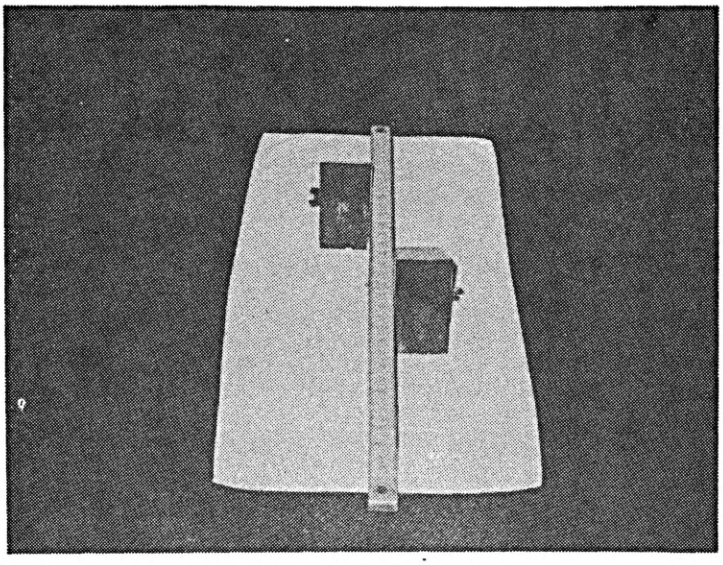


Illustration IV

Table IV presents the means and standard deviations for each of the distances recorded from the gastrocnemius. The table T was 2.07, any computed T which is greater than this represents a significant difference between the designated variables at the .05 level of confidence.

Table V presents the means and standard deviations for each of the distances recorded from the vastus medialis. The table T was 2.07, any computed T which is greater than this represents a significant difference between the designated variables at the .05 level of confidence.

Table VI presents the means and standard deviations for each of the distances recorded from the semitendinosis. The table T was 2.07, any computed T which is greater than this represents a significant difference between the designated variables at the .05 level of confidence.

Table VII presents a comparison of the means and standard deviations between Groups A and B. Group A using a 25 cm longitudinal block spacing and Group B using a 38 cm longitudinal spacing. The table T is 2.22 and any computed T which is greater than this represents a significant difference between the designated variable at the .05 level of confidence.

Table VIII presents a comparison of the means and standard deviations between Groups S and L. Group S being classified as having

short levers and Group L classified as having long levers. The table T is 2.22 and any computed T which is greater than this represents a significant difference between the designated variable at the .05 level of confidence.

Table IV presents a comparison of the gastrocnemius contractions at each of the various widths. Note that the amplitude of contractions recorded from the gastrocnemius were significantly greater at the 15 cm width than at the 4 cm width.

TABLE IV

MEANS AND STANDARD DEVIATIONS FOR THE GASTROCNEMIUS AT EACH WIDTH

Width Start	N	Mean	S.D.	T-Tests		
4 cm	12	3.59	2.17	X		
9 cm	12	5.15	1.64	1.96	X	
15 cm	12	5.78	1.72	2.72 *	0.91	X
20 cm	12	5.01	1.92	1.68	0.18	1.02

*Notes significance beyond the .05 level of significance. Table T 2.07

Table V presents a comparison of the vastus medialis contractions at each of the various widths. Note that the amplitude of contractions recorded from the vastus medialis were significantly greater at the 15 and 20 cm widths than at the 4 cm width.

TABLE V

MEANS AND STANDARD DEVIATIONS FOR THE VASTUS MEDIALIS AT EACH WIDTH

Width Start	N	Mean	S.D.	T-Tests		
4 cm	12	5.00	1.61	X		
9 cm	12	6.77	2.64	1.97	X	
15 cm	12	7.85	1.90	3.94 *	1.14	X
20 cm	12	6.89	1.60	2.86 *	0.13	1.33

*Notes significance beyond the .05 level of confidence. Table T 2.07

Table VI presents a comparison of the semitendinosis contractions at each of the various widths. Note that the amplitude of the contractions recorded from the semitendinosis at the 20 cm width were significantly greater than those at the 9 cm width.

TABLE VI

MEANS AND STANDARD DEVIATIONS FOR THE SEMITENDINOSIS AT EACH WIDTH

Width Start	N	Mean	S.D.	T-Tests		
4 cm	12	7.88	2.65	X		
9 cm	12	9.00	2.23	1.12	X	
15 cm	12	8.38	2.42	0.48	0.65	X
20 cm	12	6.37	2.64	1.39	2.63 *	1.93

*Notes significance beyond the .05 level of confidence. Table T 2.07

Table VII presents a comparison of the effects of longitudinal spacing on each of the three muscles studied at each of the various widths. Note that the group using the 25 cm longitudinal spacing had significantly better recordings on the gastrocnemius at the 20 cm width and on the semitendinosis at the 4, 9, and 20 cm widths than did the group using a 38 cm longitudinal spacing.

Table VIII presents a comparison of the effects of lever length on each of the three muscles studied at each of the various widths. Note that the group with short levers had significantly better readings on the semitendinosis at 4 cm than the group classified as having long levers.

TABLE VII

COMPARISON OF MEANS AND STANDARD DEVIATIONS BETWEEN THE TWO CLASSIFICATIONS OF LONGITUDINAL STARTING WIDTHS

	Group A			Group B			
Item	N	Mean	S.D.	N	Mean	S.D.	T-Test
Gas. @ 4 cm	6	3.23	1.79	6	3.96	2.44	0.59
Gas. @ 9 cm	6	4.58	1.00	6	5.71	1.94	1.26
Gas. @ 15 cm	6	5.25	0.91	6	6.31	2.13	1.12
Gas. @ 20 cm	6	3.53	0.79	6	6.50	1.55	4.17 *
Vas. @ 4 cm	6	5.35	0.77	6	4.66	2.09	0.74
Vas. @ 9 cm	6	7.23	2.95	6	6.31	2.19	0.61
Vas. @ 15 cm	6	7.65	2.32	6	8.05	1.33	0.36
Vas. @ 20 cm	6	6.06	0.82	6	7.71	1.77	2.06
Sem. @ 4 cm	6	6.23	1.49	6	9.53	2.53	2.74 *
Sem. @ 9 cm	6	10.36	2.30	6	7.64	1.01	2.64 *
Sem. @ 15 cm	6	9.55	2.83	6	7.21	1.00	1.90
Sem. @ 20 cm	6	3.76	0.20	6	8.98	0.60	19.86 *

*Notes significance beyond the .05 level of confidence. Table T 2.22

TABLE VIII

COMPARISON OF MEANS AND STANDARD DEVIATIONS BETWEEN THE TWO CLASSIFICATIONS OF LEVERS

	Group S			Group L			
Item	N	Mean	S.D.	N	Mean	S.D.	T-Test
Gas. @ 4 cm	6	3.26	1.75	6	3.93	2.48	0.53
Gas. @ 9 cm	6	4.60	0.89	6	5.70	2.00	1.22
Gas. @ 15 cm	6	4.41	0.61	6	7.15	1.35	4.49 *
Gas. @ 20 cm	6	4.61	0.91	6	5.41	2.50	0.73
Vas. @ 4 cm	6	5.71	1.34	6	4.30	1.55	1.69
Vas. @ 9 cm	6	6.41	2.13	6	7.13	3.01	0.47
Vas. @ 15 cm	6	6.95	1.90	6	8.75	1.41	1.85
Vas. @ 20 cm	6	6.63	1.58	6	7.15	1.58	0.56
Sem. @ 4 cm	6	6.21	1.47	6	9.55	2.53	2.78 *
Sem. @ 9 cm	6	9.68	2.76	6	8.33	1.21	1.09
Sem. @ 15 cm	6	9.55	2.87	6	7.21	0.86	1.90
Sem. @ 20 cm	6	6.21	2.45	6	6.53	2.81	0.20

*Notes significance beyond the .05 level of confidence. Table T 2.22

CHAPTER V

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

SUMMARY

This study was designed to find any existing relationships between sprint starting using various horizontal widths of foot placement. Three muscles were studied, the gastrocnemius, vastus medialis, and semitendinosis. Four starting widths were used, 4, 9, 15, and 20 centimeters. Subjects were classified according to length of levers and longitudinal block spacing used in order to determine if this had any effect on the resulting relationships. The findings were as follows:

1. Amplitude of contractions of the gastrocnemius at 15 cm were significantly greater than at 4 cm.

2. Amplitude of contractions of the vastus medialis at 15 cm and 20 cm were significantly greater than at 4 cm.

3. Amplitude of contractions of the semitendinosis at 20 cm were significantly greater than at 9 cm.

4. Amplitude of gastrocnemius contractions at 20 cm were significantly greater for subjects using a 25 cm longitudinal block spacing.

5. Amplitude of semitendinosis contractions at 4, 9, and 20 cm were significantly greater at the 25 cm longitudinal spacing.

6. Amplitude of gastrocnemius contractions at 15 cm were sig-

nificantly greater for subjects classified as having short levers.

7. Amplitude of semitendinosis contractions at 4 cm were greater for those having short levers.

CONCLUSIONS

1. 15 cm appears to be the best width for sprint starting.

2. 4 cm was found to be the least effective of the four widths studied.

3. The 20 cm width was found to be more effective than the 4 cm, but less effective than the 9 or 15 cm widths.

4. A shorter longitudinal block spacing appears to put the semitendinosis in better position for contraction.

5. Wider foot placement appears to put all the muscles studied in a better position for contraction.

RECOMMENDATIONS

It is recommended that further study be carried out in this area, including the following:

1. More subjects should be used to enable a wider range of comparisons to be made. This would bring more individual differences into play in the study and allow a greater number of comparisons to be made concerning the effects of lever length and longitudinal spacings.

2. Effects of wider foot placement should be studied on

athletes using bunch, medium, and elongated starts. This would allow more comparisons to be made concerning different longitudinal block spacings. It would also indicate the value of variable widths at each of these starting positions.

3. Hip width should be measured in order to more accurately determine the most effective foot width. An attempt should be made to place the blocks at the same width as the hips so that the force against the blocks would be exerted in a straight line from hip to toe.

4. Additional muscles should be included in the study. Other muscles involved in starting should be studied to determine the importance of their role, the amplitude of their contractions, and the effect of variable foot width placement on these muscles.

5. Subjects should also be timed over an established distance after starting from various widths to further support the findings. Times recorded for a 100 yard dash should be compared when using standard starting blocks and variable width starting blocks. This should also be done at 30, 60, and 220 yards and in the 120 yard high hurdles or other sprint events where the start is of major importance. Results should indicate whether or not speed is gained by using variable width foot placement.

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