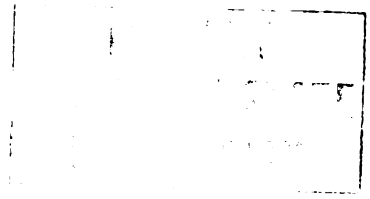

THE RELATIONSHIP OF SELECTED WRIST AND GRIP STRENGTH MEASURES TO BEGINNING BOWLING PERFORMANCE

By

WILLIAM ARTHUR HORWOOD

AN ABSTRACT

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

MASTER OF ARTS

Department of Health, Physical Education, and Recreation

Year 1957

Approved Wayne L. Van Huss

ABSTRACT

Title

The Relationship of Selected Wrist and Grip Strength Measures to Beginning Bowling Performance.

Statement of the Problem

The problem of the study is to determine the relationship of selected wrist and grip strength measures to beginning bowling averages. More specifically it consists of the following phases: (1) to determine the relationship between wrist palmar flexion and beginning bowling averages; (2) to determine the relationship between wrist dorsal flexion and beginning bowling averages; (3) to determine the relationship between wrist abduction and beginning bowling averages; (4) to determine the relationship between wrist adduction and beginning bowling averages; (5) to determine the relationship between grip strength and beginning bowling averages; (6) to determine the relationship of a composite score of wrist strength measurements and beginning bowling averages; and (7) to determine the relative contribution of each of the strengths measured to beginning bowling performance.

Methodology

Seventy-four beginning bowlers of the Michigan State University instructional bowling courses participated in the experiment. All of the subjects were measured for palmar flexion, dorsal flexion, adduction, and abduction of the wrist, along with grip strength of the dominant

hand. Reliability coefficients for the five tests ranged from .949 to .991. Pearson Product-Moment coefficients of correlation were calculated from the strength tests and bowling performance data. A multiple regression analysis was also calculated to determine the relative contributions of each of the various strength measures to bowling performance.

Conclusions

1. Grip strength, abduction, and total wrist strength are significantly related to beginning bowling performance.

2. The relationship between beginning bowling performance and the wrist measures of dorsal flexion, and adduction is statistically insignificant.

3. The battery of tests is significantly related to beginning bowling ability. Grip strength is the most dominant.

4. Subjects' weight and number of games bowled are poor predictors of a beginner's bowling ability.

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Dedicated To

My Parents

ACKNOWLEDGEMENTS

The author wishes to extend his thanks to Dr. Wayne Van Huss for his interest and guidance in the preparation of this thesis.

Special thanks is also extended to my fiancee, Miss Jean Leety, for her encouragement, suggestions, and assistance throughout the preparation of this paper. The writer is also indebted to Mr. Frank Pellerin and Mr. Don Potter for their cooperation and assistance in securing data for the study, and to Dr. Henry J. Montoye for his valuable suggestions.

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William A. Horwood

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CHAPTER I

INTRODUCTION

During the past several decades the participation and interest in the sport of bowling has grown to the point that annually approximately fifteen million people spend leisure time bowling.[1] This doesn't take into account the numbers who enjoy bowling through the medium of television. Sports Illustrated, in rating sports by the number of participants, recently ranked bowling the second most popular sport in the United States, behind fishing.[2]

Tinkle found grip strength related to achievement in physical education.[3] From an empirical evaluation it seemed that study of the relationship between bowling and strength measurements of the wrist might add further insight into bowling performance and the methodology of teaching bowling.

Statement of the Problem

To determine the relationship of selected wrist and grip strength measures to beginning bowling averages. More specifically it consists of the following phases: (1) to determine the relationship between wrist

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[1]The Athletic Institute, Recreation for Community Living:Guiding Principles (Chicago:The Athletic Institute, 1952), p. 2.

[2]Gerald Holland, "The Golden Age is Now", Sports Illustrated, 1:1: 51:46-48. August 16, 1954.

[3]W. F. Tinkle, "An Investigation of the Relationship between Grip Strength and Achievement in Physical Education", (unpublished Master's Thesis, Michigan State University, East Lansing, 1955), p. 34.

palmar flexion and beginning bowling averages; (2) to determine the relationship between wrist dorsal flexion and beginning bowling averages; (3) to determine the relationship between wrist abduction and beginning bowling averages; (4) to determine the relationship between wrist adduction and beginning bowling averages; (5) to determine the relationship between grip strength and beginning bowling averages; (6) to determine the relationship of a composite score of wrist strength measurements and beginning bowling averages; and (7) to determine the relative contribution of each of the strengths measured to beginning bowling performance.

Purpose of the Study

Approximately one thousand men a year select bowling as one of their physical educational courses at Michigan State University. Many others are unable to take the course due to lack of facilities. Goellner reports the methods now used in teaching bowling in colleges and universities are based primarily on empirical knowledge. No single method of instruction is in vogue.[4] The purpose of this study is to:

1. Find the relationship between wrist strength and grip strength beginning bowling scores.
2. To stimulate study in the methodology of teaching bowling.

Definition of Terms

Tensiometer.[5] A gauge for measuring cable tension in which the cable passes over two sectors and, when tension is applied, affects a

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[4]W. A. Goellner, "Comparison of the Effectiveness of Three Methods of Teaching Beginning Bowling", Research Quarterly, 20:4:387, December, 1956.

[5]H. H. Clarke, Cable-Tension Strength Tests (Chicapee, Massachusetts: Brown-Murphy Company, 1953), p. 2.

third sector (riser) which connects mechanically to the face of the device to permit recording in dial units which are convertable to pounds.[6]

Hand Dynamometer. The Narrogansett Hand Dynamometer Apparatus is a spring scale device which measures the amount of pressure applied to the hand grip.

Beginning Bowlers. Those who have had no previous instruction or experience in the sport of bowling.

Beginning Bowling Averages. The individual averages compiled for each of the seventy-four subjects over a ten week period.

Limitations of the Study

1. Some of the subjects tested were not only bowling in class, but to some extent, were active in open bowling and intramural leagues. No attempt was made to control this.

2. Subjects selected from bowling classes were under the guidance of three instructors. Individual difference in instruction procedure may have somewhat affected the progress of the bowlers.

3. The subjects were tested during different times of the day. Fatigue may have served to bias the results somewhat.

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[6]Figure 1.

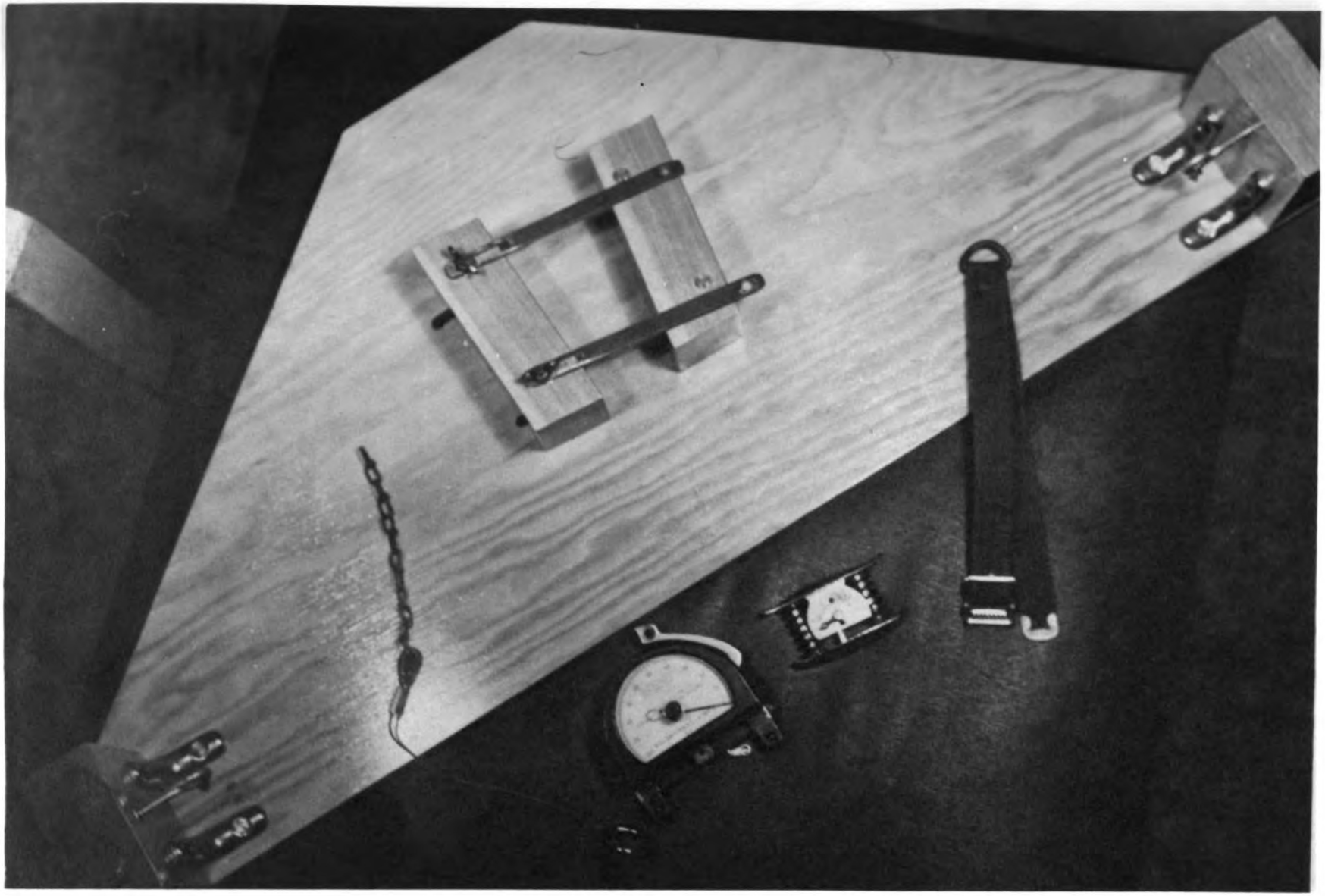

Figure 1. Equipment utilized in administering the Tensiometer and Dynamometer Tests. (portable testing board, chain and snap, cable-tensiometer, hand dynamometer, and the regualtion strap.)

CHAPTER II

REVIEW OF THE LITERATURE

Cable-Tensiometer Testing

In 1948 the initial research into cable-tensiometer strength testing was reported.[1] The apparatus and techniques of measurement of the strength of selected muscle groups were presented. Coefficients of objectivity ranging between 0.92 and 0.97 were obtained on normal college men.

The cable tensiometer was utilized to record the amount of tension the subject could apply to a cable appropriately spaced for specified movements.[2] The tensiometer was later improved by the addition of a maximum pointer to facilitate reading the subject's score.[3] A comparison of the effectiveness of four instruments for recording muscle strength was reported by Clarke.[4] The cable tensiometer, the Wakim-Porter strain gauge, the spring scale, and the Newman myometer were all studied. As a result of the study Clarke stated:

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[1] H. H. Clarke, "Objective Strength tests of Affected Muscle Groups Involved in Orthopedic Disabilities", Research Quarterly, 19:4:118-47, May, 1948.

[2] Ibid.

[3] H. H. Clarke, "Improvement of Objective Strength Tests of Muscle Groups by Cable-Tension Methods", Research Quarterly, 21:4:399-419, December 1950.

[4] H. H. Clarke, "Comparison of Instruments for Recording Muscle Strength", Research Quarterly, 25:4:398-411, December, 1954.

> As reflected by objectivity coefficients, the cable tensiometer had the greatest precision for strength testing. It was the most stable and generally useful of the instruments; and was free of most of the faults of the other devices. The strain gauge had a satisfactory degree of precision; but was extremely sensitive to slight tensions, including changes in room temperatures. Both the spring scale and the Newman myometer had deficiencies which limited their usefulness.[5]

Wakim, et al. compared the strain gauge with the tensiometer. The results are as follows:

> Simultaneous readings were taken with the two instruments at angles of pull of 90, 100, 110, and 120 degrees (200 observations of 20 young women). The average power recorded with the strain gauge was 61.1 pounds, whereas with the tensiometer it was 57.0 pounds. The average difference in readings between the two instruments was 4.1 pounds, with the strain gauge giving higher results in 183 observations, the tensiometer giving higher readings in 10, and the two giving identical recordings in 7. Since the two instruments gave identical readings under static conditions, it seemed as if the lower results with the tensiometer were due to friction within the instrument.[6]

Grip Strength Testing

Grip strength, using the hand dynamometer, is one of the earliest and best forms of strength tests.[7] The major portion of research on grip strength has been completed as one of the measures of growth and development or in batteries of tests relative to physical fitness or motor ability.

Rogers[8] found that strength varies during the day so that time of day is a factor in reliability. One subject was tested and his scores were as follows:

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[5] Ibid., p. 398.

[6] K. G. Wakim, J. W. Gersten, E. C. Elkins, and G. M. Martin, "Objective Recordings of Muscle Strength", Archives of Physical Medicine, 31:95, February 1950.

[7] W. P. Brown, Applied Anatomy and Kinesiology, (Philadelphia: Lea and Febiger, 1949), p. 36.

[8] F. R. Rogers, "The Significance of Strength Tests in Revealing Physical Condition", Research Quarterly, 5:3:43-46, October, 1934.

Time	Score
6:00 PM	175
12:00 PM	160
6:00 AM	140
12:00 AM	150
6:00 PM	160

He also found a decline in grip strength is apparent the day following strenuous exercise. Average scores dropped from 172-112 in four testing periods. Rogers concluded, as a result of study of the Physical Fitness Index, that grip strength tests are likely to prove invaluable to athletic coaches in selecting players and substitutes for any game involving large muscle activity and in deciding when and whether or not to return tired players to action.

Tinkle[9] correlated grip strength with achievement in physical education among college men. The subjects' (635 men enrolled in physical education instructional courses at Michigan State University) grip strengths of both hands were correlated with the final letter grades received in physical education. His conclusions were as follows:

A. Grip strength is important to achievement in physical education at Michigan State University.

B. Right grip strength is highly correlated with left grip strength.

C. A significantly larger proportion of left handed men have stronger right hands, as compared to right handed men with stronger left hands.

D. College students who are physically weak could benefit from a course to improve strength.

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[9]W. F. Tinkle, "An Investigation of the Relationship between Grip Strength and Achievement in Physical Education", (unpublished Master's thesis, Michigan State University, East Lansing, 1956), p. 37.

E. An individual's weight is more closely correlated with grip strength than either his height or age.

F. The statistical analysis of the data demonstrated that raw grip strength scores are nearly as accurate in predicting achievement, as are tests that consider weight in the evaluation. Although as you compare the A, B, and C students with the D and F students, weight is more significant.

Studies Related to Strength Measurements

Di Giovanna[10] conducted studies to determine the relationship of selected structural and functional measures to success in college athletics. He concluded that strength and power are more important to athletic success than bodily structure.

Ehrlich,[11] in a study of the fencing lunge and strength, concluded that measures of strength are not related to rates of learning or accuracy of total body movements.

Rasch[12] concluded there is no definite relationship between speed of arm movements and strength of the arm.

In an earlier study by McCloy,[13] however, value of arm strength in athletics was investigated. Where boys were used as subjects, with track events as criterion of athletic ability the strength of the arms was shown to be of great importance. A multiple correlation with leg,

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[10]Vincent Di Giovanna, "The Relationship of Selected Structural and Functional Measures to Success in College Athletics", Research Quarterly, 14:199-216, May, 1943.

[11]Gerald Ehrlich, "The Relation between the Learning of a Motor Skill and Measures of Strength, Ability, Educability, and Capacity", Research Quarterly, 14:46-59, May 1943.

[12]P. J. Rasch, "Relationship of Arm Strength, Weight and Length to Speed of Arm Movement", Research Quarterly, 25:328-332, October 1954.

[13]C. H. McCloy, "The Apparent Importance of Arm Strength in Athletics", Research Quarterly, 5:1:3-11, March 1934.

back, and arm strength measures resulted in an R of .9142. Deleting the back and leg elements the R remained .9106.

Gross, Griesel, and Stull[14] calculated the relationship between motor educability, strength, and wrestling ability after eight weeks' on naive subjects. The highest correlation found was ($r = .498 \pm .10$) between McCloy's General Strength Quotient and the ability to learn wrestling. Wrestling ability was evaluated by two competent judges using a rating scale.

Hinton and Rarick[15] correlated Roger's Test of Physical Capacity and the Cubberly Cozens' Measurement of Achievement in Basketball. A correlation ($r = .550$) between basketball achievement and arm strength was obtained. This would lead one to believe that strength of arms may play a greater part in acquiring basketball skills than might ordinarily be thought. The authors, however, go on to explain:

> Arm strength may be important, not because back and leg strength are not important, but because when one develops arm strength, general body strength usually develops.[16]

Bowling

There has been only a limited amount of research conducted concerning the various phases of bowling. In a documentary analysis of the contents of the Research Quarterly from 1930 to 1949, Loucks[17] lists one

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[14]E. A. Gross, D. C. Griesel, and A. Stull, "Relationship between Two Motor Educability Tests, a Strength Test, and Wrestling Ability after Eight-Weeks' Instruction", Research Quarterly, 27:4:395-402, December 1956.

[15]E. A. Hinton and L. Rarick, "The Correlation of Roger's Test of Physical Capacity and the Cubberly Cozens' Measurement of Achievement in Basketball", Research Quarterly, 11:3:58-65, October 1940.

[16]Ibid., p. 63.

[17]Donald Loucks, "An Analytical Frequency Study of the Contents of the Research Quarterly, 1930-1949", Research Quarterly, 23:2:209-220, May 1952.

article on bowling among a total of 1,080 articles reviewed.

Only four Master's theses of 3,725 completed between 1930 and 1946 deal directly with bowling.[18]

Roloff's study of kinesthesis and learning of motor skills led to this statement:

> The correlation found between the gains made by 80 bowling students and their first scores resulted in a correlation coefficient of -.76. This indicated that those who were low on their initial score had a better chance for improvement than those who started with a higher score. No correlation was found between either motor ability or kinesthesis and bowling scores.[19]

This would not necessarily mean that a lower initial score would assume more learning, but that there is more opportunity for improvement. No investigation was made to see if those with initial high scores had any exceptional contributing factor.

However, Phillips and Summers[20] found beginning bowling to be related to kinesthetic perception. Some evidence was found to support the hypothesis that kinesthesis is more related to learning in the early stages. The differences between the fast and slow learners among beginning bowlers were statistically significant at the 1 percent level.

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[18] T. K. Cureton, Master's Theses in Health, Physical Education, and Recreation (Washington: American Association for Health, Physical Education and Recreation, 1952), pp. 1-292.

[19] L. L. Roloff, "Kinesthesis in Relation to the Learnings of Selected Motor Skills", Research Quarterly, 24:2:215, May 1953.

[20] M. Phillips and D. Summers, "Relation of Kinesthetic Perceptions to Motor Learning", Research Quarterly, 23:4:456-468, December 1954.

CHAPTER III

METHODOLOGY

This study was undertaken to determine the relationship of selected wrist and grip strength measures to beginning bowling.

A total of seventy-four men were selected from nine bowling classes as a representative sample of the Michigan State University Bowling Program. The men selected were all of the beginning bowlers available in the nine sections.

The cable tensiometer test was administered as described by Clarke[1] with a change made in design of the table so as to make the equipment portable. The change was accomplished by constructing a base with a hooking device at each end. Moveable blocks were positioned in the center of the board to assist in immobilizing the subject's arm.[2] The subjects were not seated during the testing, but stood before a counter upon which the equipment rested.

Grip strength was measured in the manner described by Hunsicker and Montoye.[3]

All of the subjects were measured for palmar flexion, dorsal flexion, adduction and abduction of the wrist, along with grip strength of the dominant hand.

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[1]H. H. Clarke, Cable-Tension Strength Tests (Chicopee, Massachusetts: Brown-Murphy Company, 1953), pp. 12-15.

[2]Figures 1 and 2.

[3]P. A. Hunsicker and H. J. Montoye, Applied Tests and Measurements in Physical Education (New York: Prentice Hall, Inc., 1953), p. 55.

Figure 2. Table and equipment as used in the Tensiometer Test.

A reliability coefficient was obtained for each of the tests administered. Thirty of the subjects were retested on the same day by the writer. The established coefficients of reliability for the tests are as follows:

Test	r
Palmar flexion.....	.987
Dorsal flexion.....	.991
Adduction.....	.977
Abduction.....	.949
Grip strength.....	.976

These reliability coefficients are high enough to meet requirements for the self-correlation of a physical test.[4]

Reading and recording of the strength scores for each student was done by the author. Cable tensiometer readings were made to the nearest quarter-dial unit and then converted to pounds. Grip strength scores were recorded to the nearest pound. All data were recorded on a separate card for each man.[5] The scores of the dominant wrist and hand were recorded, the better score of two trials being used. Testing for each individual was completed in a single class period.

Pearsen Product-Moment coefficients of correlation[6] were calculated from the strength tests and bowling performance data. A multiple regres-

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[4]H. E. Garret, Statistics in Psychology and Education (New York: Longmans, Green and Co., 1926), p. 59.

[5]Appendix A.

[6]E. F. Lindquist, A First Course in Statistics (Boston:Houghton Mifflin Company, 1942), pp. 139, 240.

sion analysis[7] was also calculated to determine the relative contributions of each of the various strength measures to bowling performance.

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[7] C. C. Peters and W. R. Van Voorhis, Statistical Procedures and their Mathematical Basis (New York:McGraw-Hill Book Company, Inc., 1940) pp. 225-234.

CHAPTER IV

ANALYSIS AND PRESENTATION OF THE DATA

In an effort to determine the contribution of selected wrist and grip strength measures to beginning bowling performance this study was undertaken. Seventy-four men from the Michigan State University beginning bowling program participated in the experiment.

The subjects were tested successively for wrist palmar flexion, dorsal flexion, adduction, abduction, and grip strength. A record of weight, total games bowled and a ten week bowling average was collected.

Analysis of Data

The data were analyzed in the following manner: the strength measures, total games bowled, and weight were correlated with the beginning bowling average. Also a multiple correlation between the criterion and a composite score of the four wrist strength tests and the grip test was calculated.

Results

Bowling averages compared to weight and total games. Since the subjects weight and the number of games he bowled were available, these were compared with the bowling averages. The correlation coefficients were .161 and .094 respectively and neither is considered large enough to be very useful.

Comparison of strength scores with bowling. Table 1 shows the relationship of bowling performance with palmar flexion, dorsal flexion, adduction, abduction, grip strength, and a composite score of the wrist

measures. This composite included the measures of palmar flexion, dorsal flexion, adduction and abduction.

TABLE 1

RELATIONSHIP BETWEEN SELECTED WRIST STRENGTH SCORES, GRIP STRENGTH, AND BEGINNING BOWLING PERFORMANCE

Strength Tests	Bowling Performance
Palmar Flexion	.166
Dorsal Flexion	.260
Adduction	.218
Abduction	.388
Grip Strength	.507
Composite Wrist Strength	.319

The highest correlation coefficient found was .507 between grip strength and beginning bowling performance, and abduction followed with an $r = .388$. These two coefficients are considered to be statistically significant at the 1 percent level.[1] Dorsal flexion ($r = .260$ was found to be significant at the 5 percent level, while adduction ($r = .218$) was not statistically significant. The low correlation coefficient of palmar flexion (.166) makes it of little value in predicting bowling ability. It should be noted that the composite score of the four wrist scores was very highly significant ($r = .319$).

[1] J. P. Guilford, Psychometric Methods (New York and London: McGraw-Hill Book Company, Inc., 1936), p. 549.

A multiple R of .5801 between the criterion, beginning bowling performance, and the four wrist and the grip strength tests is shown in Table 2. This R is statistically significant at the 1 percent level. The intercorrelations for the selected strength measures also appear in the table. Furthermore the percent contribution of each of the measures is indicated.

TABLE 2

MULTIPLE CORRELATION BETWEEN THE CRITERION, BEGINNING BOWLING PERFORMANCE, AND A COMPOSITE SCORE OF FOUR WRIST STRENGTH TESTS AND A GRIP STRENGTH TEST

Strength tests	Bowling Average	1	2	3	4	B	B^2	% of Contribution
1. Palmar Flexion	.166					.037	.0014	.48
2. Dorsal Flexion	.260	.425				.064	.0041	1.41
3. Adduction	.218	.300	.528			.010	.0001	.03
4. Abduction	.389	.670	.503	.440		.171	.0291	9.94
5. Grip Strength	.507	.318	.323	.278	.325	.508	.2580	88.14
							.2927	100.00

R = .5801

The following observations may be made relative to the intercorrelations of various wrist strength and grip strength measures:

> All of the correlations are significant at the 1 percent level of confidence excepting palmar flexion with adduction and adduction with grip strength. These correlations were both found statistically significant at the 5 percent level of confidence.

In studying the percent of contribution we note that grip strength accounts for 88 percent of the predictive variance. This seems to indicate that this measure alone might be useful in predicting beginning bowling ability.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

Seventy-four men, who had no previous bowling instruction or experience, were selected from the Michigan State University instructional bowling program to participate in a battery of five strength tests. These tests included: palmar flexion, dorsal flexion, adduction, abduction, and grip strength. The purpose of the experiment was to determine the relationship between these measurements and beginning bowling performance. Intercorrelations of these strength scores were also investigated. The reliability of the testing ranged from .949 to .991.

Conclusions

The following conclusions seem justified on the basis of the statistical data presented:

1. Grip strength, abduction, and total wrist strength are significantly related to beginning bowling performance.
2. The relationship between beginning bowling performance and the wrist measures of dorsal flexion and adduction is statistically insignificant.
3. The battery of tests is significantly related to beginning bowling ability. Grip strength is the most dominant.
4. Subjects' weight and number of games bowled are poor predictors of a beginner's bowling abiltiy.

Recommendations

The following recommendations are made for additional study with beginning bowling performance:

1. A similar investigation using female college students might prove to be more helpful.
2. Other strength measures such as back and leg strength could be correlated with the same criterion.
3. A study correlating arm-leg coordination, along with body balance, with performance of beginning bowlers could be conducted.
4. An investigation of the experience possessed by students admitted to bowling classes at Michigan State University. This might give inexperienced bowlers more opportunity to enroll in the beginning class.
5. Additional investigation of the battery included in this study might further validate the data presented herein.
6. A similar study in such a sport as golf might prove valuable.

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APPENDIX

APPENDIX A

Card For Recording Data

Name.....

Section.....

Weight.....

Previous Bowling Experience:

League Experience..... Average.....

Years Bowled.....

Previous Instruction.....

Total Games Previous to this Term.....

Bowling Hand: Left..... Right.....

Strength Scores:	First Test	Second Test
Palmar Flexion	.....	.....
Dorsal Flexion	.....	.....
Adduction	.....	.....
Abduction	.....	.....
Grip Strength	.....	.....

Bowling Average for Term.....

Games Bowled During Term.....

APPENDIX B

A TABLE OF MEASURES OF SEVENTY-FOUR BEGINNING BOWLERS

Subject	Bowling Average	Palmar Flexion	Dorsal Flexion	Adduction	Abduction	Total Wrist Strength	Grip Strength	Weight	Total Games
1	157	53	31	33	42	159	138	170	21
2	144	75	47	47	55	224	110	140	26
3	142	53	40	29	40	162	115	165	33
4	137	57	47	39	53	196	140	157	21
5	135	71	56	63	73	263	125	190	29
6	134	60	39	18	53	170	140	170	24
7	133	55	36	27	50	168	117	150	35
8	133	60	30	38	57	185	140	265	27
9	132	80	46	32	61	219	128	200	23
10	125	69	57	33	45	204	158	180	40
11	124	42	48	22	41	153	120	155	24
12	121	52	36	28	41	157	133	162	34
13	121	77	50	39	43	209	118	145	22

Subject	Bowling Average	Palmar Flexion	Dorsal Flexion	Adduc-tion	Abduc-tion	Total Wrist Strength	Grip Strength	Weight	Total Games
14	118	52	43	27	39	161	150	160	28
15	115	48	42	62	43	195	145	150	24
16	113	42	35	36	41	154	97	190	29
17	111	57	50	27	57	191	145	165	24
18	110	52	41	27	42	162	115	137	23
19	108	51	36	27	30	144	108	160	26
20	107	50	40	31	42	163	100	155	24
21	103	50	40	28	35	153	68	140	23
22	89	45	36	22	35	138	100	165	25
23	156	60	53	44	45	202	185	185	23
24	155	61	70	70	70	271	140	180	28
25	138	62	51	29	45	187	145	165	29
26	138	34	36	22	33	125	105	145	31
27	135	42	56	33	46	177	125	160	28
28	135	82	39	29	48	198	133	160	25
29	135	57	46	34	56	193	126	152	27

Subject	Bowling Average	Palmar Flexion	Dorsal Flexion	Adduc-tion	Abduc-tion	Total Wrist Strength	Grip Strength	Weight	Total Games
30	131	41	39	38	33	151	112	180	32
31	130	57	44	23	44	168	140	160	27
32	128	93	51	44	62	250	142	185	21
33	127	50	45	33	34	162	105	168	32
34	127	60	48	33	46	187	140	150	31
35	127	54	40	28	57	179	116	135	32
36	127	95	49	31	68	243	136	160	22
37	125	89	60	43	70	262	140	195	27
38	122	47	38	25	42	152	105	155	32
39	121	77	47	38	50	212	120	160	32
40	121	75	42	23	51	191	130	175	30
41	121	76	41	28	33	178	105	132	26
42	120	40	44	27	31	142	95	160	18
43	119	113	42	41	59	255	128	230	23
44	118	42	27	23	28	120	100	145	33
45	117	50	44	31	39	164	120	135	25

Subjects	Bowling Average	Palmar Flexion	Dorsal Flexion	Adduction	Abduction	Total Wrist Strength	Grip Strength	Weight	Total Games
46	116	49	38	27	50	164	105	150	22
47	115	73	46	38	53	210	126	145	29
48	114	61	36	27	44	168	108	170	25
49	113	50	48	39	44	181	140	195	26
50	107	54	49	32	46	181	68	155	22
51	106	49	39	16	32	136	106	140	20
52	158	63	44	30	49	186	138	160	28
53	146	47	33	37	50	167	142	145	30
54	141	73	49	36	43	201	162	185	29
55	137	62	41	38	55	196	138	200	28
56	135	47	46	28	56	177	145	165	40
57	135	48	33	38	42	161	102	150	30
58	132	55	44	20	55	174	129	174	28
59	131	58	38	38	46	180	130	165	32
60	131	60	36	27	39	162	118	190	28
61	129	44	47	22	44	157	125	160	29

Subjects	Bowling Average	Palmar Flexion	Dorsal Flexion	Adduc-tion	Abduc-tion	Total Wrist Strength	Grip Strength	Weight	Total Games
62	126	34	45	45	27	151	105	125	34
63	124	21	31	24	18	94	136	146	32
64	123	38	40	32	27	137	112	145	39
65	123	72	49	40	29	190	140	175	21
66	121	40	42	27	27	136	130	134	33
67	120	65	48	45	59	217	120	180	26
68	119	87	40	28	53	208	118	160	28
69	118	63	47	28	43	181	130	180	30
70	118	47	28	25	44	144	102	138	26
71	113	28	30	16	14	88	108	150	34
72	109	50	39	33	33	155	120	150	35
73	102	35	36	33	27	131	126	190	26
74	100	44	42	30	33	149	115	145	32