THE EFFECT OF WEIGHT CHANGE UPON GRIP STRENGTH OF COLLEGE WRESTLERS

A Thesis

Presented to

the Division of Health,

Physical Education and Recreation

Kansas State Teachers College of Emporia

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

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by

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August 1970

William A. Harper
Approved for the Major Department

Approved for the Graduate Council

ACKNOWLEDGMENTS

For initial introduction to the sport of wrestling, guidance, and a goal in life, acknowledgment and appreciation is expressed to William P. Happ, University of Northern Iowa High School; Dave McCuskey, State University of Iowa; and Frank Powell, Adams State College.

For assistance in compiling the research material needed for background, acknowledgment and thanks is extended to Harold D. Trotter, Coe College; John D. Trotter, University of South Dakota; and Joseph H. Spearing, MD, Harlan, Iowa.

For continual encouragement, editing and typing, acknowledgment and love is directed to my wife.

For direction, deep patience and constant assistance in compiling this study, acknowledgment and friendship is extended to William A. Harper, Kansas State Teachers College of Emporia.

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Chapter 1

INTRODUCTION

Wrestling, dating back to 1788 B. C., is the oldest form of organized sport, outdating its closest competitor, boxing, by over 900 years.[1] The Greeks popularized wrestling during the rise of the Olympics when it was proclaimed the chief event of the pentathlon. As the Olympics spread, the sport was carried to Europe and Asia, and later to the United States.

European wrestling is centered around the Greco-Roman style, and is best exemplified on the continent by competitors from Germany and Belgium; moving away from the continent Turkey and Russia. Asian nations, notably China, Japan, and more recently Korea, utilize the free style form of wrestling. Japan also competes in Sumo, another style of wrestling.

Wrestlers in the United States employ both Greco-Roman and free style when competing internationally. Generally however, the Collegiate style (sometimes referred to as "catch-as-catch-can") is employed among high school and college competitors. Amateur style wrestling should not be confused with professional acting type wrestling which is

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[1]Marvin H. Eyler, "Origins of Contemporary Sports," Research Quarterly, XXXII (December, 1961), 484.

peculiar to the United States. The latter form is strictly a performance put on for entertainment purposes and does not exemplify the good sportsmanship or skill required in amateur wrestling.

Because of the varied types of wrestling, there are different rules to regulate each style. However, one rule which is basic to all styles of amateur wrestling, is that rule related to weight divisions or classifications. A curious paradox exists in regard to this common regulation. On one side, weight classification allows for equal competition; on the other, this necessitates regulations in order to keep that very competition equal because of weight classification. The harshest criticism of wrestling is centered around this point.

Opponents of wrestling generally base their opinion in one of three areas: 1) the methods used in achieving desired certification weight are medically unsound, 2) allowing competitors to wrestle at a weight lower than their normal level gives them an unfair advantage over those who wrestle at their natural weight, and 3) it is virtually impossible to police the regulations which control weight classification.

Proponents, on the other hand, base their opinion on three main points: 1) the abuse in methods of weight control are small in number and are not condoned by the vast majority of coaches, wrestlers, and national wrestling associations, 2) there is a constant check on the regulations of weight classification which is eliminating those

who abuse the weight division system, and 3) there is a semantic problem in that terms such as weight cutting, starvation, and weight control are used interchangeably. In actuality their meanings vary decisively.

Thus, the issues of weight classification have raised much concern among coaches, doctors, school administrators, and wrestling fans. Fortunately however, it has not dampened the spirit of the sport, as wrestling is now the fastest growing sport in high schools. The 1969 Sports Participation Survey, compiled by the National Federation of State High School Athletic Associations, revealed that even with the reduction of the number of schools through consolidation, there has been an increase of 2,224 participating schools and an added 85,962 participants in wrestling since 1965. According to this survey, Arkansas and Mississippi are the only states listing no wrestling teams.[2]

This rapid growth pattern of wrestling has served to further intensify concern over problems relating to weight classification. Specifically, hundreds of articles, editorials, studies, and theses have been presented on the question of means and motives of weight control in wrestling. Concern is growing. Wrestling is growing. Literature is growing. It is the hope of this writer that all three continue in this vein.

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[2]"Wrestling Grows Fastest," Amateur Wrestling News, XV (September 24, 1969), 19.

NATURE OF THE PROBLEM

Athletes have long been known as trained people who function most effectively when they have well-conditioned and well toned bodies. The condition of the body has been important in all sports; in the fields of boxing and wrestling the body condition has been critical because of weight regulations basic to both sports.

Each wrestler has had to select the weight class best suited to his particular body build. This selection has been colored by many outside factors, such as, the number of wrestlers in a weight class, the improved chance of competing in another class, the parental opinion of weight control.

The wrestler has been further subjected to outside influences because of the attention which has been given to the practice of cutting weight. Several series of articles have shown the dangers of such an athletic policy. And these publications have prompted others to do more thorough research into a policy which if challenged could change the entire perspective on a classical sport.

Importance of the study

This study was undertaken to provide additional material to wrestlers and coaches of wrestling who need to have objective literature in order to make their personal decision on weight control.

Statement of the problem

The purpose of this study was to determine the effect of weight change among competing intercollegiate varsity wrestlers upon grip strength.

Statement of the hypothesis

There is no significant relationship between weight change of competing intercollegiate varsity wrestlers and hand grip strength.

Limitations of the study

This study was limited by three main factors:

1. The original number of subjects were not able to complete the entire testing program.

2. The writer was also the varsity wrestling coach.

3. It appeared that some of the subjects had a poor attitude toward the study.

Delimitations of the study

This study was delimited by three main factors:

1. This study was not concerned with overall strength; hand grip strength was the only criteria involved.

2. To measure this criteria, the Naragansett hand dynamometer was selected for its easy use, compactness, and high reliability.

3. The testing procedure and dates were established to show the effects of various levels of weight loss.

Therefore, one testing site was used which differed from the other three in order to test the hypothesis at the first maximum weight loss level.

Thus, the study was not concerned with controlling outside factors such as psychological effects of competition on the strength test results. Neither was it concerned with methods or amount of weight loss achieved during a specific period of time. Nor was this study corrected statistically for outside influences such as the physical involvement of the subjects beyond the actual wrestling program.

Rather, this study was confined only to the relationship, if any, between weight change and hand grip strength among competing intercollegiate varsity wrestlers.

DEFINITION OF TERMS

Weight change

In this study weight change refers to the amount of weight a wrestler gains or loses from one testing period to another.

Weight control

In this study weight control refers to a systematic plan of weight loss followed by a program of maintaining weight. It differs from weight cutting in that proper diet is required and methods of weight loss are carefully regulated to avoid crash diet losses or dehydration. The means is as important as the end result.

Weight cutting

The end result is most important when weight cutting is defined as it relates to this study. Without regard for the means of weight reduction, the wrestler is concerned only with achieving the weight level which he desires.

Hand grip strength

The gripping strength of the hand is the amount of force exerted with the finger and thumb flexors. These flexors have origin in both the forearm and hand and insertion at the fingers and thumb.

Hand dynamometer

The hand dynamometer is a strength testing device which measures the maximal force exerted by the finger and thumb flexors.

Chapter 2

REVIEW OF LITERATURE

The concern with the possible dangers involved in wrestling weight control programs has produced many attempts to either oppose or defend the present system. Because of these vested interests little of the literature studied can claim total objectivity, but it is clear that some literature is more objective than others.

The greatest problem arising from attempting such a review is that the issue of weight control is charged with strong feelings and factional disputes. No single person can satisfy all sides of the issue, for it is an issue, and it appears that the real issue involved has not yet been clearly stated. Much of the difficulty in attempting to resolve the conflicts has been caused by the inability of the writers to clearly see the nature of the problem. This difficulty is further aggrevated because it appears that there is no simple corrective to the problem even if its nature were clearly perceived. Such problems force the researcher into skirting the issue, or at best, merely alluding to it. It is, indeed, a complex problem, one which requires an objective observer to grant some validity to each of the divisive points of view.

It is unnecessary and perhaps even impossible to spell out here the enormous scope of literature pertaining

to the problems inherent in weight control as it relates to wrestling. Rather, it was the purpose of this review to concentrate on two aspects of the question: 1) Weight Loss Specific to Wrestling, and 2) Strength Testing Specific to Wrestling.

Because of the deep divisions noted, a comparative approach is utilized through a systematic study beginning with the conservative and gradually progressing toward the more liberal views specific to the issue of weight control in wrestling. Although the studies differ superficially in approach and empirical value, such a comparison will indicate the great similarities among them.

WEIGHT LOSS SPECIFIC TO WRESTLING

The most conservative literature on weight loss as it relates to wrestling is found to be either that published by the medical profession or that material published which cites the authority of medical opinions. In 1958, the American Medical Association Committee on the Medical Aspects of Sports (hereafter referred to as the Committee) issued a news release which declared its objection, both on ethical and physiological grounds, to the practices of "making weight."[3] The National Federation of State High School Athletic Associations (NFSHSAA) found that this charge appeared to be valid in some instances, but poorly founded in others. In order to attain further clarification,

[3]"Making Weight," News Release. (Chicago: American Medical Association Committee on the Medical Aspects of Sports, December, 1958).

they asked the Committee for guidance in establishing a factual approach to the issue.

The Committee agreed to reexamine the issue at the 1965 and 1966 National Conventions on the Medical Aspects of Sports. Prior to the convening of these conventions, the Committee and the NFSHSAA issued the following statement:

> Reduction of caloric intake to starvation levels, particularly when fluids are withheld or sharply limited reduces energy drastically and impairs physical performance.[4]

Following the conventions, this view remained intact. In addition, the Committee offered suggestions for the control of abuse in wrestling weight control programs.[5]

Even though this statement is the official position of certain physicians, many other stances have been adopted ranging from highly conservative to dangerously radical. As an example of one physician who faithfully supports and extends the Committee proclamation, the work of William Paul can be cited. Paul, athletic physician for the University of Iowa, is often cited in studies on the dangers of weight control. Because of the frequency of reference to Paul as an authority, it was necessary to carefully examine his main publication on this topic: "Crash Diets and Wrestling."[6]

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[4]"'Making Weight' Draws Criticism," School Activities, March, 1964, p. 208.

[5]For reprints of the Committee report on "Wrestling and Weight Control," send requests to Dr. Kenneth Clarke, 535 N. Dearborn St., Chicago, Illinois 60610.

[6]William D. Paul, MD, "Crash Diets and Wrestling," Journal of Iowa Medical Society, LVI (August, 1966).

Paul based his opposition to weight loss primarily on studies relating to starvation combined with hard physical work and examples of illnesses which have followed excessive weight loss. These studies and examples were then applied to wrestling by observation of the clinical symptoms of starvation. Paul noted for example, that fatigue occurs as the wrestler progresses throughout the match, and concluded from this observation that starvation causes fatigue. Although no doubt bound together, Paul makes no mention of other factors which could contribute to this state of fatigue, such as lack of proper conditioning.[7]

In an attempt to denounce some of the severe techniques of achieving weight loss, Paul makes it appear that all wrestlers use such methods. He continues this overgeneralization by stating that wrestling coaches expect boys to practically undergo starvation for two or two and one half days prior to competition. This distorted emphasis nullifies much of the effect of an otherwise sincere investigation.

Although Paul has indeed presented many accurate observations, because of his incorrect causal connections and overgeneralizations the reader is advised to carefully examine the work before acceptance as an authority.

In agreement with Paul, Blyth has presented case studies which indicate possible dangers of weight loss in

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[7]It is not improper for this study to contain important and relevant material on starvation; it is unfair to pass this theory off as something which is inherent in wrestling.

wrestling. He cited a study by McDermott, et. al[8] which revealed a case of pancreatitis as the result of a seven percent total body weight loss which followed a post-Christmas crash diet.[9] Another case study revealed exhaustion and dehydration as the result of a sixteen percent total body weight loss. Kidney dysfunction is reported as the result of thirteen percent total body weight loss. In view of this evidence Blyth recommended that crash dieting be prohibited.[10]

Other studies do not appear to show evidence of such extreme reaction to weight control. For instance, Nelson, in a comparison of the development of tenth, eleventh, and twelfth grade wrestlers who achieved their desired certification weight and those who did not, found no significant difference between the groups. There was, however, an indication that those who did not achieve their desired certification weight made a slightly greater gain in height.[11]

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[8]W.V. McDermott, Jr., et.al, "Acute Pancreatitis After Prolonged Fast and Subsequent Surfeit," New England Journal of Medicine, CCLIV (February, 1955), 379-380, cited by Carl Blyth, "Weight Loss in Wrestling," Journal of the Athletic Trainers Association, III (Summer, 1968), 8.

[9]It should be noted that although this case study appears repeatedly in the literature reviewed, it is the only case of pancreatitis ever mentioned.

[10]Carl Blyth, "Weight Loss in Wrestling," Journal of the National Athletic Trainers Association, III (Summer, 1968), 8-9.

[11]William B. Nelson, "The Relationship of Weight Cutting to Certain Physical Growth Factors of Selected High School Wrestlers in Minnesota" (Unpublished Master's thesis, Mankato State College, 1962).

Focusing upon strength changes, Alitz found that wrestlers who reached their desired certification weight, as opposed to those who did not, achieved identical gains in strength. However, he reported that those who lost weight appeared to be more susceptible to colds.[12]

The question of dehydration is found to be discussed frequently. Thus far, however, the research accomplished has not dealt with wrestlers. Animal experimentation has shown that better performance results from water supplementation during running.[13] Blyth and Burt found that a loss of water amounting to three percent of total body weight resulted in a significant reduction of work performance.[14]

Drawing support from evidences other than empirical investigations, nutritionists in opposition to weight control in wrestling, have suggested that self-inflicted starvation and dehydration "...serves no more the ethics of sportsmanship than it does the health of the individual."[15]

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[12]LeRoy A. Alitz, "The Effect of Participation in a High School Wrestling Program upon Physical Status" (Unpublished Master's thesis, State University of Iowa, 1959), cited by Philip Rasch, Jr. and Walter Kroll, What Research Tells the Coach About Wrestling (Washington, D.C.: American Association for Health, Physical Education and Recreation, 1964), p. 42.

[13]Anon., "Restriction of Food or Water and Work Capacity," Nutritional Review, XIV (1961), 23-25.

[14]Carl S. Blyth and John J. Burt, "Effect of Water Balance on Ability to Perform in High Ambient Temperatures," Research Quarterly, XXXII (December, 1961).

[15]Jean Mayer and Beverly Bullen, "Nutrition and Athletic Performance," Colloquium on Exercise and Fitness (University of Illinois: College of Physical Education and The Athletic Institute, 1959), chap. 13.

Biologists, raising similar questions, charge that normal growth and development is altered and constant weight change may contribute to the development of heart disease.[16]

Literature covered thus far has prompted severe comment and action as the result of a one sided approach to the question of weight control. The following incident is exemplary. In 1966, a freak accident which occurred during a practice session claimed the life of a young Muscatine, Iowa wrestler. The following year, the Muscatine Medical Association advised that wrestling be dropped from the school athletic program. This decision was based on two points: 1) the forced reduction of weight so that boys are able to compete in the lower classes, and 2) the physical danger involved.[17]

Robert Kistler, reporting on the incident, abused the freedom of the press by declaring: "Many of Iowa's 10,000 high school wrestlers are being driven past the physical breaking point by an unbridled desire of their coaches to win."[18]

Immediate rebutal to these charges appeared throughout the state. Jack Ogden, sports editor for the Cedar Rapids Gazette, stated that the Iowa High School Athletic Association insurance program indicated that wrestling is

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[16]"Weight Manipulation Called Dangerous," The American Biology Teacher, December, 1966. (reprint)

[17]"Muscatine Doctors Advise Preps to Drop Wrestling," Des Moines Register, December 13, 1967.

[18]Robert Kistler, "Outcry Over Harsh Diets," Des Moines Register, December 17, 1967.

one of the least dangerous sports. This is supported by the fact that there were only 307 claims made by wrestlers in comparison with 481 by basketball players during the 1966 school year.[19]

A sports fan, K. L. Cassat, suggested that:

> The real reasons for any abuses that occur in amateur athletics can be laid at the feet of us fans--the parents, the townspeople, the quarterback clubs and even the school boards who demand success of their coaches.[20]

It is unfortunate that incidents such as these and the concerned emotional outbursts which follow color wrestling black. Because of the difficulty in assessing the truth of the matter, specific to the effect of weight loss upon wrestlers, much remains clouded. However, the following studies are reported as attempts to take the issue from the often unsupported opinions of the many and examine it under close empirical scrutiny. In order to achieve maximum clarity, and to escape unnecessary redundancy, the studies presented will progress from the least to the greatest amount of weight loss.

To investigate the effects of rapid weight loss upon the physical efficiency of wrestlers, Englund tested six college wrestling teams. The tool selected was an adapted Harvard step test. The 66 wrestlers were tested over a three week period of rapid weight reduction. A mean loss of 4.41 percent of body weight when compared with step

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[19]Jack Ogden, "Meet the Preps," Cedar Rapids Gazette, December, 1967. (reprint)

[20]The People's Open Forum, Des Moines Register, December 24, 1967, p. 5T.

test results produced a correlation coefficient of .03. Thus, the physical efficiency of the wrestlers as measured by the Harvard step test was not significantly affected by rapid weight reduction.[21]

Tuttle studied the effects of weight loss accomplished by withholding food and water combined with use of steam baths and a heat lamp. He concluded that strength, steadiness, accuracy of movement, and reaction time were not affected in cases involving up to a 5 percent total body weight loss.[22] The results are, however, somewhat questionable, as only five out of the original thirteen testees completed the battery of tests.

Edwards found that wrestlers who lost a mean of 6.37 percent of their body weight during a seven day period showed no significant change in strength.[23]

Nichols tested the effects of rapid weight loss of college wrestlers on balance, power, reaction time, strength and endurance. Findings revealed that wrestlers who lost an overall average of 10.29 pounds, or 6.78 percent of body

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[21]John Homer Englund, "A Comparative Study of Cardiovascular Adjustment to Rapid and Extreme Weight Reduction in College Wrestlers" (Unpublished research study, Colorado State College, 1962).

[22]W. W. Tuttle, "The Effect of Weight Loss by Dehydration and the Withholding of Food on the Physiologic Responses of Wrestlers," Research Quarterly, XIV (1943).

[23]Jennings B. Edwards, "A Study of the Effect of Semi-Starvation and Dehydration on the Strength and Endurance with Reference to College Wrestlers" (Unpublished Master's thesis, University of North Carolina, 1951).

weight, did not show a loss in any of the test areas.[24]

James tested twenty high school wrestlers to see if pulse rate, blood pressure, and performance on the Carlson fatigue curve test would be affected by weight reduction. The results indicated that no ill effect occurred as a result of 6.9 percent weight loss.[25]

Dynamic strength tests and performance tests were utilized by Schuster in studying the effects of rapid weight reduction upon wrestlers engaged in actual competition. The test group was instructed to lose ten pounds during a seven day period, while the control group maintained their weight. Judges evaluated wrestling performance before and after the reduction period. Criteria were the maximum number of miles recorded on an ergocycle, and the maximum number of push-ups and squat-thrusts performed. There was no significant difference in testing before or after the 7 percent body weight loss. Also, the judges found no difference in wrestling ability.[26]

Singer and Weiss conducted one of the most comprehensive studies on the effects of weight reduction upon

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[24]Harold Nichols, Jr., "The Effects of Rapid Weight Loss on Selected Physiologic Responses of Wrestlers" (Unpublished Doctor's dissertation, University of Michigan, 1957).

[25]Byron Dean James, "The Effects of Weight Reduction on the Physical Condition of High School Wrestlers" (Unpublished Master's thesis, State University of Iowa, 1950). (microfilm)

[26]Abraham Z. Schuster, "The Effects of Rapid Weight Reduction on the Endurance and Performance of Wrestlers" (Unpublished Master's thesis, Pennsylvania State University, 1954).

wrestlers. Ten wrestlers from Illinois State University were tested for five consecutive days. The body weight was measured daily in quarter pounds. Anthropometric measures were employed to record five areas of girth and seven areas of skinfold. Physical measures were tested by means of a cable tensiometer and the Harvard step test. Performance was tested by measuring the response time during a sit out maneuver on a Dekan automatic performance analyzer. It was found that up to 7.10 percent of body weight loss did not significantly affect strength or cardiovascular endurance. Also, response time of the wrestlers was significantly faster.[27]

In a review by Rasch and Kroll a number of studies related to weight loss were reported. Their review concluded that up to 10 percent of total body weight may be lost without adverse effects on strength, endurance, reaction time, fatigue rate, or blood pressure.[28] Likewise, Taylor, et.al, found that maximal oxygen intake per kilogram of body weight, and strength measurements were not affected by up to 10 percent loss of body weight.[29]

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[27]Robert N. Singer and Steven A. Weiss, "Effects of Weight Reduction on Selected Anthropometric, Physical, and Performance Measures of Wrestlers," Research Quarterly, XXXIX (May, 1968).

[28]Philip J. Rasch and Walter Kroll, What Research Tells the Coach About Wrestling (Washington, D.C.: American Association for Health, Physical Education, and Recreation, 1964), p. 47.

[29]H. L. Taylor, et. al, "Performance Capacity and Effects of Calorie Restriction with Hard Physical Work on Young Men," Journal of Applied Physiology, X (1957).

Byram measured the muscular endurance isometrically and the circulatory-respiratory endurance on the Carlson fatigue curve test of State University of Iowa wrestlers. The test group, which was required to make certification weight, and the control group, which maintained normal weight, were tested prior to and following an 11.04 percent body weight loss. No statistically significant differences were noted between the groups in the areas tested.[30]

Adding support to Singer and Weiss' study, Nauert investigated the effect of weight loss on the strength of collegiate wrestlers. Eleven wrestlers from the University of Missouri were tested during the wrestling season. The strength of the neck, legs, shoulders, and hands was measured four times and correlated with the mean weight loss. Nauert found that a weight loss of up to 11.3 percent of body weight had no effect upon the strength of the wrestlers.[31]

Additional studies have shown that conditioning causes improvement in general fitness of wrestlers. Since this may, in part, account for a specific improvement in test scores, it is necessary to consider these studies before evaluating the literature cited thus far. Also, since this presentation is concerned with weight loss, it

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[30]Howard Marion Byram, "Effects of Weight Reduction on Strength and on Muscular Endurance" (Unpublished Master's thesis, State University of Iowa, 1953).

[31]Jerry F. Nauert, "An Abstract of the Effect of Weight Loss on Strength of College Wrestlers," The Journal of the National Athletic Trainers Association, III (Summer, 1968).

may be helpful to consider the relationships between conditioning, weight loss, and strength.

Commenting on diet and conditioning, Mickelsen described his reason for conditioning as follows:

> The removal of any surplus fat plus the increase in muscle strength are the primary objectives of a training program and the goal is to reach each player's ideal playing weight.[32]

Landiss tested a group of students according to the fifteen item Armed Forces Physical Fitness Test. He found that students who participated in wrestling classes made greater gains in fitness than those in swimming, but less than those in tumbling, gymnastics, or conditioning programs.[33]

Berrafato showed, by dynamic strength tests, that following a fifteen week physical education service course, wrestlers improved more than volleyball players, but less than weight lifters and boxers.[34] It should be noted that many wrestling programs encourage weight lifting which could accordingly improve dynamic strength.

Other effects of conditioning are shown by the fact that wrestlers show higher scores on the McCurdy-Larson

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[32]Olaf Mickelsen, "Do Athletes Need A Different Diet"? National 4-H News, May, 1968, p. 22.

[33]Carl W. Landiss, "Relative Influence of Various Physical Education Activities on Motor Ability and Physical Fitness of Male College Freshmen" (Unpublished Doctor's dissertation, Pennsylvania State College, 1951).

[34]Peter R. Berrafato, "The Effect of Various Physical Education Service Courses on the All-Around Muscular Endurance of University Students" (Unpublished Master's thesis, University of Illinois, 1949).

Organic Efficiency Index than do untrained men.[35] Another study, reported by Tomaras, showed a two percent improvement in the step test following wrestling season.[36]

Although this concludes the review of available research material specific to weight loss and wrestling, it is supposed that the reader is as confused as the previously cited literature is confusing. Perhaps the reader could benefit from a look at one additional study which attempts both to summarize the prevalent positions and to state conclusions based upon current literature.

Amid the often emotional controversy, Cooper, the team physician at Oklahoma State University, has presented a remarkably objective paper: "Medical Aspects of Weight Control."[37] Cooper states that 95 percent of all criticism directed at wrestling involves making weight.

> However, the number of serious medical problems that occur from making weight is small or poorly reported. I find only meager evidence in the literature of any serious medical problems incurred by wrestlers making or cutting weight. I never have seen any.[38]

Cooper speaks out against crash diets, especially

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[35]Kenneth A. Dening, "Circulatory-Respiratory Characteristics of Men in Training for Wrestling" (Unpublished Master's thesis, Springfield College, 1952).

[36]William A. Tomaras, "The Effect of Wrestling Upon Physical Fitness" (Unpublished Master's thesis, University of Illinois, 1948).

[37]Donald L. Cooper, MD, "Medical Aspects of Weight Control" (paper read at the American Medical Association 8th National Conference on the Medical Aspects of Sports, 1965). (reprint)

[38]Ibid.

when dehydration is involved. He states that fluids should be replaced and that weight loss should involve the subcutaneous (sub-q) fat. A test advocated by Cooper is to pinch the skin over the eye at the outer edge of the forehead, and then compare it to the skinfold over the abdomen and behind the arm. A well conditioned wrestler should have the same amount of skinfold in all three locations.

Cooper suggests that in order to achieve the desired weight, hard work and a balanced diet are the only means which should be used. The program should not allow a greater reduction than two to five pounds per week. Furthermore, once the desired weight is achieved, the wrestler should not be allowed to vary more than two or three pounds from flat or certified weight.

Dr. Cooper also notes that weight cutting can be injurious under certain circumstances. In order to avoid this, he suggests a complete medical examination by the family or school physician.

> If such conditions as early diabetes, pulmonary stenosis, aortic stenosis, kidney disease, low grade infections, chronic asthma, or bronchial conditions are found, it would be best to discourage this boy from participating in as rugged a program as wrestling.[39]

In closing, Dr. Cooper comments on the paradoxical question of proper weight.

> A major public health problem today, one that will take far greater toll of lives in the years ahead is the combination of overeating and inactivity. The idea that we should eat until we feel full is sad and causes far more damage

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[39] Ibid.

> than most of us realize....No one gets excited about the kid who wants to eat all the time, is overweight, enjoys this habit, and is getting heavier all the time. He actually is abusing himself more in the long run than the boy who stays down with very little sub-q fat and from hard work.
>
> Nutritionists tell us we have the most overfed, undernourished teenagers in the world today. I don't think anyone should be starved if starvation means being deprived of food intake, but no one has yet shown any harm from slowly cutting down and reducing the caloric intake when the diet and fluid intake are balanced.
>
> It seems puzzling that we allow one end of a spectrum to be unattended by rules, laws, or regulations, and concentrate all our time and energy on regulating what the body was made to do: be used, be active, and not overstuffed.[40]

The literature on weight loss specific to wrestling appears to be decisively varied. However, one primary feature appears throughout--concern for the wrestler. For example, Paul and Cooper are on opposite sides of the spectrum, or so it appears specific to the issue of weight control, i.e., the former holds conservative views while the latter supports a more liberal position. But Paul greatly resembles Cooper when their conclusions are compared. Paul, noted for his opposition to weight control concludes thusly:

> Since increasing emphasis is being placed on wrestling at the junior high school and high school levels, it is necessary for the physicians to help coaches select boys for the proper weight classifications, to supervise their diets and above all, to teach their parents that athletic prowess does not require an excessive food intake.[41]

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[40] Ibid.

[41] Paul, op. cit., p. 840.

SUMMARY

It is generally recognized that crash diets and dehydration amounting to more than three percent of total body weight are causes of serious health problems. Such measures should not be used in the wrestling weight control program.

Apparently, dangers in weight reduction are negligible if four basic principles are followed:

1. A physical examination should precede the wrestling season. Preferably, the family physician should be consulted as he will have complete background material on the student.

2. If weight loss is desired it should occur over a five to six week period with no more than two to five pounds per week.

3. The diet may be reduced but must be well balanced.

4. Fluid supplementation is advised.

There is no significant difference in health between wrestlers who reach certified weight desired and those who do not. However, susceptibility to colds by weight cutters and a slight gain in height among non-weight cutters is noted.

Studies indicate that an average loss of 7.81 percent of total body weight does not significantly affect physical efficiency, strength, steadiness, accuracy of movement, response time, balance, pulse rate, blood

pressure, performance, cardiovascular endurance, or maximal oxygen intake.

Further studies show that wrestling improves conditioning. Conditioning, in turn, plays a vital role in adjustment to weight reduction and performance.

According to the literature reviewed, a carefully prepared program of weight reduction, which includes the above mentioned principles, does not appear to cause health problems when an average loss of 7.81 percent of total body weight is achieved.

STRENGTH TESTS SPECIFIC TO WRESTLING

Man has been scientifically measuring strength since 1699 when De La Hire compared the ability of men and horses to lift weights and carry burdens.[42] Since then, the techniques of strength measurement have improved and the tools have grown immensely in number. Available today are a wide variety of devices assessing strength, each having peculiar assets and limitations. This review is concerned only with those tools which are pertinent to strength testing in wrestling.

The dynamometer is an apparatus which measures torque developed by the prime mover. Graham was the first

[42]M. De La Hire, "Examen de la force de l'homme," Memoires del'Academie Royale des Sciences, XII (November 14, 1699), 153-162, cited by Paul A. Hunsicker and Richard J. Donnelly, "Instruments to Measure Strength," Research Quarterly, XXVI (December, 1955), 408.

to use such an instrument,[43] but Desaguliers attracted initial attention to it in the late eighteenth century. His mechanism consisted of:

> ...a large wooden frame and stout uprights to offer points of support or resistance, and handles attached to a crossbar which moved a steelyard. By hanging weights on the latter the force used could be directly determined.[44]

Leroy, a member of the French Academy of Science, developed a more practical version of the dynamometer early in the nineteenth century. This mechanism consisted of:

> ...a metalic tube, within which was placed a spiral spring with an attached graduated rod terminating above in a globe. This was to be grasped by the hand, and the spring compressed from above, the amount of force exerted being marked on the rod.[45]

In 1807, Regnier introduced the first practical spring steel dynamometer.[46] In a recent translation of Jullien's Esquisse, the use of this instrument appears as follows:

> [5](footnote) The dynameter is a mechanical instrument known in England, perfected in France by M. Regnier, (a) competent as well as estimable engineer (living in Paris, rue du Bac No. 28). This instrument is used to estimate and compare the strength of men, of horses,

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[43]Paul A. Hunsicker and Richard J. Donnelly, "Instruments to Measure Strength," Research Quarterly, XXVI (December, 1955), 408.

[44]William N. Bullard, Dynamometer, in Albert H. Buck (ed.) Reference Handbook of the Medical Sciences, II (New York: William Wood & Co., 1886), 544, cited in Hunsicker and Donnelly, op. cit.

[45]Ibid.

[46]Roy Pangle and Leon Garrett, "Origin of the Spring Scale Dynamometer," Research Quarterly, XXXVII (March, 1966).

> the resistance of plows to tillage, and the power of machines in general. Its work has demonstrated in southern lands, that the savages are constantly less robust than civilized people. In many institutions it has been made use of for observing the progress of young people. This instrument, enclosed in its box with accessories, costs 180 francs.[47]

Modifications on the elliptical spring dynamometer by Burq[48] and Duchenne[49] in the mid-nineteenth century produced an efficient testing tool. In 1875, Galton adapted their modifications, further changed them, and perfected the tool which enabled him to run a thorough six year study on the strength of British males.[50]

Toward the end of the nineteenth century, Sargent adopted the steel spring dynamometer for testing purposes at Harvard University.[51] Although other methods of strength testing were evident prior to this time in the United

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[47]Stewart Fraser, Jullien's Plan For Comparative Education 1816-1817 (New York: Bureau of Publications, Teachers College, Columbia University, 1964), pp. 70-71, cited by Pangle and Garrett, Ibid.

[48]D. Burq, "Dynamometrie Medicale," L'Union Medicale, 2 eme serie, III (September, 1859), 460-462, cited by Hunsicker and Donnelly, op. cit., p. 409.

[49]G. V. Poore, Selections from the Clinical Works of Dr. Duchenne (de Boulogne) (London: The New Sydenham Society, 1883), cited by Hunsicker and Donnelly, Ibid.

[50]Francis Galton, "Range in Height, Weight, and Strength of Arm of Males at Each Age," under Report of the Anthropometric Committee in Reports of the British Association for the Advancement of Science, 1881, cited by Hunsicker and Donnelly, op. cit., 409-410.

[51]D. A. Sargent, "Strength Tests and the Strong Man of Harvard," American Physical Education Review, II (1897), 108-119, cited by Hunsicker and Donnelly, op. cit., 411.

States, Sargent initiated the usage of these tools for physical education purposes.

While physical therapists and orthopedists concentrated on means of adapting the dynamometers for their purposes, physiologists developed the strain gauge dynamometer to measure total strength effort. The strain gauge consists of:

> ...a wire of 0.0001 in. diameter fixed in a circular steel ring or an L-shaped bar. Any deformation of the bar or the ring will change the electical resistance of the strain gauge. By use of the appropriate amplification and recording system, the amount of force applied can be determined.[52]

More recently, the cable tensiometer was introduced to give added depth to strength testing. Originally designed to measure the tension of aircraft cable, the tensiometer measures the amount of force required to offset a riser in a cable which is stretched between two set points. In a comparison of several testing devices, Clarke found the tensiometer to produce the greatest precision in measuring strength. The strain gauge was found to be sensitive to changes in temperature, and the spring scale allowed too much joint movement.[53]

A review of the studies on strength tests specific to wrestling showed that the testing device used was not always noted. However, those most frequently mentioned

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[52]Hunsicker and Donnelly, op. cit., pp. 416-417.

[53]H. Harrison Clarke, "Recent Advances in Measurement and Understanding of Volitional Muscular Strength," Research Quarterly, XXVII (October, 1956).

are the cable tensiometer, grip dynamometer, and dynamic strength indices such as push-ups or squat-thrusts. The latter method is valuable, but is difficult to administer and complicated to evaluate.[54] The cable tensiometer is noted for great precision, but it involves extensive testing and access to large pieces of equipment.

Hand grip dynamometers are both compact and precise in measurement. Bowers indicated in a study of the relationship of hand size and lower arm girths that the Naragansett Hand Spring Dynamometer has a reliability coefficient of .89, the Stoelting Adjustable Dynamometer .91, and the Cable Tensiometer .94.[55] Rogers supports this in reporting that the reliability coefficient of grip tests is consistently above .90.[56] However, Griffith has concluded that accuracy of grip strength scores is dependent upon the instrument used to measure it.[57] Montoye and Faulkner found that a slight advantage is gained through use of an adjustable hand dynamometer, especially for those

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[54]D. M. Hall, "Selection and Standardization of Strength Tests for 4-H Club Members," Research Quarterly, XXVII (October, 1956).

[55]Louis E. Bowers, "Investigation of the Relationship of Hand Size and Lower Arm Girths to Hand Grip Strength as Measured by Selected Hand Dynamometers," Research Quarterly, XXXII (October, 1961), 312.

[56]Frederick Rand Rogers, "The Significance of Strength Tests in Revealing Physical Condition," Research Quarterly, V (October, 1934).

[57]C. H. Griffith, "The Inadequacy of Strength Norms," Research Quarterly, VI (December, 1935).

subjects with large or small hand size.[58]

Bowers has modified this study somewhat by limiting the age group of the subjects. His test on eighteen to twenty-four year olds revealed correlations on grip strength which are much lower than those of Montoye and Faulkner. Bowers further stated that although body weight and hand grip strength are related, the correlation coefficient is not highly significant.[59]

This low correlation was not demonstrated by Pierson and O'Connell who reported in a study of 299 healthy males that grip strength is significantly related to weight, but not to height or age.[60]

Tomaras, in an attempt to determine the effect of wrestling upon physical fitness, showed that wrestlers tested by the Total Proportion Strength test were stronger per pound of body weight than any other group of athletes tested. He noted, however, that the wrestlers did not have strong grips.[61] This may not be significant, however, as Mustaine has reported that hand dynamometers measure the forearm muscles, not hand grip strength.[62]

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[58]Henry J. Montoye and John A. Faulkner, "Determination of the Optimum Setting of an Adjustable Grip Dynamometer," Research Quarterly, XXXV (March, 1964).

[59]Bowers, op. cit.

[60]William R. Pierson and Eugene R. O'Connell, "Age, Height, Weight, and Grip Strength," Research Quarterly, XXXIII (October, 1962).

[61]Tomaras, op. cit.

[62]W. W. H. Mustaine, "Tests and Measurements in Physical Education," Supplement to Research Quarterly, VI (March, 1935), 7.

Studies on wrestling often use grip strength as an important means of determining cause and effect relationships. Mooney tested 66 freshman college students enrolled in a physical education wrestling class in an attempt to find the effect of wrestling upon muscular strength. Dynamometer scores were recorded in October, then again in December. Although there was a significant improvement in chest, neck, and abdominal strength, no change developed in back or grip strength.[63] Likewise, Johnson discovered no increase in grip strength when college men who participated in wrestling for six weeks were tested.[64]

In direct opposition to studies which show no relationship between grip strength and fitness, Rogers has stated that grip strength responds remarkably well to general physical condition. He further stated that their validity has also been established.[65]

Variations in test scores should not necessarily be related to the effectiveness of the investigator in administering tests. Cousins found that trained and untrained testers were equally effective in the adminis-

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[63]B. F. Mooney, "The Effect of Wrestling on Muscular Strengths" (Unpublished Master's thesis, International YMCA College, 1931), cited by Rasch and Kroll, op. cit., p. 3.

[64]Neil R. Johnson, "The Effectiveness of Wrestling Compared to Standard Weight Training Procedures for the Development of Strength" (Unpublished Master's thesis, Pennsylvania State University, 1960), cited by Rasch and Kroll, Ibid.

[65]Rogers, op. cit.

tration of grip strength results.[66] Hassman revealed that fatigue from arduous training may result in a decline in strength test results.[67] Clarke also found that there is a strength loss resulting from exhaustive exercise.[68]

SUMMARY

Modern strength testing devices are the result of almost 300 years of modification and scientific improvement. A vast assortment of devices are available which allow the tester to select those which are best suited to a particular study without sacrificing either validity or reliability.

Researchers who study the effect of wrestling upon strength generally have used the cable tensiometer and various dynamometers. The tensiometer appears to be the most favorable device for both precision and diversity, however it necessitates an extensive and complicated study. When outside influences are controlled, the dynamometers are also highly reliable instruments. In particular, the hand dynamometer is a compact and precise instrument. The adjustable dynamometer is best suited to tests involving

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[66]George F. Cousins, "Effect of Trained and Untrained Testers Upon the Administration of Grip Strength Tests," Research Quarterly, XXVI (October, 1955).

[67]Ralph P. Hassman, "Changes in the Physical Status of Varsity and Freshmen Wrestlers at the University of Oregon Following a Six Week Cessation of Organized Team Practice and Competition" (Unpublished Doctor's dissertation, University of Oregon, 1960), cited by Rasch and Kroll, op. cit.

[68]Clarke, op. cit.

wide areas of age or both sexes. However, the Naragansett Hand Dynamometer is reliable as a tool for measuring smaller age groupings.

There are conflicting opinions in regards to the relationships between hand grip strength, weight change, and fitness. This indicates that further research is warranted, especially in areas which will provide evidence as to the appropriateness of using hand grip strength measures in determining cause and effect relationships in wrestling.

Chapter 3

PROCEDURES

This study proposed to investigate the relationship, if any, between weight change and hand grip strength of competing intercollegiate wrestlers. Prior to the selection of the tool and the administration of the test, a review of related literature was conducted to lend insight into proper procedure of and tools available for strength measurement in conjunction with wrestling. In addition, several coaches and one medical doctor acted as consultants to both the design and procedures of this investigation.

NATURE OF THE STUDY

The intercollegiate varsity wrestling program at Kansas State Teachers College of Emporia (KSTC) has membership in the National Association of Intercollegiate Athletics (NAIA) and the Rocky Mountain Athletic Conference (RMAC). Any full time (12 hours) male student who meets the NAIA and RMAC requirements is eligible to enroll in Physical Education 172: Wrestling, for one hour of credit. Enrollment in the class is suggested but not required for participation in the varsity intercollegiate wrestling program.

During the course of this study, all subjects met

the above stipulations. In addition, all students who participated in the wrestling program were awarded partial athletic scholarships for the second semester of the 1969-1970 school year.

Varsity wrestling practice officially commenced on October 15, 1969. The season terminated with the last practice which was held on March 16, 1970. Practice sessions were held daily at 3:30, Monday through Friday, and varied in duration from one to three hours. No practice was held on days of actual competition. From February 8, 1970 to the end of the season, either practice or competition was held seven days a week.

Prior to and following the official season, the wrestlers were strongly recommended to participate in a coach directed conditioning and weight lifting program.

SUBJECTS

All of the subjects were members of the KSTC varsity intercollegiate wrestling squad between the ages of eighteen and twenty-three and met the regulations of the NAIA and RMAC. Twenty-one subjects took the first test; 21 the second; 17 the third; and 15 the fourth test. Of the original number, two quit the team, two dropped out of college, one was eliminated because of a broken finger, and one because he did not participate in intercollegiate competition.

EQUIPMENT AND FACILITIES

The equipment used in this study consisted of: 1) a Continental adjustable weight and height scale; 2) a Naragansett Hand Dynamometer; and 3) a 4 x 6 card for each subject (see Appendix A). The scale used for the third test at the University of Nebraska at Omaha was the same model as that used on the other three tests.

The wrestling quanset hut on the KSTC campus and the locker room in the field house on the University of Nebraska at Omaha were used as testing sites for the study. The third test was administered at the University of Nebraska facility, while the first, second and fourth tests were administered at the KSTC facility.

TESTING PROCEDURE

The subjects were instructed to completely disrobe prior to each testing period. On all testing dates the subjects were first weighed on the Continental scale. The recording was made to the nearest quarter of a pound after the dial had ceased to move. Then the subjects were administered the hand grip test using first the right, then the left hand. Before taking the strength test the wrestlers were instructed: 1) to squeeze, not jerk, 2) to not touch the arm to any part of the body, 3) to not allow the angle of elbow extension to exceed 45 degrees, 4) to squeeze on the command "Go," and 5) to release the grip by the count of five. Prior to the fourth instruction the

subject was told his score from the previous test. When the subjects failed to follow the instructions, a second test was allowed with the properly executed one being recorded. In this group testing situation all wrestlers were allowed and did watch the others being tested.

The first test was given after two weeks of self conditioning and two weeks of wrestling practice. The only reference to weight loss at this time was the suggestion for the wrestlers to start cutting down on high caloric foods and to maintain a controlled but balanced diet. The test was administered between 3:30 and 4:00, just prior to the daily practice session.

The second test was administered two weeks after the initial test. At this time the wrestlers were competing for a position on the team. In order to try out for a particular class, the wrestler was required to be within five pounds of scratch weight (desired certification weight). A penalty point was awarded to the opponent (one point for each pound over) if the wrestler was not within the required weight bracket. Those wrestlers who were not competing for a team place at this time were directed to begin the weight control program.

The third test was administered four weeks after the initial test. The wrestlers were required to be at regulation weight in order to compete in the first wrestling meet of the season. The test was given five hours prior to the actual competition to coincide with the official weigh-in time.

The fourth test was administered sixteen weeks after the initial test. Those wrestlers who were participating in the final meet of the season (10) had maintained scratch weight, while the others (5) had begun to regain weight as they would not be involved in further competition.

The subjects were not instructed to use any particular method of weight control. They were instructed only to make the weight which they had selected for competition. Most of the subjects used rubberized suits during practices and also had access to a steam room. The most common means of weight control, however, was limiting food and water consumption. These methods produced a mean body weight loss of 8.40 percent between the first and fourth test.

STATISTICAL PROCEDURE

Following the test period, the information was transferred from the 4 x 6 cards to a chart. The pertinent information consisted of the weight and hand grip strength measured during each of the four test administrations. This information was then programmed for the 1401 computer which is located on the KSTC campus. Initial results were reviewed by a statistician who recommended further computations. Additional variables were added to the program and returned to Data Processing for the final read out.

Following computer analysis, the coefficient of correlation was employed to determine if there was a relationship between weight change and hand grip strength. See chapter four, Analysis of Data, for specific data.

Chapter 4

ANALYSIS OF DATA

The changes between the first and fourth test scores on grip strength and weight change were the data used for this study. The coefficient of correlation was employed for the computation in this investigation.

STATISTICAL ANALYSIS OF TESTS ONE AND FOUR

The purpose of this study was to determine if a relationship existed between weight change and grip strength change of competing intercollegiate varsity wrestlers. The scores of all four test periods were computed. On the first grip strength test, the fifteen subjects had a mean score of 143.86 pounds with a range from 113 to 177 producing a standard deviation of 19.14. On the first weight recording the wrestlers had a mean weight of 164.33 pounds with a range from 127.50 to 228.50 pounds which produced a standard deviation of 29.98.

These scores were correlated against the final test scores (fourth test). The mean score for the fourth grip strength test was 138.40 pounds with a range of from 101 to 182 which produced a standard deviation of 25.00. The mean weight on the fourth test was 150.53 pounds with a range from 118 to 208 which produced a standard deviation of 25.43.

The coefficient of correlation (Table I) between the first weight and grip strength test correlated with the change which occurred with the scores received from the fourth weight and grip strength test was +0.2075. This indicated that there is a very slight relationship (but not significant) between weight change and hand grip strength of competing intercollegiate varsity wrestlers. The relationship of +0.2075 was not significant when computed with the test of correlation of significance from zero which needed an r of +0.2886. Therefore, the null hypothesis, as issued by the writer, was retained.

DISCUSSION

As the design of this investigation was specific to the question of the relationship, if any, between a change in weight and a change in hand grip strength, over an entire wrestling season, the recent conclusions were between tests one and four. Such comparisons were necessary to determine the effects of a wrestling season on grip strength and therefore included pre and post testing. However, the reader will notice that several other tests were conducted and many other comparisons were therefore possible. This discussion will focus on some of the more interesting comparisons not otherwise reported in the analysis of data.

Between tests one and two the weight change had a mean of -7.59 pounds while the grip strength change mean was -5.47 pounds. Between tests one and three the weight

Table 1

Coefficient of Correlation for
All Testing Periods

Group	df	N	r	P
1-4	28	30	+0.2075	-
1-2	28	30	+0.0970	-
1-3	28	30	+0.0133	-
2-3	28	30	-0.4604	.05[a]
2-4	28	30	+0.1615	-
3-4	28	30	+0.7023	.01[b]

[a]With 28 df the level of significance needed at the .05 level is .361.

[b]With 28 df the level of significance needed at the .01 level is .463.

change revealed a mean of -12.42 pounds while grip strength change showed a mean of -8.94 pounds. This was the greatest grip strength change among the six variables. The greatest weight change came between tests one and four with a mean change of -13.12 pounds while grip strength change revealed a mean of -3.47 pounds. This indicates a grip strength recovery over test three although the weight continued to change negatively. The variable between tests two and three showed a weight change mean of -4.17 pounds compared with a mean grip strength change of -4.00 pounds. Scores between the second and fourth tests produced a mean weight change of -6.09 pounds matched for the same period with the grip strength change mean of -0.74 pounds. This variable revealed the least amount of grip strength change. Comparing tests three and four, the data showed the smallest amount of weight change, -1.92 pounds, and a strength change mean of +2.53 pounds, which indicates that strength is regaining though not surpassing the original test score. (See Appendix B)

By removing the amount of change as the test criterion, the data revealed the following correlations from each of the four tests. In comparing grip strength and weight, test one revealed an r of +0.7537. Test two produced an r of +0.6736. The r for test three was +0.6793. The fourth test showed an r of +0.3614. (See Appendix C)

Returning to the criterion of change it will be remembered that tests one and four produced an r of +0.2075. The following coefficients of correlation were found for

the remaining five testing variables. A comparison of tests one and two produced an r of +0.0970; tests one and three an r of +0.0133; tests two and three an r of -0.0583; tests two and four an r of +0.1615; and tests three and four an r of +0.7023. The correlation between tests two and three was the only measurement to reveal a negative relationship. (See Table 1)

It is clear from the above stated data that grip strength and weight change did not vary concomitantly together. In fact it was shown that the greatest weight change, occurring between tests one and four, produced a 13.12 pound mean loss (8.40%), while a look at the strength change of the last two tests, namely three and four, resulted in a mean gain of 2.53 pounds. The reader is again advised to glance at Appendix B which demonstrates this interesting observation.

This investigator could hypothesize that the gain of grip strength between three and four, which occurred late in the season, could indicate that perhaps conditioning may have had an effect on the previously reported loss in grip strength. The reader is directed to Appendix D which illustrates the initial relationships between grip strength and weight and the later divergence of the same variables.

Chapter 5

SUMMARY AND CONCLUSION

It was the purpose of this study to determine the effect of weight change among competing intercollegiate varsity wrestlers upon hand grip strength.

The subjects for this study were fifteen competing members of the varsity wrestling team enrolled as full time students at KSTC for the 1969-1970 school year. All the subjects were tested for hand grip strength with the Naragansett Hand Dynamometer four times during the wrestling season. On each test date the subjects were also weighed on a Continental scale. The results of each test were recorded.

The computation for this study was the coefficient of correlation. The mean scores from the hand grip strength change and weight change were the data used for the correlation.

FINDING

The finding from this study was that the coefficient of correlation of +0.2075 did exist between the hand grip strength change and weight change of the first and fourth tests. This indicates a slight (but not significant) relationship did occur between hand grip strength change

and weight change. An r of +0.2886 was needed for significance.

CONCLUSION

It is within the scope of this investigation to be able to conclude that early in a wrestling season one may expect to find some degree of relation between weight change and hand grip strength change, but as the season progresses the relationship ceases to continue. Therefore, it appears that over an entire season of wrestling, change in grip strength and change in weight operate independently of one another.

RECOMMENDATIONS FOR FURTHER STUDY

As a result of the finding from this study the following recommendations are suggested.

1. A study employing similar procedures but using a control group of non-wrestlers may determine the effect, if any, of conditioning upon grip strength.

2. A study employing similar procedures but testing the subjects more frequently may produce a more accurate picture by presenting more variables.

3. A study employing similar procedures but using high school wrestlers as subjects may indicate the difference, if any, between the two age groups specific to weight change and grip strength.

4. A study employing similar procedures but testing for a longer period of time may indicate how

distinct the relationship appears to be between weight change and grip strength.

5. A study employing similar procedures but using a control group of wrestlers who maintain normal weight may indicate both the effect of conditioning, if any, upon grip strength and the effect of weight loss, if any, upon grip strength.

6. A study employing similar procedures but using the cable tensiometer or some other tool for evaluating total body strength may indicate if grip strength is a valid means of determining the relation between weight change and strength in toto.

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APPENDICES

APPENDIX A

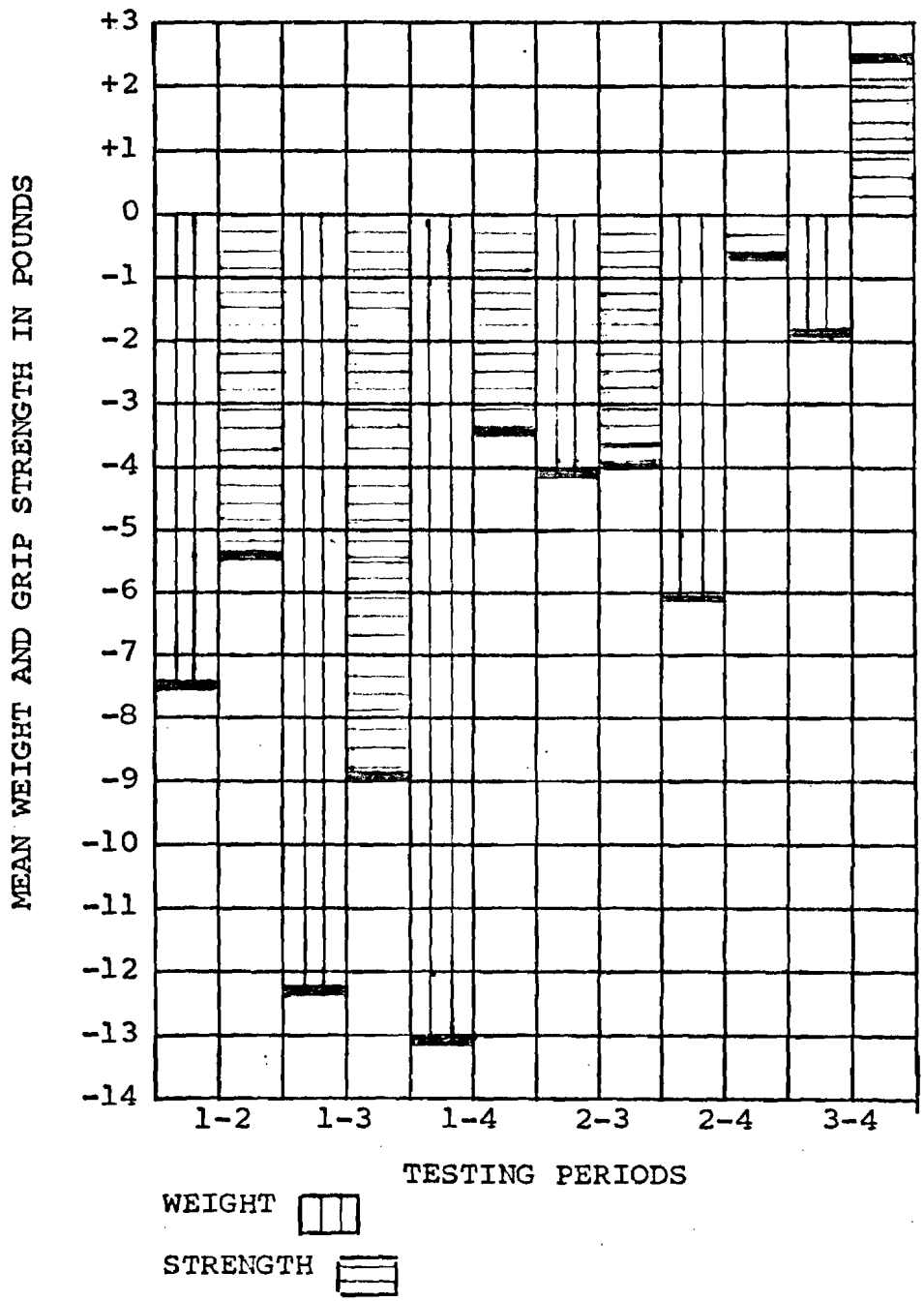
RECORDING CARD

NAME							WRESTLING WEIGHT		
	Date		Date		Date		Date		
WEIGHT	Total Weight	+ −	Total Weight	+ −	Total Weight	+ −	Total Weight	+ −	
GRIP STRENGTH	R.Grip / L.Grip / Total	+ −	R.Grip / L.Grip / Total	+ −	R.Grip / L.Grip / Total	+ −	R.Grip / L.Grip / Total	+ −	

COMMENTS:

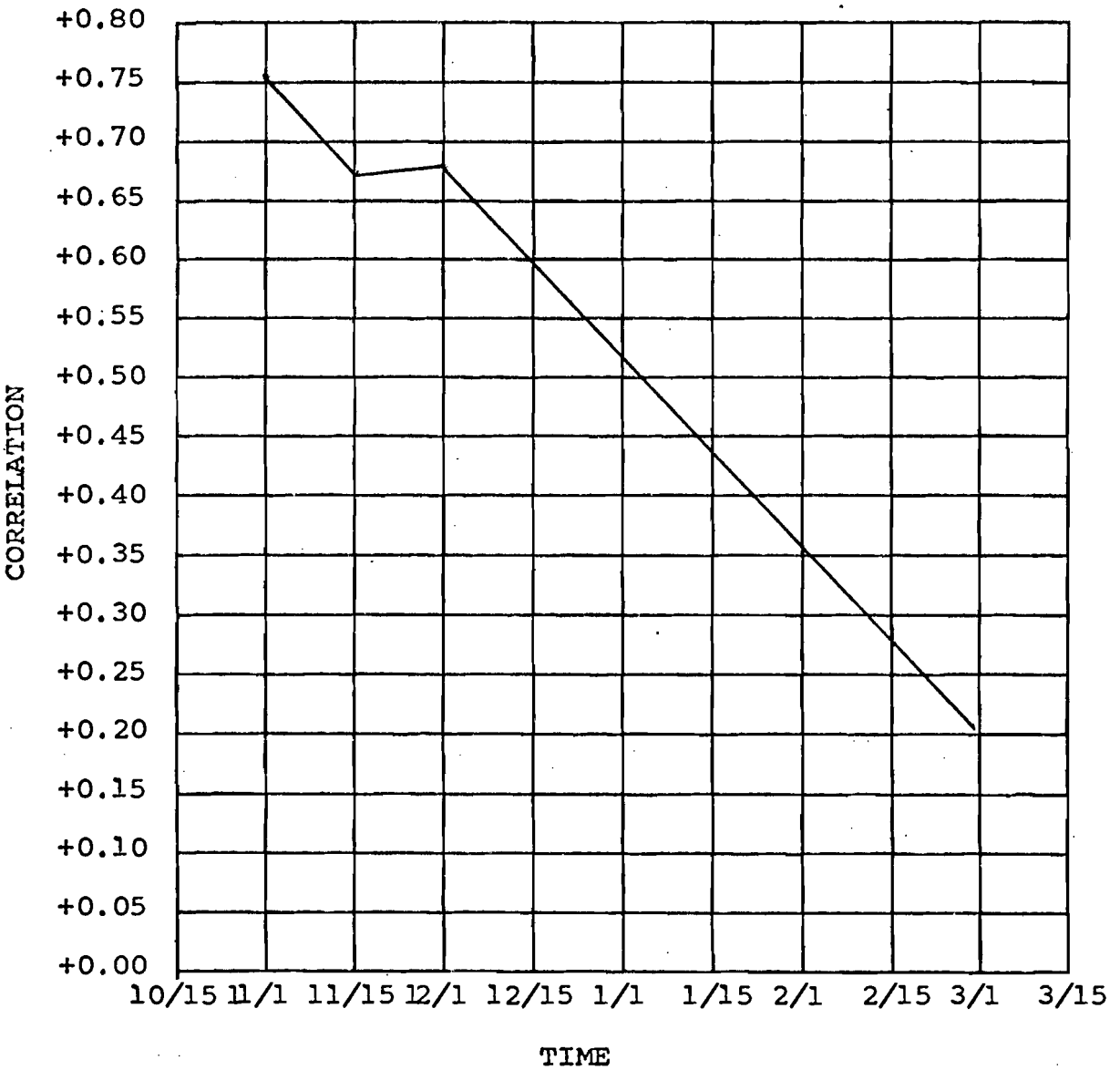
APPENDIX B

COMPARISON OF MEAN GRIP STRENGTH
AND MEAN WEIGHT CHANGES FOR
ALL TESTING PERIODS



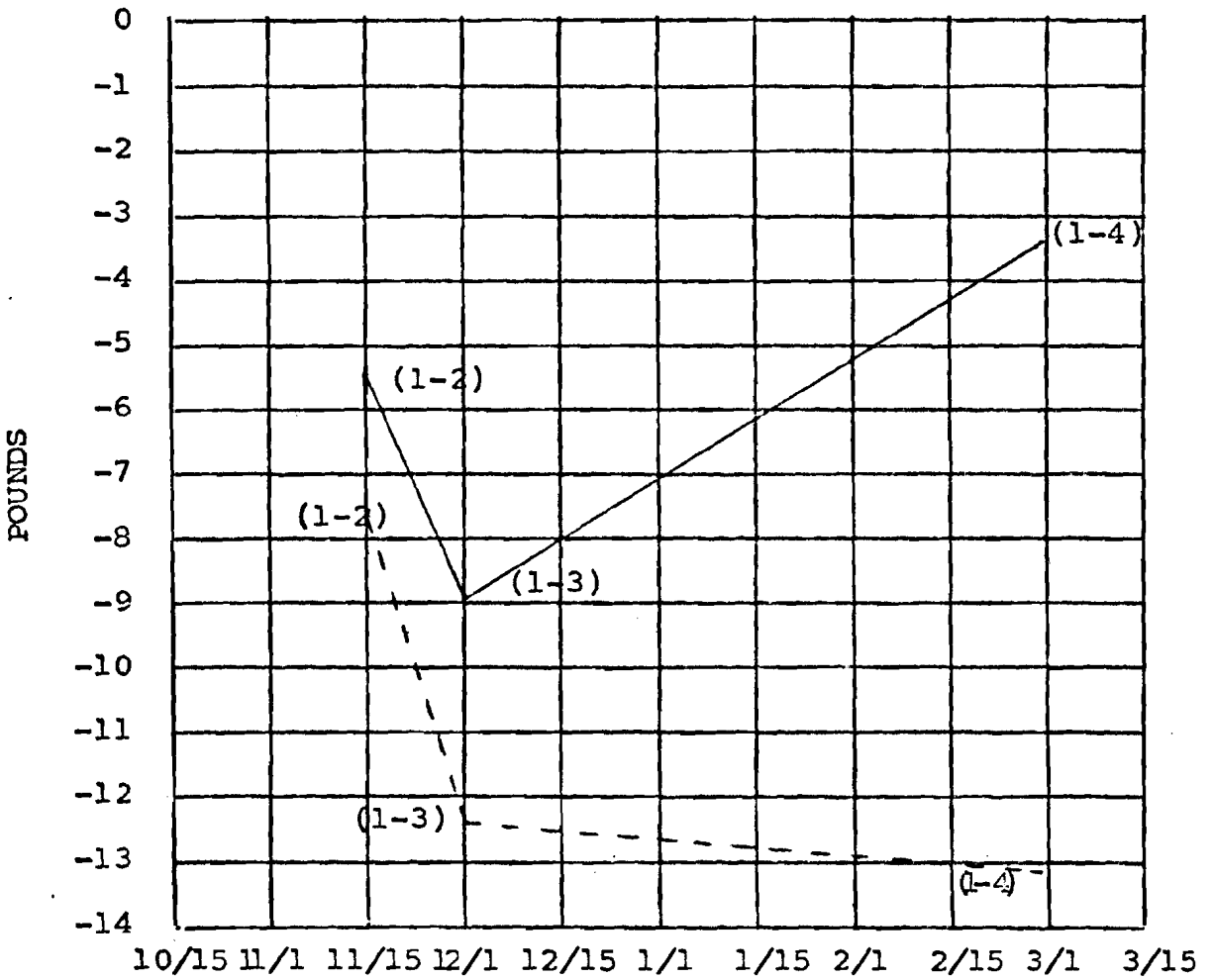
APPENDIX C

CORRELATION OF WEIGHT AND GRIP STRENGTH



APPENDIX D

MEAN CHANGE IN POUNDS OF GRIP STRENGTH
AND WEIGHT COMPARING THE FIRST TEST
WITH THE SECOND, THIRD AND FOURTH



STRENGTH = ————————
WEIGHT = ----------

(1-2) = first and second tests
(1-3) = first and third tests
(1-4) = first and fourth tests