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The estimation of body fat from skinfold measurements for the determination of minimal wrestling weight for high school wrestlers

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THE ESTIMATION OF BODY FAT FROM SKINFOLD MEASUREMENTS FOR THE DETERMINATION OF MINIMAL WRESTLING WEIGHT FOR HIGH SCHOOL WRESTLERS

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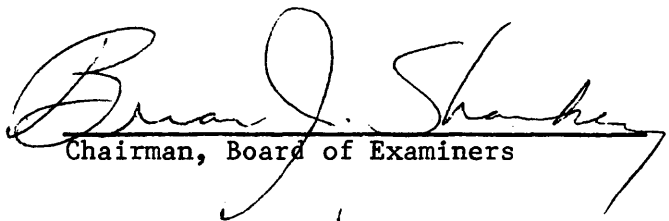

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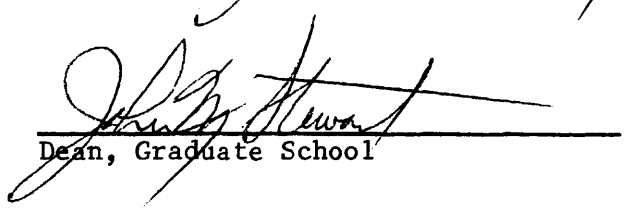

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CHAPTER I

THE PROBLEM AND DEFINITIONS OF THE TERMS USED

I. INTRODUCTION

Amateur wrestling has long been recognized by researchers as an extremely vigorous activity. The physiological stresses of wrestling have motivated a wide variety of studies. The studies in the area of weight loss through dehydration and fasting practices reflect the concern for this area. Ekfelt (12) stated that weight reduction practices constitute a main argument cited by some school officials against the introduction of the sport into interscholastic competition. However, while wrestlers and coaches may dislike the practice, they often utilize it in order to gain a competitive edge over an opponent. This factor more than any other impedes the search for a reliable guideline for establishing the optimal wrestling weight for each boy.

Questions regarding normal growth and development of the high school wrestler underlie the concern for the practices used to "make weight." MacKenzie, Dugelmass, Poull, and others (16) report a positive relationship between physiological status and scholastic attainment in adolescent individuals. However, in studies dealing directly with the problem, Nelson (35) showed no distinct developmental differences between those who made weight to the customary extent, and those who did not, although there was an indication that the latter tended to make a slightly greater gain in height. Similarly, Alitz (33) reported that wrestlers who made weight and those who did not both achieved normal gains in weight and strength during the period extending from the beginning of the season to three months after its termi-

nation.

Systematic research provides evidence that weight losses beyond 3 per cent of the body weight have a harmful effect upon neuromuscular, cardiovascular, and respiratory systems, and the oxygen requirements of the wrestlers. Buskirk, Iampietro, and Bass (6) found significant differences between untrained men and men in good physical condition while observing cardiovascular strain due to dehydration. Fatigue has been found to be the main result from prolonged water restriction, while the primary danger from extended reduction of caloric intake seems to be vitamin and mineral deficiency.

Cooper (7) states that there are two main sources of weight which can be reduced in the body, body fat and body fluid. Body fluid is the most easily lost by wrestlers, but evidence indicates that a reduction of work performance accompanies a dehydration level higher than 3 per cent body weight. For athletes, however, depot fat is excess weight. The body utilizes it too slowly to be useful during an athletic contest. For wrestlers, Henson (13) suggests that the storage fat should be lost at a slow, even rate, and is best done before the season begins.

II. THE PROBLEM

As recommended by Hermes (34) and others, there is a need for finding a simple, scientific, physiologically sound method for determining the minimum weight at which a wrestler could compete. The Nebraska Plan (the system used in Minnesota high schools) and others are attempts to define this minimal weight. But, as Tillman (29) states, "Part of the difficulty in developing standard guidelines lies

in the great differences among individuals. Body build, cardiovascular condition, amount of fat, previous experience in weight reduction and mental discipline are some of the factors that must be considered in individual weight control plans."

The determination of the minimum weight class for each high school wrestler could be done accurately by estimating the percentage of his total body weight that is depot fat. In 1951, Brozek and Keys (4) demonstrated the use of skinfold measurements for the evaluation of fatness-leanness in men. Since then, Michael, Katch (19) and others have demonstrated high positive correlations between estimations of body fat from skinfold measurements and determinations by other reliable methods. The specific purpose of this study has been to use and assess this procedure in the weight certification process.

III. DEFINITIONS

The following terms are defined as they are used in this study:

1. Body Fat.--Refers to fat that is in depots and is stored in reserve, but accumulated from excess caloric intake above the expenditures of energy.

2. Body Fluid.--Not excess weight, but fluid necessary to maintain the electrolyte balance and the blood volume.

3. Lean Body Mass.--The total body weight minus the body fat.

4. Weight Control.--The practice of manipulating one's body weight for a specific purpose.

5. Weight Certification--The process by which a wrestler's minimum weight class is ascertained in accordance with the Official Wrestling Rules Handbook.

6. Minimal Wrestling Weight (MWW).--The lean body mass plus 5 per cent body fat (14, 36).

CHAPTER II

WEIGHT CONTROL PLANS

All of the weight control plans reviewed attempt to provide some tangible means for establishing a wrestler's minimum weight class. Some are better than others because they are more definitive, and provide less latitude for the individual physician, coach, or parent to be unscientific in this determination. It appears that this controversial problem can be eliminated, but not until a concise, easily implemented plan is developed and put into effect.

Currently, the high school association in each of the states is responsible for the weight certifying process. Differences among the states were found. In relation to the rules stated in the Official Wrestling Guide, they ranged from conservative to radical in the view of the coaches.

I. MONTANA PLAN

The system used in the Montana high schools is an example of a conservative plan. It states that a doctor, at the time of a physical examination, determine how much weight a boy can lose. This report must be filed with the State Association by a specified date. It allows a boy to cut weight or gain weight from one weight class to another with no restriction or penalty (34).

II. NEBRASKA PLAN

The Nebraska Plan, used in that state and several others, is considered a radical plan by many coaches. This plan eliminates weighing in at all after the first weigh-in, and is based on a handi-

cap system of forcing the wrestler to add pounds, not lose them. This plan sets a minimal weight under which a wrestler cannot wrestle. This is done by conducting a surprise weigh-in at the beginning of the season. The weigh-in is supervised by the Activities Association. The boy then receives a weight handicap that starts with five pounds at the 98 pound class and goes up one pound for every twenty pounds a boy weighs over 98. Therefore, a boy weighing in at 98 would add five pounds and now weighs 103. Thus, he would be too heavy to wrestle at 98 pounds so he would be forced into the 105 pound class. As mentioned above, the "advantage" of this plan is that after this initial weigh-in the boy does not weigh-in again until the final tournament of the year. This plan eliminates weigh-ins and allows a coach to "coach" and not worry about the effects weight reduction might have on his wrestlers (34).

III. OREGON PLAN

The plan used by the Oregon State Athletic Association is similar to the Nebraska Plan in that it adds a five pound handicap at 98 and a one pound additional handicap for every twenty pounds a wrestler weighs over 98. The difference between the two plans is that the Oregon Plan allows a challenge weigh-in anytime an opposing coach feels a boy is not within three pounds of his handicap weight. Under this plan, if a boy exceeds his handicap weight allowance by more than three pounds, he automatically forfeits the match (34).

IV. NORTH DAKOTA PLAN

The present North Dakota Plan states each wrestler's weight

class must be set and certified by a physician. After this certification, a boy must make his assigned weight prior to every match and cannot change weight classes for the remainder of the season unless he is recertified for a heavier weight class than the initial certification. Under this plan, a one pound allowance for growth is added in January and an additional two pounds in February (34).

V. SOUTHERN CALIFORNIA PLAN

Still another alternative is the Southern California Plan. After the first match of the year a boy cannot compete in a class lighter than the one in which he wrestles during that first meet (2).

It is clear that the intent of each of the plans is to provide safeguards for each wrestler within the limits of the recognized guidelines. Impartial observers view "making weight" as little more than a subterfuge whereby one wrestler is able to secure unfair advantage over another. This deplorable practice is certainly not the intention of the rule.

CHAPTER III

FEEDBACK FROM THE WRESTLING COACHING PROFESSION

This study included comments from wrestling coaches (N = 53). These responses were collected following a demonstration relating to the use of the skinfold caliper for estimating body fat. This procedure was demonstrated during a coaches' meeting at a regional elimination tournament. After the demonstration, the coaches were asked to write down those considerations which they felt should be included in the framework of an improved guideline plan. A profile of those comments follows:

1. Determine the per cent of body fat in the wrestler.
2. Consider the age of the wrestler.
3. Note any unusual features in the body structure.
4. Identify the attitude of the wrestler and his family toward weight control practices.
5. Assess the cardiovascular condition of the wrestler.
6. Make allowances for possible growth changes in wrestlers during a season.
7. Have some idea of what the boy's average weight was during the off-season.

This list of comments focuses upon some of the pertinent thoughts relating to the design of new guidelines. They also illustrate how members of the coaching profession are aware of the gross inefficiencies in the methods currently used.

CHAPTER IV

SKINFOLD MEASUREMENTS: RATIONALE

Only in recent years has the complexity of the subject of body weight fluctuation been fully realized. Studies dealing with the deposition of fat help one understand body weight and the significance of weight changes. The role of skinfold measurements in body composition research has been prominent.

About one-half of an individual's total body fat is deposited in the subcutaneous tissue as a single sheet of tela adiposa. This sheet of fat is, in many parts of the body, only loosely attached to the underlying tissue and can be pulled up between thumb and forefinger into a fold (17). Since the volume of subcutaneous fat is related to the volume of inner fat, it is possible to estimate the fat weight or percentage of fat from skinfold thickness.

Measuring skinfolds is a fairly simple procedure. It requires that close attention be given to the precise location of the site to be measured, and that firm pressure be applied by the fingers in lifting the skinfold. It is necessary that the distance between the point at which the skinfold is lifted and the point at which the calipers are applied be constant. Also, the pressure of the caliper on the skinfold should not vary (3).

The choice of sites for measurement involves such considerations as accessibility, accuracy and rapidity with which a site can be located in different persons. Other considerations include relative homogeneity of the layer of skin and subcutaneous fat in a given region, and the validity of the measurement as an index of total fat. These

factors affect the repeatability of the measurements (11).

In a study on the distribution of subcutaneous fat, Edwards selected 53 sites as representative of most of the body and offering good repeatability (11). Clearly, both the number and location of sites will depend on the investigator's purpose and available time. But, for practical determination of leanness or fatness, the choice will be the smallest number of skinfold sites which provide a satisfactory prediction of fat content.

Brozek and Keys (4) found a correlation coefficient of .87 for predicting body density when using sites on the chest, triceps, and abdominal region as compared with underwater weighings. While predicting body density from both skinfold and girth measurements in boys from 15 to 17 years of age, Michael and Katch (19) obtained a correlation range of .94-.99. However, the findings of other studies agree that the triceps, chest and abdominal skinfolds all relate well to body density in boys. Pascale (24) reported that chest and triceps were the best measures ($r = .85$). Similarly, Parizkova (23) and Sloan (28) reported on the use of the triceps and the scapula skinfolds and some improvement was noted by adding the thigh skinfold measurement.

CHAPTER V

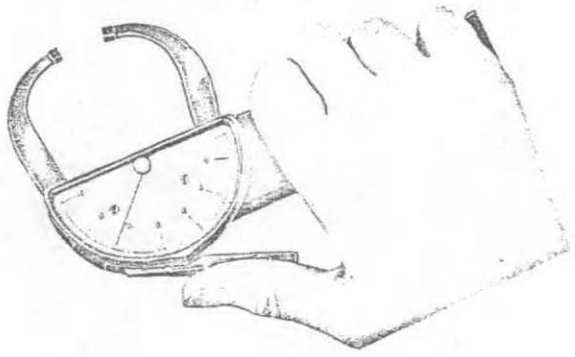
PROCEDURE

I. THE CALIPER

An improved, constant tension Lange Skinfold Caliper was used for the collection of the data. A small, reasonably accurate metric

FIGURE 1

LANGE SKINFOLD CALIPER



spring scale was used to check the reliability of the constant tension of the caliper, and tension was found to be 10gm/mm^2 over a range of openings from 2 to at least 40mm.

II. DATA COLLECTION

This study utilized the techniques described in other similar investigations to collect the skinfold data. Previous studies had emphasized several basic points in regard to how the subjects should be positioned when the measurements were being taken. First, the subjects should stand errect, and second, the folds should all be taken from the right side of the body while the underlying muscles were in a semi-

contracted state. A mean value for each fold site was produced by measuring the fold at least three times. However, the pinching of the folds were interrupted and interspersed between the three sites (chest, abdomen, and triceps).

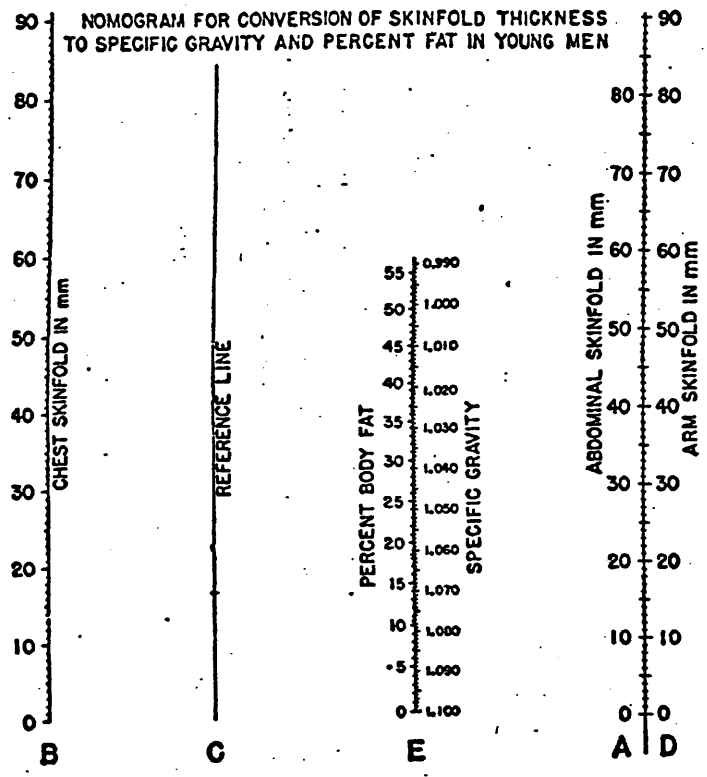
Accuracy was further enhanced by the standard manner in which each skinfold was grasped. The thumb and forefinger of the left hand were placed just far enough apart that a full fold could be pinched up firmly and cleanly from the underlying tissue. The fold was then held firmly between the fingers while the measurement was taken. The calipers were applied to the fold one centimeter below the fingers so that the pressure at the point measured was exerted by the caliper faces and not by the fingers. Readings to the nearest mm were considered adequate.

The accessibility of the sites used was considered important. They were: (1) the abdomen, a vertical fold on the anterior abdominal wall one inch to the right of the umbilicus; (2) the chest, an oblique fold halfway from the nipple to the anterior axillary fold on the line joining these; (3) the arm, a vertical fold on the posterior midline of the arm halfway from the acromion to the olecranon process. The ability to produce a measurable fold at each of these sites proved to be easy.

III. USE OF THE NOMOGRAM

The mean value for each site was determined by averaging the raw values of each reading. This was done by an assistant coach and was under the close scrutiny of the team physician. Interpolation of these values was then made by application to the nomogram which was designed and validated by C. F. Consolazio. Subsequently, estimation

TABLE I



of the percentage of body fat for each wrestler was made.

The following is a step-by-step example of the procedure used after the mean value for each site was determined:

Mean values - abdominal skinfold of 10mm, chest skinfold of 15mm, and arm skinfold of 20mm;

1. With straight-edge align abdominal value (10mm) in column A with chest value (15mm) in column B.

2. Place pin at point where straight-edge crosses reference

line C.

3. Pivot straight-edge on pin to arm skinfold value (20mm) in column D.

4. Read specific gravity (1.070) and per cent body fat (14%) where straight-edge crosses column E.

IV. WEIGHT CERTIFICATION

While the skinfold measurement forms the core of the procedure used, the following is a concise outline of the steps involved in the weight certification process:

1. All wrestlers were weighed to the nearest pound on a standard school scale that was certified accurate by the Minnesota Weights and Measures Department.

2. Skinfold measurements were taken from the three sites while both the subject and data collector were standing.

3. Interpolation of the data was then made with the aid of the nomogram.

4. The lean body mass of the wrestler was then calculated to the nearest pound [lean body mass = total body weight - (per cent fat - 5 per cent)].

5. The team physician then observed the wrestler and his measurements.

6. The team physician then conferred briefly with the coach and they determined the minimum weight class for that wrestler.

7. The wrestler then gained approval of this weight class decision from his parent or guardian.

A value judgment is made by the team physician and coach in

step #6. The major variables considered in this judgment are: (1) the maturity and grade level of the wrestler; (2) the attitude and willingness of the wrestler to drop to a lower weight class. Also considered, but to a lesser degree, are: (1) a boy's previous experience in weight control; (2) allowance for unusual body build or features; (3) cardiovascular condition; (4) previous experiences with the family's attitude toward weight control practices.

CHAPTER VI

RESULTS AND DISCUSSION

The descriptive statistics of the study are shown in the table below. Mean values were established for body weight and per cent of body fat in ten weight classes. The wrestlers (N = 64) were grouped according to their certified wrestling weight class. The ages ranged from 14 to 18 years. Ranges of body weight and per cent fat are also included for the sake of illustration. Subjects were measured at the beginning of the wrestling season.

TABLE II

MEAN VALUES AND RANGES OF BODY WEIGHT AND BODY FAT PER CENT OF HIGH SCHOOL WRESTLERS WHEN GROUPED BY MINIMUM WEIGHT CLASS CERTIFICATION

Wt. Class	N	X Body Wt.	Body Wt. Range	X Body Fat %	Body Fat % Range
98	10	100.3	88-112	6.3	5- 9
105	5	116.6	111-122	6.6	5- 9
112	11	120.6	116-125	6.6	5-10
119	4	123.2	116-126	6.3	5.5- 8
126	10	134.1	126-142	8.5	6-13
132	3	140.0	131-149	11.1	8-15
138	6	152.3	145-157	10.0	5-16
145	6	159.5	151-165	10.0	6-19
155	6	170.5	162-175	13.0	9-21
167	3	181.3	179-184	17.1	11.5-24

Estimation of the mean body fat percentages and their respective ranges show individuals in the middle and lower categories to be

lower than those wrestlers in the heavier categories. These findings are similar to those of Rasch (25) and Katch and Michael (14). When grouped according to weight category, Rasch established a mean per cent of 15.1 in 172 lb. wrestlers and only 8.4 in Olympic wrestlers in the 136.5 lb. weight class. When comparing the heaviest individuals with the 98 lb. wrestler, Katch and Michael found the heavyweights to possess four times as much body fat. This was partially explained by the difference in body composition that was found (skinfold thickness, girth measurements, etc.).

I. CHANGES IN BODY COMPOSITION

Motivated primarily by curiosity, a recheck of skinfold measurements was taken after sixteen weeks of intensive training on a representative sample of the original group. All cases witnessed showed the body fat percentage had dropped and in the middle and lower weight categories were approaching a minimum level of 5 per cent. Several individuals who were members of the original group had just finished cross country training and were found to be right at 5 per cent body fat. This would correlate highly with the reported findings of Katch and Michael (14) on 94 high school wrestlers. They found that wrestlers in the light to medium weight categories averaged 4.9 per cent fat while those in the heavier weights carried 11.7 per cent of their weight as fat.

A redistribution of body weight, and changes in skinfold measurements, has been found in investigations where skinfolds have been checked before and after a season of play. In two separate studies, Thompson and others (30, 31) found no change in body weight, but did

note a decline in skinfold measurements among football, hockey, and basketball players. Presumably, this change was due to loss of body fat, and an increase in muscle mass and other bodily components. Buskirk (6) found a group of college wrestlers and cross country runners to have higher body densities, and less fat than the average college student. The significance of this information to this procedure is that the coach or team physician should pay particular attention to the time of the season when estimating the minimum weight class, and should expect wrestlers to have lower per cents of fat than most other groups of athletes. Also, in states that allow recertifying during the course of the season, attempts should be made to be consistent in terms of the time of the measurement for each team.

II. PROBLEMS NOTED IN THE STUDY

One of the problems noted in the study was the low repeatability of fat percentage estimations in individuals with levels above 18-20 per cent. A study by Damon and Goldman (10) dealing with predicting fat from body measurements noted difficulty in repeating fat percentages in three types of individuals. They were: (1) individuals of extremely high or low body weight; (2) tall individuals; and (3) extreme endomorphic individuals.

A further problem that was cited in some studies, but not found in this one, was a variance in predicted lean body mass due to irregular skinfold thickness, and changes in the hydration-dehydration balance of the subject. Brozek and Keyes (15) stated that, " . . . under conditions of normal hydration the principal source of error of measurement of subcutaneous fat, outside of positioning and grasping of the fold, is

variation in the thickness of the skin proper." Also, Sloan (27) states that, " . . . the density of the lean body mass is significantly altered by gross variations in the degree of hydration of the body, but is remarkably constant in healthy young men." This information should signal caution to the investigator to avoid measurement following a strenuous workout, or following periods of voluntary dehydration.

CHAPTER VII

PREDICTION EQUATIONS

The search for a simplified technique to predict man's lean body mass resulted in the use of anthropometric measurements for the development of prediction equations. In a study that dealt with body fat estimates among marathon runners, Costill and others (9) illustrated the use of equations formulated by Brozek, Pascale, and Sloan. The three equations were used in order to offer some frame of reference with previous investigation. A comparison of the estimated body density means for the three formulae revealed no statistical differences. Consistency was noted. All three equations predicted similar body fat estimates for each group.

A study conducted by Katch and Michael (14) dealing exclusively with 15-18 year old high school wrestlers found large discrepancies between the results obtained by using their skinfold regression equation, the Yuhasz formula, and the adjusted formulae of Brozek and Pascale. The discrepancies appeared in all four age categories in the study, and were calculated as the difference between the mean value of density as measured by underwater weighing and the mean predicted values based on skinfolds.

When compared, all of the formulae reviewed appeared to be similar. Each formula designates various skinfold measurement values to be used. Also, the equations have calculated constants which, when used with the skinfold values, produce an estimation of lean body mass and per cent fat. Generally, the required number of skinfold measurements is three, but the Yuhasz equation utilizes four. The

typical equation is lengthy and one would need the use of a computer to obtain rapid results.

A final formula that should be noted is the "Tcheng-Tipton Equation" (36). It is the most specific of the equations reviewed because it was designed specifically for high school wrestlers. It is considered simple, reliable, and suitable for use in the scholastic environment. The development of this equation was completed from data collected from 3,000 high school wrestlers in Iowa. They used the state wrestling championship finalist as criterion for their model. The equation has both a long and a short form and multiple Rs of .933 have been obtained when compared to indirect methods.

The data needed for the equation are the wrestler's height, chest depth, chest diameter, both wrist widths, the bitrochanteric diameter, both ankle widths, and the bi-iliac diameter. The long form of the equation is as follows: Minimal weight (lbs.) = 1.84 height (inches) + 3.31 chest depth (cm.) + 3.28 chest diameter (cm.) + 3.56 both wrists (cm.) + bitrochanteric diameter (cm.) + 2.15 both ankles (cm.) + 0.82 bi-iliac diameter (cm.) - 281.72. The short form has slightly different constant values, and doesn't require the measurement of both ankles or the chest diameter. The main tools of the procedure are a commercial weight scale with attachments for measuring standing height, and an anthropometric caliper.

CHAPTER VIII

SUMMARY

Wrestling is conducted at the interscholastic level throughout the country. The fact that it has gained this position of wide acceptance accentuates the need for strict and thorough administration of the sport. Abuses of the weight certification process occur because of the inability of those within the sport to cope effectively with the need to win. Indirectly, the desire to compete successfully forces coaches and wrestlers to submit to a practice they know is not in their best interest or that of the sport. Thus, it is clear why the implementation of effective change must come from outside the sport. Those cognizant of the situation should seek objective action that is fair and impartial to all.

Wrestling is conducted with competition between wrestlers in the same weight category. The purpose of weight categorization is to equalize competition by the pairing of individuals of the same weight. Wrestlers who engage in dehydration and severe fasting prior to the competition attempt to gain an unfair advantage. The match should be won by the most skilled wrestler. However, because of the disproportionate size between them, the smaller of the two will often experience difficulty in the execution of skills. Thus, the intent of the weight class design is not realized.

The establishment of a minimum wrestling weight could be done in a scientific manner with prediction equations. They are simple to use, produce reliable results, and are suitable when dealing with a specific group. The typical equation requires the use of an automatic

calculator or computer, and necessitates obtaining a series of anthropometric measurements (skinfold, girth, etc.). The time needed to gather the input data, and complete the calculation is reasonable.

The implementation of the prediction equation method would necessitate the training of a team of individuals to take the required measurements. Referees or responsible league officials could conduct these evaluations. The measurement team would visit a number of schools in a specific area. Obviously, this procedure would eliminate the need for a coach or team physician to make a value judgment based upon unobservable criteria (i.e., attitudes, experience, etc.) when certifying a boy.

Finally, the most important advantage of the use of prediction equations is the high correlation obtained between the predicted and actual values of body fat. Thus, the minimum body weight could be determined in spite of varying individual differences (body composition, stature, etc.).

I. EVALUATION OF THE CERTIFICATION PROCEDURE USED IN THIS STUDY

This method provides the advantages of simplicity and ease of administration. However, when compared to methods using prediction equations several differences appear. First, this method only measures body fat. In addition to body fat, there are other anthropometric factors that could be considered, such as chest depth, bitrochanteric diameter, etc. Research indicates that wrestlers do not differ in body indices from the average young American male, but a wide range of body type differences are seen.

Secondly, in step #6 of the procedure followed in this study,

a value judgment by a team physician or coach is required. While in some cases they may have the necessary expertise, it remains doubtful that consistency in objectivity can be maintained. A case in point would be when several boys would have the same estimated minimum wrestling weight, but are assigned to different weight classifications. The author noted this problem several times in situations involving potentially outstanding athletes.

II. RECOMMENDATIONS

The following is a prescriptive outline of the ingredients needed to produce a "model system" governing wrestling weight control practices:

1. Minimum weight determinations shall be conducted by a measurement team composed of unbiased individuals.

2. The minimum wrestling weight should include at least 5 per cent fat (14, 36).

3. The minimum weight calculations shall be implemented with a prediction equation that is designed specifically for 15-18 year old high school wrestlers (i.e., Tcheng-Tipton Prediction Equation).

4. The expertise will be provided by the sports medicine centers, or related fields (exercise physiologists, etc.).

Finally, there will be a need to further substantiate the feasibility of the above-recommended procedure. Assessments of the procedure should be made after it has been fully implemented. This assessment procedure should be organized under the leadership of a specific sports medicine center or university. This leadership would then recruit and instruct data gathering teams across the state. The impact

of this fact-finding procedure would then be used as the major input for changes and modifications of the present rule.

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