Body Composition Assessment and Minimal Weight Recommendations for High School Wrestlers

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Objective: To describe a procedure to estimate a minimal wrestling weight based on percent body fat.

Background: Weight reduction and weight restriction are health issues that have sparked much debate among those involved with high school wrestling. Recently, programs have been developed to curtail dangerous weight loss practices and severe weight reduction in this population.

Description: Skinfold sites, measurement technique, and an equation, based on skinfolds, specific to the high school wrestling population are presented. Recommendations for minimizing error are also presented.

Clinical Advantages: This article provides a detailed program for measuring skinfold sites and interpreting these measurements.

Key Words: wrestling, skinfolds, body fat, adolescence

Body weight is often a concern for athletes for both appearance and performance. The need to control body weight is very evident in wrestling where "making weight" at a lower weight class gives one an assumed advantage over an opponent. Additionally, it is common practice for a wrestler who is not making the team to "drop weight" in order to fill a void in the team's roster at a lower weight class.[3]

Traditionally, wrestlers have used aggressive methods such as food restriction, dehydration, vomiting, diuretics, and exercise in thermal environments to accomplish weight loss.[13,14,16] These athletes also go through weekly weight fluctuations, losing weight rapidly before a match only to regain it immediately following weigh-in. Although there is a lack of research on this practice of weight cycling, investigators have suggested that it may be detrimental to the athlete's behavior, metabolism, health, and performance.[3] These practices occur despite warnings from the American College of Sports Medicine[1] and the American Medical Association.[2] Brownell and Steen[3] stated, "Legislation defining a minimum weight for competition, perhaps based on an individual's percent body fat, might be the only means for altering these practices."

Recently, programs such as the Wisconsin Wrestling Minimum Weight project[12] have been put into place to curtail the practice of excessive weight reduction among high school wrestlers. This program includes nutrition education, a limit on weekly weight loss, and skinfold measurements to estimate body fat for determination of a minimum wrestling weight. The purpose of this article is to give the clinician who is responsible for assessing the body composition of the high school wrestler a detailed description of the skinfold sites, a measurement technique, and an equation for estimating body fat and determining minimal weight standards for this population.

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BACKGROUND RESEARCH

Over two decades of research went into developing an optimal equation for estimating percent body fat and minimal wrestling weight in high school wrestlers.[8] This research culminated in a landmark cross-validation study by Thorland et al[15] involving 860 high school wrestlers from the midwestern United States. They found several equations to be acceptable for predicting body density and fat-free body mass. Of the equations with the lowest prediction error, Lohman's[9] is the most practical. The Wisconsin Wrestling Minimum Weight project[12] used a Thorland et al[15] modification of the Lohman[9] equation. This equation and a description of the skinfold sites and measurement technique associated with it are presented below.

SKINFOLD SITES

Lohman's[9] equation uses three skinfold sites: triceps, subscapular, and abdominal. The anatomical landmarks for these sites are detailed in the *Anthropometric Standardization Reference Manual*[5] and are as follows.

1. Triceps: a vertical fold in the midline of the posterior aspect of the arm at a point midway between the acromion process of the scapula and the olecranon process of the ulna (Figs 1 and 2).
2. Subscapular: a diagonal fold along the natural cleavage line of the skin just inferior to the inferior angle of the scapula (Figs 1 and 3).
3. Abdominal: a horizontal fold 3 cm lateral and 1 cm inferior to the center of the umbilicus (Figs 4 and 5).

MEASUREMENT TECHNIQUE

Several standardization procedures have been established to increase the accuracy and reliability of the skinfold measurements.[5] All measurements should be taken on the right side of the body with the clinician meticulously identifying and marking the skinfold sites. A skinfold is lifted by placing the

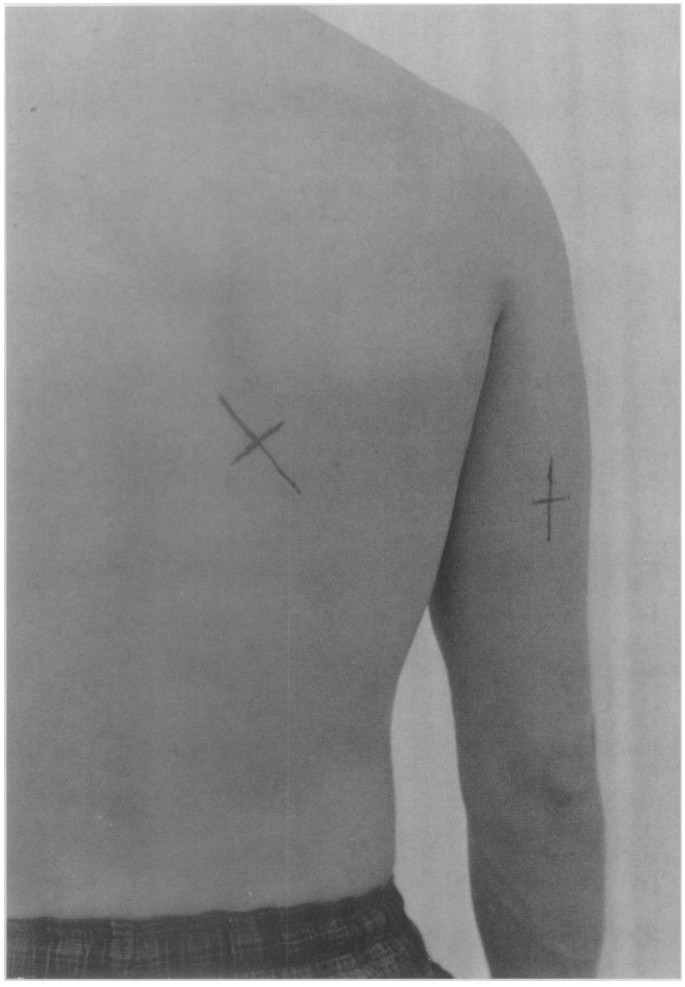

Fig 1. Sites for triceps and subscapular skinfolds.

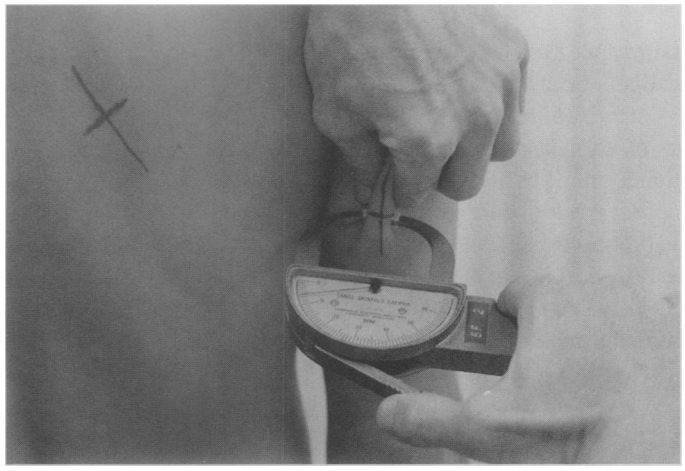

Fig 2. Measurement of triceps skinfold.

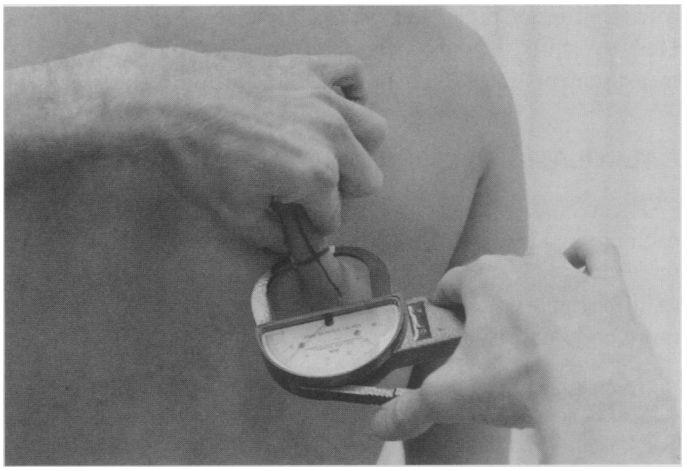

Fig 3. Measurement of subscapular skinfold.

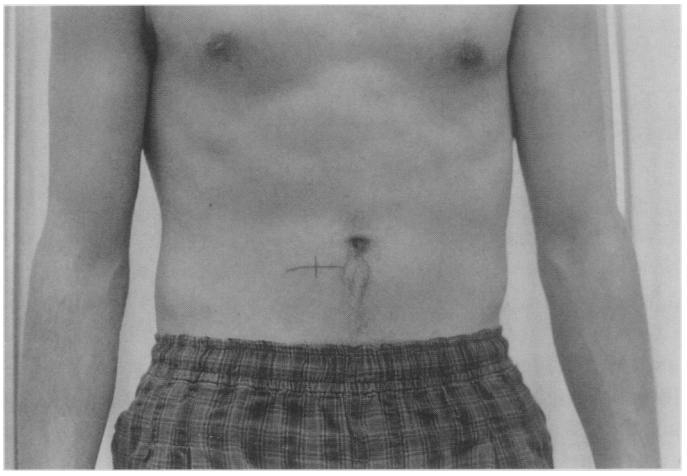

Fig 4. Site for abdominal skinfold.

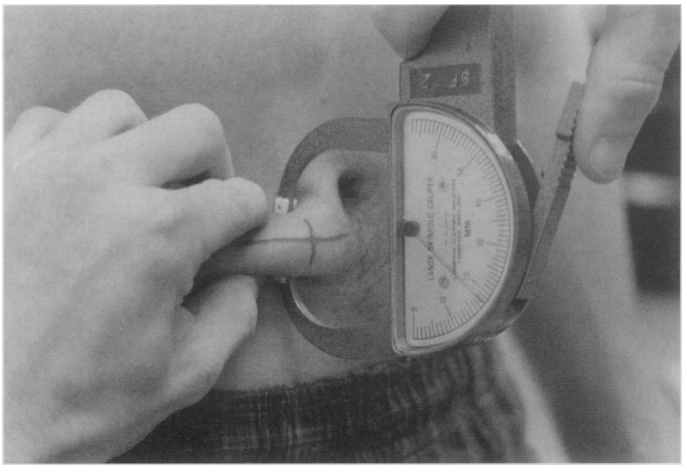

Fig 5. Measurement of abdominal skinfold.

thumb and index finger of the left hand about 8 cm apart and drawing them together so that the fold is grasped firmly. Be careful to elevate only skin and adipose tissue. Use your right hand to place the jaws of the caliper perpendicular to and 1 cm away from the left thumb and index finger, which are keeping the fold elevated. Thus, in relation to the fingers holding the skinfold, the caliper is placed below them for the triceps measurement, diagonal to them for the subscapular reading, and to the right of the fingers for the abdominal measurement. A caliper reading is taken 4 seconds after the jaw pressure is released.

Heyward and Stolarczyk[6] recommend taking a minimum of two measurements at each site. If the values differ from each other by more than ± 10%, additional measurements should be taken. The three skinfold (SKF) sites should be measured in a

rotational order rather than consecutive readings at each site. Due to shifts in body fluids, they also recommend that measurements not be taken immediately after exercise.

CALCULATIONS

The average of two measurements that are within ± 10% of each other at each site is calculated. The average values for the three sites—triceps, subscapular, and abdominal—are summed (Σ3SKF) and entered into the following equation[15] to determine body density (Db).

$$Db = [1.0973 - (0.000815 \times \Sigma 3SKF)] + [0.00000084 \times (\Sigma 3SKF)^2] \quad (1)$$

Body density (Db) is then converted to percent body fat (%BF) using the formula of Brozek et al.[4]

$$\%BF = (457.0 \div Db) - 414.2 \quad (2)$$

Subsequently, once body weight (BW) is measured, fat-free mass (FFM) can easily be calculated.

$$FFM = (1 - \%BF)BW \quad (3)$$

While there does not appear to be a definitive criterion level of body fat for making minimal wrestling weight recommendations, most experts have chosen values of 5% to 7%. Lohman[8] cited 5% as the minimal amount of body fat that male athletes should maintain, while the Wisconsin Wrestling Minimum Weight project[12] chose 7% body fat as the lowest acceptable value at which a high school wrestler should be competing. Recent recommendations from the American College of Sports Medicine[1] set minimal standards for percent body fat at 7% for males 16 years and younger, and 5% for those over 16 years. It is recommended that female wrestlers maintain a body fat of at least 12% to 14%.[1] A minimal wrestling weight (MWW) can easily be calculated from fat-free mass (FFM).

$$MWW(@5\%) = FFM \div 0.95 \quad (4)$$

Finally, Lohman[8] suggested making an adjustment in the young athlete's minimal wrestling weight to account for small differences in chemical maturity and reduce the error associated with age.

$$adjustment = 0.406(age - 17.2) \quad (5)$$

$$final\ MWW = MWW + adjustment \quad (6)$$

A sample case study example of these calculations is provided in Table 1.

Table 1. Example of Minimal Wrestling Weight Calculations

Age: 16.5 years — Wt: 145.0 lb (65.77 kg)

Skinfold measurements			Avg
Triceps	6.0	6.0	6.0
Subscapular	10.5	11.0	10.75
Abdominal	8.5	8.0	8.25
			25.0 Σ3SKF

1. Calculation for body density (Db)
   Db = [1.0973 − (0.000815 × Σ3SKF)] + [0.00000084 × (Σ3SKF)²]
   Db = [1.0973 − (0.000815 × 25.0)] + [0.00000084 × (25.0)²]
   Db = 1.07745 g/cc

2. Calculation for percent body fat (%BF)
   %BF = (457.0 ÷ BD) − 414.2
   %BF = (457.0 ÷ 1.07745) − 414.2
   %BF = 9.9

3. Calculation of fat-free mass (FFM)
   FFM = (1 − BF) BW (in kg)
   FFM = (1 − 0.099) 65.77
   FFM = 59.26 kg

4. Calculation of minimal wrestling weight (MWW)
   MWW (@ 5%) = FFM ÷ 0.95
   MWW = 59.26 ÷ 0.95
   MWW = 62.38 kg

5. Calculation of age adjustment
   Adjustment = 0.406 (age - 17.2)
   Adjustment = 0.406 (16.5–17.2)
   Adjustment = −0.2842 kg

6. Final calculation of minimal wrestling weight (MWW) adjusted for age
   Adjusted MWW = MWW + adjustment
   Adjusted MWW = 62.38 + (−0.2842)
   Adjusted MWW = 62.09 kg (136.9 lb)

MEASUREMENT ERROR

Lohman[8] cited measurement technique, site location, and type of caliper as potential sources of technical error that can affect the accuracy of the skinfold method. Thus, the clinician must be precise in locating the proper skinfold site and taking the measurement as outlined above. Harpenden, Lange, Holtain, and Lafayette calipers are recommended high quality calipers because they exert a constant pressure (~10 g/mm²).[6]

A trained, skilled technician is critical for valid and reliable skinfold measurements. Experts in the field recommend practicing on 50 to 100 clients to gain proficiency.[6,7] However, it appears that even relatively inexperienced testers can produce valid and reliable measurements when given training in standardized skinfold site location and measurement techniques. Morrow et al[10] reported that inexperienced testers obtained reliable measurements at the triceps and subscapular sites of adolescents after only a brief practice session. Following a 5-hour clinic that included demonstration and practice of the protocol described in this article, Oppliger et al[11] noted that clinic-trained testers are able to produce skinfold measurements with an accuracy similar to that of trained testers on a sample of high school wrestlers.

RECOMMENDATIONS

Making wrestling safer and healthier for athletes should be a goal of all coaches, athletic trainers, and clinicians involved with the sport. Determining a minimal wrestling weight based on body fat could be a big step toward eliminating some of the unhealthy weight reduction and dietary practices currently seen

Table 2. Checklist to Minimize Errors in Skinfold Measurement (adapted from Heyward/Stolarczyk[6])

- Take all skinfold measurements on the right side of the body.
- Use anatomical landmarks to carefully identify and mark the skinfold site.
- Use an 8-cm spread between thumb and index finger to form the skinfold.
- Place caliper jaws 1 cm away from and perpendicular to the elevated skinfold.
- Read skinfold measurement 4 sec after pressure is released from caliper jaws.
- In a rotational order, take a minimum of two measurements at each site (±10% variability).
- Take skinfold measurements when the skin is dry and not immediately after exercise.
- Use high quality skinfold calipers (~10 g/mm^2 jaw pressure).
- Practice, practice, practice! Do skinfolds on 50 to 100 "practice clients" of varying body types before applying your skills to determine the minimal weight of a wrestler. Compare your measurements to those of a skilled skinfold technician.

Table 3. Recommendations for Implementing a Minimal Wrestling Weight Program (adapted from American College of Sports Medicine[1])

- Advocate a state mandate for minimal wrestling weight standards so that wrestlers from all districts/regions are competing under the same stipulations.
- Assess the athlete's body composition and establish a minimal wrestling weight prior to the first practice session using the methods described in this article.
- Provide a nutrition education program/seminar prior to the start of the season for wrestlers, coaches, and parents.
- Work with a nutritionist to establish minimal caloric intakes for wrestlers.
- Place a limit on the amount of weight that can be lost per week (eg, 3 lb/wk[12]).
- Eliminate "sweat boxes," rubber suits, laxatives, and other methods of dehydration as a means of "making weight."
- Schedule weigh-ins immediately prior to competition so that wrestlers are competing at their "true" weight.
- Consider the possibility of allowing more than one wrestler from each school to compete at the same weight class.
- Have athletes, coaches, parents, athletic trainers, and physicians evaluate the program at the end of each season to address concerns and implement improvements.

in the sport. Oppliger et al[13] reported significant decreases in weekly weight cycling, fasting before weigh-in, and amount of weight lost when the Wisconsin Wrestling Minimum Weight project was mandated. Lohman[8] estimated that if measurement procedures are followed carefully, the error in estimating fat-free mass and minimal wrestling weight could be reduced to 1.2, 1.6, and 1.9 kg for lightweight, middleweight, and heavyweight groups, respectively. A checklist for proper skinfold technique to minimize measurement error is presented in Table 2. With such a small error in estimating a minimal weight, much of the guesswork associated with selecting an appropriate weight class can be removed. Oppliger et al[12] stated that although there was initially some opposition to establishing a minimal wrestling weight based on percent body fat, both wrestlers and coaches in the Wisconsin Wrestling Minimum Weight project now overwhelmingly accept this procedure.

In conclusion, wrestling programs should have a minimal wrestling weight standard based on percent body fat to protect the safety and health of high school wrestlers. A comprehensive program, such as the Wisconsin Wrestling Minimum Weight project,[12] should include nutritional counseling and limitations on weekly weight loss, as well as a minimal weight standard. Specific recommendations for establishing a minimal wrestling weight program are provided in Table 3. Ideally, skinfold technicians should undergo extensive training with experienced testers before taking measurements that will be used to determine a wrestler's weight classification. The skinfold procedures and equations outlined in this article have been developed specifically for this population. Implementing this procedure and developing a minimal wrestling weight at the time of the preseason physical examination will allow the high school wrestler to remain competitive at a healthy weight throughout the season.

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