

Validity of the Current NCAA Minimum Weight Protocol: A Brief Review

Jeremy P. Loenneke^a Jacob M. Wilson^b Jeremy T. Barnes^c Thomas J. Pujol^c

^aDepartment of Health and Exercise Science, The University of Oklahoma, Norman, Okla., ^bDepartment of Exercise Science and Sport Studies, University of Tampa, Tampa, Fla., and ^cDepartment of Health, Human Performance, and Recreation, Southeast Missouri State University, Cape Girardeau, Mo., USA

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Abstract

Historically, collegiate wrestlers have been associated with utilizing rapid weight loss methods to reach a desired weight class. Following three deaths in 1997, the National Collegiate Athletic Association (NCAA) implemented a program which prevents wrestlers from wrestling below a minimum weight (MW) of 5% body fat. Although numerous studies have investigated adolescent wrestlers, few have investigated collegiate wrestlers using the methods outlined by the NCAA. The purpose of this review paper is to outline potential problems with the current NCAA protocol as well as critique studies investigating the validity of methods to assess MW.

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Introduction

Minimum weight (MW) is used to identify a weight at which a wrestler can safely compete. The National Collegiate Athletic Association (NCAA) has implemented a rule stating that no wrestler may compete below this MW, which is a body fat estimated at 5% [1]. The purpose of

this review paper is to outline potential problems with the current NCAA protocol as well as critique studies investigating the validity of methods to assess MW. In particular, the validity of methods currently accepted for use by the NCAA as well as other research investigating possible alternatives will be examined. The reliability of each method to accurately track changes over time will not be discussed as the purpose of this paper is the calculation of MW which occurs at a single time point.

History of Minimum Weight

Wrestling is a sport historically associated with use of extreme methods to lose weight rapidly to compete at the lowest weight class possible [2]. The concern over cutting weight is not new; in fact, Kenny [3] expressed concern over the potential dangers of weight loss as early as 1930. He believed that wrestlers should be weighed in not only at the official weigh-in but additionally at mat side prior to competition and that any wrestler who had gained more than 3 pounds should be disqualified from competition. Again, in 1944, Doshner et al. [4] described extreme stories in which weight class athletes were exposed to extreme heat in an effort to lose water. Additionally, many coaches withheld food and water in hopes of lower-

ing body weight and increasing aggression. Due to concerns about the weight-cutting behavior of wrestlers, questionnaires were sent to coaches. The results indicated that: (1) the majority of coaches were aware of the rapid weight loss practices, (2) the majority of coaches were also aware of the possible health problems that could occur as a consequence of those methods, and (3) the majority of coaches thought that weight loss of 5–10% was not unhealthy. Although heavier weight wrestlers with more body fat might be able to safely lose 10% gradually over time, a leaner lighter weight wrestler could potentially be in great danger doing the same, especially when done so rapidly.

In response to continued concern, Tipton and Tcheng [5] completed two studies in which they found that the average weight loss of 747 high school wrestlers was 3.1 kg of initial body weight within a 17-day period. In 1973, these authors asserted that wrestlers should not be allowed to wrestle if their body fat percentage (BF%) was less than 5% [6]. This recommendation has since been adopted by the NCAA.

Three deaths in the course of 1 month provided the final justification for the implementation of MW. Three experienced collegiate wrestlers participated in food and fluid restriction in the hours preceding the weigh-in. In an effort to maximize sweat loss, they wore sweat suits under cotton warm-up suits and exercised in a hot environment. As a result, all became incommunicative and underwent cardiac arrest due to dehydration-related hyperthermia [7]. Following these events in 1997, the NCAA developed and implemented a weight certification program.

NCAA Minimum Weight

The methods addressed in this paper are according to the most recent memorandum sent to head wrestling coaches and certified athletic trainers at NCAA institutions that sponsor wrestling [1]. The NCAA states that MW is to be determined in a euhydrated state which they define as a urine specific gravity (USG) of less than 1.020 g/ml measured using a refractometer or urinometer. The NCAA does not allow the use of test strips to determine hydration due to the overall inaccuracy of this method. In addition, measurements are only to be taken by a physician, athletic trainer, or registered dietician. The NCAA does not require that the technicians provide documentation of tester reliability, which could potentially lead to increased error. For collegiate athletics, a skinfold (SKF)

reliability of $r > 0.90$ should be required of all testers to ensure technical ability.

The NCAA states that body density (BD) is to be estimated using SKF, although hydrostatic weighing (HW) and air displacement plethysmography are also acceptable but are not used as primary methods. SKF are assessed at 3 sites all located in the upper body (abdomen, subscapular, and triceps). The NCAA allows measurements to be taken with Lange, Lafayette, or Harpenden skinfold calipers, and BD is estimated using the modified Lohman equation as described by Thorland [8]. BD estimates are entered into the Brozek equation to compute a BF%, and MW is determined by adding 5% body fat to the fat-free mass (FFM) ($MW = FFM + 5\% FFM$).

Potential problems with current methods for assessing BD by SKF include the modified Lohman equation used to assess BD because it was developed on predominately white (>95%) high school adolescents (~16 years) [8]. Furthermore, the hydration status was assumed to be normal and the Lange and Harpenden calipers were used interchangeably, which could provide different measurements [9–11]. Additionally, different technicians were used for assessing SKF, which can result in an approximately 8.8% error for the abdomen, 3–5% error for the subscapular, and 3% error for the triceps [10–12]. Although the equation was developed on adolescents, Clark et al. [13] cross-validated the modified Lohman equation on NCAA Division 1 wrestlers ($n = 93$) and found the total error (TE) to be 2.51%. This is normally an acceptable TE; however, in a sport stratified into weight classes, it is ideal to set the TE at less than 2. Furthermore, in the cross-validation study the hydration status was again assumed to be normal but was not measured.

With HW the NCAA states that BD should be calculated using a standard underwater weighing technique with a direct measure of residual volume (RV). The BF%, like SKF, is calculated using the Brozek equation. Similar standard recommendations apply for air displacement plethysmography estimates of BD. The NCAA states that 2 body volume (BV) measurements should agree within 150 ml and, if they do not, a third volume measurement should be taken. A potential problem is that a recent study found that athletes can change their estimated body composition, and subsequent MW, by simply altering their breathing pattern [14]. An overestimation of MW would place a wrestler inappropriately into a higher weight class, removing the competitive fairness of weight classes, and an underestimation of MW would allow a wrestler to reach a weight class that could potentially be deleterious to overall health.

Although wrestlers are prevented from being tested in a dehydrated state, no rules are currently in place preventing them from being overhydrated (USG <1.004); this would violate the assumption that hydration is 73% of FFM which is assumed in the 2-component (2-C) model (FFM: FM) [15]. Additionally, the Brozek equation is universally used across all races. However, it may underestimate the BF% of African-Americans; thus, the Schutte or Wagner and Heyward [16] equation might be more appropriate in that specific population [17]. Additionally the accepted use of different SKF calipers could lead to differing calculations of MW depending on the caliper used. To illustrate this, the Lafayette was used in neither the validation nor the cross-validation of the modified Lohman equation but is still an accepted caliper according to the NCAA. The absolute impact of that difference is likely minimal, but Heyward and Wagner suggest that the calipers used to develop an equation are the only ones that should be used and that an equation acceptable for one caliper is not necessarily acceptable for another [18].

Validity of Other Methods

Although the NCAA currently accepts only SKF (modified Lohman), HW, or air displacement plethysmography calculations of MW, numerous investigations have sought to find suitable alternatives, with the majority of studies completed using high school wrestlers. Bioelectrical impedance analysis (BIA), dual-energy X-ray absorptiometry (DXA), and other SKF equations will be reviewed. Due to the paucity of data from collegiate wrestlers, the studies currently available will be critically evaluated with emphasis placed on the TE of the measurement and not on the method's ease of use. Studies were excluded from the current review if the method was not validated against HW or a multicomponent model and/or if the TE was not assessed. It is essential that the calculation of MW be made from the most valid measurement possible and not the one that is easiest to administer.

Clark et al. [19, 20] investigated BIA, SKF, DXA, and HW compared to a 4-component model (4-C). The earlier study was completed on 53 Division 1 wrestlers with a mean body mass of 75.6 kg (range 56.4–94.1) [19]. The purpose was to determine whether the assumptions made by the 2-C model are violated in collegiate wrestlers due to possible differences in hydration and muscularity. In addition, SKF (Lange), BIA (TBF-305GS) with a frequen-

cy of 50 kHz, DXA (XR-36), and HW were all compared against the multicomponent model. RV was directly measured and all subjects were fasted and had a USG of less than 1.020.

Results from the 2004 study indicated that HW (2-C) could accurately reflect MW as the TE was 1.34 compared to that in a 4-C model [19]. SKF also produced an ideal TE of 1.73; however, caution should be applied when interpreting this finding as this does not necessarily validate the use of SKF as an acceptable estimate of MW because the equation used by the NCAA is the modified Lohman, not the original Lohman. In addition, both DXA (TE = 2.22) and BIA (TE = 3.08) produced acceptable but not ideal values of TE.

In a later study, Clark et al. [20] investigated another BIA machine (TBF-350) in 'athletic mode' with a frequency of 50 kHz and validated it against the 4-C model in 57 Division 1 wrestlers with a mean body mass of 77.7 kg (range 56.4–125.5). As in their earlier work, RV was measured and all wrestlers had a USG of less than 1.020. The results indicated that the TBF-350 underpredicted the MW in leaner wrestlers and overpredicted the MW in wrestlers with higher body fat and had a TE of 3.5 kg, making it an unacceptable method for assessing MW. Underestimating the MW for leaner wrestlers could produce a potentially dangerous scenario, with a wrestler being allowed to potentially fall below the 5% recommendation.

Dixon et al. [21] investigated several different body composition assessment methods on 25 Division 3 wrestlers with a mean body mass of 76.9 kg (range 54.9–112.2). Air displacement plethysmography (BOD POD), BIA (Tanita-300A), and SKF (Lange) were compared to HW. RV was measured and subjects were tested in a hydrated state determined by USG (1.001–1.019). Interestingly, a USG of 1.001 would indicate that at least one wrestler was hyperhydrated (<1.004), which could violate the assumptions for hydration of FFM made by the 2-C model. The results indicate that both air displacement plethysmography (TE 1.94%) and SKF (1.88%) provide a valid method to assess MW in collegiate wrestlers. Although SKF in this study provided a valid estimation of MW, the formula used was the Lohman and not the modified Lohman equation which is currently used by the NCAA. However, air displacement plethysmography using the methods outlined by the NCAA does provide an accurate estimate compared to HW. The BIA machine which measured subjects in the 'athletic mode' produced an unacceptable TE of 4.16.

Future Research Considerations

The NCAA requires that all wrestlers adhere to the MW calculated prior to the start of the competitive season, with the main method used being SKF [1]. Despite this, the methods currently outlined by the NCAA for SKF have little research to support their use in collegiate wrestlers. As highlighted in this review, many of the studies which seem to support the validity use different methods from those outlined by the NCAA. To illustrate this, although the modified Lohman is the equation used to predict BD by the governing body, the research has been completed using the regular Lohman equation. This difference, while likely small, should nevertheless be considered in future research. Furthermore, the NCAA allows the use of Lange, Lafayette, and Harpenden calipers, although the research completed thus far uses only the Lange SKF caliper.

DXA is a 2-C method for determining body composition which is growing increasingly popular. The DXA is often erroneously considered a 3-C model; however, it does not provide 3 independent measures of body composition but rather comprises 2 separate sets of 2-C model equations [18]. The data of wrestlers indicates that while this method produces an acceptable TE, it is not as accurate as SKF. In addition, the DXA used was a Norland XR-36 and variations in software across differing manufacturers questions whether or not another DXA would produce similar results. Future research should investigate the validity of other DXA software in the calculation of MW.

Race is another important variable to consider when estimating body composition. A difference in BD across races questions the accepted use of one equation to estimate body composition in collegiate wrestlers. For example, African-Americans have been systematically un-

derestimated when using the Brozek equation [22, 23], meaning they would have an artificially raised MW which may compromise competitive fairness for those athletes. It is clear that the Brozek equation might not accurately reflect MW for all wrestlers; thus, future research should investigate the potential differences.

Athlete manipulation of the testing is a variable that needs to be further addressed when forming MW guidelines. Athletes may try to alter the test to overestimate their body fat at preseason, which would allow them to lower their MW. Technicians should remain attentive to the possibility of these deliberate actions by athletes attempting to alter their estimated body composition. Technicians should also ensure that the manufacturer guidelines and approved procedures are carefully followed as they are in the research setting. To illustrate this, studies have found that failure to adhere to the recommended manufacturer guidelines regarding body temperature [24], clothing [25], and hair [26] can underestimate body fat by 1.8% or overestimate it up to 9%.

Conclusions

MW has been established to protect the overall health of collegiate wrestlers. Although methods outlined by the NCAA are currently in place to estimate body composition, few of the current methods have much research to support their validity. Most of the literature has been completed on adolescents which likely do not reflect accurate estimates of collegiate wrestlers' body composition. Research using the methods outlined by the NCAA is needed to validate the methods currently in place to determine if the MW is being accurately predicted across individuals or if modification of the current methods is warranted.

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