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Dehydration and Performance on Clinical Concussion Measures in Collegiate Wrestlers

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Context: The effects of dehydration induced by wrestling-related weight-cutting tactics on clinical concussion outcomes, such as neurocognitive function, balance performance, and symptoms, have not been adequately studied.

Objective: To evaluate the effects of dehydration on the outcome of clinical concussion measures in National Collegiate Athletic Association Division I collegiate wrestlers.

Design: Repeated-measures design.

Setting: Clinical research laboratory.

Patients or Other Participants: Thirty-two Division I healthy collegiate male wrestlers (age = 20.0 ± 1.4 years; height = 175.0 ± 7.5 cm; baseline mass = 79.2 ± 12.6 kg).

Intervention(s): Participants completed preseason concussion baseline testing in early September. Weight and urine samples were also collected at this time. All participants reported to prewrestling practice and postwrestling practice for the same test battery and protocol in mid-October. They had begun practicing weight-cutting tactics a day before prepractice and postpractice testing. Differences between these measures permitted us to evaluate how dehydration and weight-cutting tactics affected concussion measures.

Main Outcome Measures: Sport Concussion Assessment Tool 2 (SCAT2), Balance Error Scoring System, Graded Symptom Checklist, and Simple Reaction Time scores. The Simple Reaction Time was measured using the Automated Neuropsychological Assessment Metrics.

Results: The SCAT2 measurements were lower at prepractice ($P = .002$) and postpractice ($P < .001$) when compared with baseline. The BESS error scores were higher at postpractice when compared with baseline ($P = .015$). The GSC severity scores were higher at prepractice ($P = .011$) and postpractice ($P < .001$) than at baseline and at postpractice when than at prepractice ($P = .003$). The number of Graded Symptom Checklist symptoms reported was also higher at prepractice ($P = .036$) and postpractice ($P < .001$) when compared with baseline, and at postpractice when compared with prepractice ($P = .003$).

Conclusions: Our results suggest that it is important for wrestlers to be evaluated in a euhydrated state to ensure that dehydration is not influencing the outcome of the clinical measures.

Key Words: balance, mild traumatic brain injury, neurocognitive test, SCAT2

Key Points

- The effects of dehydration and weight-cutting tactics on clinical measures of concussion in wrestlers are not well understood.
- Weight-cutting tactics commonly used by collegiate wrestlers may interfere with the concussion diagnosis decision-making process.
- We recommend evaluating athletes with suspected concussions only after they have been properly rehydrated.

A total of 6000 men participate in collegiate wrestling each year.[1] In 2006–2007, more than 255 000 males and 5000 females participated at the high school level.[2] Due to wrestling's physical nature, injuries in wrestling are common. At the collegiate level, injury rates per 1000 athlete-exposures (AEs) during competition are second only to those in spring season football[3] and wrestling ranks third behind lacrosse and ice hockey for the most concussions sustained during competition.[4] Injuries, particularly concussions, are thought to be more often sustained during a match because of more direct contact with the opponent's head, elbow, and knee during poor takedown attempts.[5] Takedowns are practiced frequently because they yield high point values when performed during competition. However, takedowns account for many injuries in wrestlers (41.9%),[6] and the risk of injury remains prevalent during wrestling practices. Paradoxically, although more injuries occur during matches than practices, the preseason accounts for twice as many injuries as the regular season.[5]

The risks of injury aside, wrestling places significant emphasis on an athlete's weight. Competing in the lowest possible weight class is perceived to give the athlete an advantage over a smaller opponent. This mentality causes wrestlers to practice various weight-cutting techniques, including fluid and food restriction, exercising in excessively warm environments, wearing vapor-impermeable suits under cotton warm-ups, and using laxatives or diuretics. All of these tactics result in dehydration and water weight loss. Recent survey data[7] suggested that high school and collegiate wrestlers lose an average of 4.3% of their body weight on a weekly basis and that 12.1% of National Collegiate Athletic Association Division I collegiate wrestlers cycled their weight by at least 6%. Wrestlers are limited to 1 hour between weigh-in and competition in dual meets. One group[8] noted that rehydration cannot be achieved by hydrating with water alone in the hour between weigh-in and competition in wrestlers who cut 5% or more of their total body weight. Thus, wrestlers employing weight-cutting tactics to meet weight-class requirements are very likely competing in a dehydrated state.

The negative effects of dehydration include decreased mental and psychomotor ability[9]; decreased reaction time, accuracy, and mental endurance; increased problem-solving time[10]; increased subjective feelings of tiredness; and decreased alertness.[11] Fluid-restricting athletes have also experienced increased heart rates and levels of perceived exertion and decreased altered postural control, compared with a fluid-replacement group.[9] More subjective symptoms were reported by dehydrated study participants than by euhydrated participants.[12] These negative effects of dehydration on outcomes typically assessed as part of a concussion management protocol may further complicate the evaluation and management of concussed athletes.

To our knowledge, no authors have studied collegiate wrestlers to understand how objective concussion measures are affected by weight-cutting tactics. As a result, the effects of dehydration and weight-cutting tactics on clinical measures of concussion in wrestling are not well understood. Therefore, the purpose of our study was to investigate the effect of dehydration on outcomes of clinical concussion measures during preseason practices in Division I collegiate wrestlers. We hypothesized that weight-cutting tactics, which often lead to dehydration in wrestlers, would adversely affect their performance on clinical measures of concussion and, thus, have the potential to influence postinjury clinical interpretation of these metrics and confound return-to-participation decision making.

METHODS

Participants

A total of 34 Division I male collegiate wrestlers were originally enrolled in our study. Two participants were removed from this study: 1 sustained a concussion during the study timeframe, and the other was unable to complete all test sessions due to physical illness. Thus, 32 participants completed all test sessions (age = 20.0 $\pm$ 1.4 years; height = 175.0 $\pm$ 7.5 cm; baseline mass = 79.2 $\pm$ 12.6 kg). Of these 32, 6 had been diagnosed with attention-deficit hyperactivity disorder. Preliminary analyses were performed with and without these participants, but the disorder did not appear to have an effect and, therefore, all participants were included in the formal analyses we present in this paper. An a priori power analysis revealed that with the measures we were using, 20 participants would yield a power of 0.80. Because we assessed uninjured athletes, we recruited 32 participants as a more conservative estimate for power.

Instrumentation

Sport Concussion Assessment Tool (SCAT2). The SCAT2 is a concise and relevant sideline clinical concussion evaluation tool that includes a Graded Symptom Checklist (GSC); the Standardized Assessment of Concussion (SAC); and the 3 firm-surface conditions of the Balance Error Scoring System (BESS). The GSC assesses 22 symptoms commonly associated with concussion. A 7-point Likert scale is used to rate each symptom as 0 for *not present*, 1 for *mild*, and 6 being the *most severe*. The GSC is a practical measure for monitoring concussive symptoms.[13,14] The SAC measures mental status by testing orientation, immediate memory, concentration, and delayed recall. Alternate word lists are provided for the immediate memory and delayed recall sections to limit learning effects. The SAC is sensitive to the immediate mental-status deficits of concussion and a reliable, valid clinical measure.[15–17]

We used the full 6-condition version of the BESS; however, only the 3 firm-surfaced conditions are included in the SCAT2. The 6 conditions are the double-legged, single-legged, and tandem stances performed on a firm surface and then repeated on a foam surface. For the single-legged stance conditions, the athlete stands on the *nondominant foot* (defined as the leg opposite the foot the athlete would use to kick a ball for maximal distance). The nondominant foot is positioned behind the dominant foot for the tandem-stance conditions. The The athlete performs each 20-second trial with eyes closed. All firm-surface conditions were conducted as a part of the SCAT2. After the full SCAT2 test battery was completed, the 3 foam-surface stances of the BESS were then performed. All foam balance trials were performed on a medium-density foam surface 41.6 $\times$ 50.8 $\times$ 6.3 cm (Balance Pad; Alcan Airex AG, Sins, Switzerland). Each 20-second trial is scored by counting the number of times the following errors are committed: lifting hands off the iliac crests; opening eyes; taking a step, stumbling, or falling; moving hips into more than 30° of abduction; lifting the forefoot or rearfoot off the surface; and remaining out of test position for more than 5 seconds. The 3 firm and 3 foam surfaces of the BESS have been found to correlate with other laboratory measures of balance.[18–20] The SCAT2 also includes a physical signs section, which assesses if balance problems or unresponsiveness are present, and the Glasgow Coma Scale, which assesses eye, verbal, and motor responses immediately after injury. Upper limb coordination is evaluated through a finger-to-nose touching task.

Simple Reaction Time (SRT). In addition to the SCAT2, we measured simple reaction time by having participants perform the Simple Reaction Time (SRT) module of the Automated Neuropsychological Assessment Metrics (ANAM), a computerized neurocognitive test battery. Participants completed this computer-administered subtest and were asked to click a computer mouse button as quickly as possible in response to a visual stimulus presented on the screen in front of them.[21] The ANAM, and particularly the SRT subtest, are valid and reliable measures.[21,22]

Refractometry. Refractometry is a method used to measure the specific gravity of urine. Refractometers are small, handheld devices that are portable and easy to use, making hydration assessments in athletes more feasible.

The digital refractometer (Misco Products Design, Cleveland, OH) was calibrated by inserting the tip of the refractometer into distilled water, which should cause the refractometer to read 1.000. If it did not read 1.000, the tip of the refractometer was cleaned and recalibrated. For urine collection, participants were provided with sterile plastic specimen cups. They were asked to begin urinating into the toilet and then midway, collect urine in the cups. We inserted the refractometer into the specimen so that the tip was not touching the bottom of the cup. The urine specimen was then disposed of down a drain. After each urine test, the refractometer was cleaned with a damp and soapy cloth and wiped dry, so that no residue remained on the device. Recalibration was performed at the beginning of each testing day. Specific gravity measures via refractometry are reliable and valid measures of hydration status when compared with osmolality and urine color.[23,24] We tested a separate group of urine samples as part of a pilot reliability study. In this pilot study, we assessed the reliability of urine specific gravity measures for samples at several time intervals: immediately after collection, 1 hour postsample, and 6 hours postsample. This was done to evaluate whether the urine specific gravity readings would fluctuate as a result of time delays between collection of the sample and measurement of the sample urine specific gravity during the study. We observed an intraclass correlation coefficient (ICC [3,k]) of 0.9995 (SEM = 0.000691), ensuring very high reliability; therefore, any reading of the urine sample within 6 hours of collection would be consistent with an immediate reading or a reading at any time interval in between.

Procedures

Recruitment. Before recruiting volunteers, the principal investigator (A.F.W.) contacted the coaches and athletic administrators for permission to work with their varsity wrestling program. She spoke with varsity wrestlers to inform them of the study. Our institutional review board approved the study, and those participants meeting our inclusion criteria signed informed consent forms.

Baseline session. To ensure adequate hydration, participants were instructed to consume at least 250 mL of water the morning of the study.[8] They reported to our clinical research center in early September before the start of in-season practices. They wore paper shorts for each weight measurement. All participants were hydrated at the time of baseline testing, and none had to reschedule testing.

Participants reported for testing, provided a urine sample, and were weighed, in no specific order. The counterbalanced testing order consisted of either the SRT followed by the SCAT2 and BESS foam-surfaced stances or the SCAT2 and BESS followed by the SRT. The BESS foam-surfaced stances always immediately followed the SCAT2.

All trials of the SCAT2 and BESS were videotaped, and errors were graded at a later time by the principal investigator. We demonstrated high intratester reliability for evaluating the BESS (ICC [3,1] = 0.95095; SEM = 1.224 errors).

Prepractice Session. Participants were randomly assigned into 2 groups of 16 without replacement. Each group was tested once on consecutive Mondays before wrestling practice. This was done to account for the logistics involved in testing all 32 participants on a single day. Both groups practiced for the same amount of time and performed the same physical workout under the same environmental conditions. Several days before the test sessions, the participants were provided a log sheet to track food and fluid intake and exercise activity leading up to the prepractice assessment, as well as a food measurement guide.

The temperature in the wrestling room was measured at half-hour intervals during practice sessions using a standard ambient air thermometer in order to ensure consistency from 1 group to the next. The same protocol was followed to ensure that environmental and physical exertion factors were the same for all sessions. Before Monday's test session, participants were instructed to treat Sunday evening and Monday as though they were weighing in for a competition to be held on Tuesday. They were instructed to chart any food or fluid intake and exercise activity on the log sheet from 7:00 PM Sunday and leading up to Monday's practice. Participants reported for testing 1 hour before practice.

During Practice Session. We did not restrict athletes from consuming the fluids they felt necessary during their training session, nor did we specify the clothing they wore during practice. Our goal was to simulate a real-world practice session and the habits collegiate wrestlers use to attain their desired competitive weight class.

Postpractice. After practice, participants were not allowed to consume fluids or ingest foods until they had been tested. They were instructed to shower and dry off thoroughly before testing. Weight measurement and urine collection were conducted once the participants had showered. The SCAT2, 3 foam-surfaced BESS conditions, and SRT administration were postponed until 20 minutes after practice to offset the effects of initial fatigue.[25,26] Participants were also administered a weight-cutting tactics sheet on which they were asked to identify all such tactics throughout the study. This form was placed in a sealed envelope along with the food, fluid, and exercise log sheet. A co-investigator briefly reviewed the form to ensure completion, but the data were not shared with anyone outside the immediate research team and were not formally analyzed until all data collection was complete. The principal investigator (A.F.W.) was blinded to this information until data collection ended.

During preseason baseline testing, "flat weight" was determined by each participant's self-reported anticipated competition weight class. This was to give participants a target and goal to help encourage compliance during the study period. To further encourage compliance, they were told to be within 5 lb (2 kg) of flat or competition weight before the next day's practice (Tuesday). Concussion tests were administered only during prepractice and postpractice on Monday and not during the Tuesday weigh-in session.

Data Reduction. For the GSC, the 7-point Likert scale was used to rate each symptom between 0 (*not present*) and 6 (*most severe*). The total number of symptoms out of 22 was recorded. All individual symptom scores were summed into a total symptom severity score, with a maximum possible score of 132. For the SAC, the maximum score for the 4 subsections (orientation, immediate memory,

Table 1. Descriptive Data, Statistical Outcomes, and Effect Sizes Across Time Sessions

	Time, Mean (± SD)					Effect Size		
	Baseline	Prepractice	Postpractice	*F* Value	*P* Value	Pre-practice–Baseline	Post-practice–Baseline	Post-practice–Prepractice
Sport Concussion Assessment Tool 2	93.06(3.88)	90.16(5.01)	87.94(6.39)	13.91	$<$0.001[ab]	0.65	1.00	0.39
Standardized Assessment of Concussion	27.72(1.91)	27.06(1.34)	27.62(2.00)	2.32	0.107	0.41	0.05	0.34
Graded Symptom Checklist severity	1.03(2.91)	5.41(9.78)	12.69(13.80)	16.54	$<$0.001[abc]	0.69	1.40	0.62
Graded Symptom Checklist symptoms	0.44(1.24)	2.44(3.69)	5.03(5.23)	18.24	$<$0.001[abc]	0.81	1.42	0.58
Simple Reaction Time	254.92(18.11)	259.37(22.82)	262.82(22.82)	2.08	0.133	0.22	0.39	0.15
Balance Error Scoring System	15.72(5.09)	18.44(6.44)	18.81(6.68)	5.69	0.005[b]	0.47	0.53	0.06

[a] Difference between prepractice and baseline ($P < .05$).
[b] Difference between postpractice and baseline ($P < .05$).
[c] Difference between postpractice and prepractice ($P < .05$).

concentration, and delayed recall) is 30 points. Higher scores represent better mental status. On the BESS, we recorded the total number of errors. No more than 10 errors can be attributed to any given condition and, thus, the maximum BESS score is 60. Lower scores represent better balance performance. For the SCAT2, 100 points are possible, with lower scores representing inferior performance. The SRT outcome was a throughput score, characterized by the product of response accuracy and response speed. Higher throughput scores indicate better reaction time.

Finally, percentage of body mass change from baseline to prepractice was calculated for each participant using the following equation: ([baseline body mass − prepractice body mass]/baseline body mass × 100). Percentage of body mass change was also calculated for baseline to postpractice and prepractice to postpractice using the same equation. Change in urine specific gravity was also calculated between test sessions. Change between baseline and prepractice urine specific gravity was calculated using the equation: [(baseline urine − prepractice urine)/baseline urine). The same formula was also used to calculate changes between baseline and postpractice, and between prepractice and postpractice.

Data Analysis. Data were analyzed using SPSS statistical software (version 16.0; SPSS Inc, Chicago, IL). An α level of .05 was set a priori for each respective test. We conducted a within-subjects repeated-measures analysis of variance to compare baseline, prepractice, and postpractice total SCAT2 scores, total SAC scores, total BESS scores, total number of symptoms reported, and total symptom severity score. If the omnibus model was significant, Tukey post hoc analyses were calculated to identify any test differences over time.

We acknowledge the potential for an interaction between weight class and our dependent clinical measures. We employed mixed-model analyses of variance with test session as the within-subject effect and weight class (lightweight, middleweight, and heavyweight) as the between-subjects effect. Lightweight wrestlers were those competing in the 125-lb (57-kg), 133-lb (60-kg), or 141-lb (64-kg) weight classes (n = 10). Middleweight wrestlers were those competing in the 149-lb (68-kg), 157-lb (71-kg), and 165-lb (75-kg) weight classes (n = 12). Heavyweight wrestlers were those competing in the 174-lb (79-kg), 184-lb (84-kg), 197-lb (89-kg), and classes (n = 10). Weight class had no effect on any of our dependent measures and, thus, all data were collapsed for the remainder of our analyses.

RESULTS

Wrestlers were evaluated at baseline, before wrestling practice, and after wrestling practice on 5 commonly used clinical concussion measures (SCAT2, SAC, GSC, SRT, and BESS). Descriptive data, statistical outcomes, and effect sizes for our dependent measures of interest are provided in Table 1. Urine specific gravity, weight-change

Table 2. Urine Specific Gravity, Percentage in Weight Changes, and Training Facility Ambient Air Temperatures

Descriptor	Mean(±SD)	Minimum	Maximum
Urine specific gravity			
Baseline	1.006(0.006)	1.000	1.019
Prepractice	1.025(0.008)	1.001	1.035
Postpractice	1.025(0.008)	1.005	1.036
Weight changes, %[a]			
Baseline versus prepractice	2.36(3.67)	−11.44	6.80
Baseline versus postpractice	4.83(3.43)	−7.78	9.92
Prepractice versus postpractice	2.52(0.84)	0.60	4.77
Training facility ambient air temperature, °F [°C]			
Group 1[b]	83.46 [28.60] (1.29 [0.71])	81.0 [27.2]	85.1 [29.5]
Group 2	83.10 [28.40] (0.67 [0.36])	81.8 [27.67]	83.7 [28.72]

[a] Positive percentages represent a drop in weight relative to the first time point.
[b] One-half of the wrestlers (group 1) practiced 1 Monday, and the other half (group 2) practiced the following Monday, as described in our procedures.

Table 3. Frequency of Participation in Weight-Cutting Tactics

Weight-Cutting Tactic	Used Tactic (n)	Did Not Use Tactic (n)
Food restriction	27	5[b]
Fluid restriction	27	5[c]
Hours of excessive exercise[a]	23	9[d]
Sweats	26	6[e]

[a] *Excessive exercise* was operationally defined as any exercise outside of team practice.
[b] Weight class of individuals who did not participate in food restriction (157 lb [71 kg]: 1; 197 lb [89 kg]: 1; heavyweights: 3).
[c] Weight class of individuals who did not participate in fluid restriction (174 lb [79 kg]: 1; 197 lb [89 kg]: 1; heavyweights: 3).
[d] Weight class of individuals who did not participate in excessive exercise (141 lb [64 kg]: 1; 149 lb [68 kg]: 2; 165 lb [75 kg]: 2; 174 lb [79 kg]: 1; 184 lb [84 kg]: 1; 197 lb [89 kg]: 1).
[e] Weight class of individuals who did not participate in wearing sweats (149 lb [68 kg]: 1; 174 lb [79 kg]: 1; 197 lb [89 kg]: 1; heavyweights: 3).

percentages, and mean training facility ambient air temperatures are presented in Table 2. The frequency of weight-cutting tactics used by the wrestlers is shown in Table 3.

We found an effect of time on SCAT2 outcomes ($F_{2,62} = 13.91$, $P < .001$). Scores decreased from baseline (93.06 ± 3.88) to prepractice (90.16 ± 5.01; $P = .002$) and from baseline to postpractice (87.94 ± 6.39; $P < .001$). Similarly, an effect of time on BESS total error scores was observed ($F_{2,62} = 5.69$, $P = .005$), such that the total number of errors increased from baseline (15.72 ± 5.09 errors) to postpractice (18.81 ± 6.68 errors; $P = .015$). No effects of time on the SAC total score or SRT throughput scores were noted ($P > .05$).

Time affected total symptom severity score ($F_{2,62} = 16.542$, $P < .001$). Total symptom severity scores increased from baseline (1.03 ± 2.91) to prepractice (5.41 ± 9.78; $P = .011$) and from baseline to postpractice (12.69 ± 13.80; $P < .001$). We also observed that total symptom severity scores were greater postpractice than at prepractice ($P = .003$). Similarly, a time effect was seen for the number of symptoms reported ($F_{2,62} = 18.24$, $P < .001$). Wrestlers in our sample reported a greater number of individual symptoms during the prepractice session (2.44 ± 3.69 symptoms) than at baseline (0.44 ± 1.24 symptoms; $P = .036$) and during the postpractice than at baseline (5.03 ± 5.23; $P < .001$). Furthermore, wrestlers demonstrated a greater number of symptoms at postpractice compared with prepractice ($P = .003$).

DISCUSSION

To our knowledge, only 1 group[12] has investigated how dehydration affected performance on objective concussion tests. We are the first to study the effects of wrestling weight-cutting tactics on similar measures. We found that wrestlers should be tested in a fully hydrated (euhydrated) state to ensure that weight-cutting tactics do not negatively influence the clinical measures. These findings further suggest that after injury, in the absence of obvious neurologic deterioration, adequate time should be allowed for the athlete to rehydrate and discontinue practice of weight-cutting tactics. Clinicians will then be able to differentiate between changes in scores due to injury versus weight-cutting tactics.

Balance Error Scoring System

We supplemented the BESS portion of the SCAT2 by incorporating the foam-surface conditions. The BESS total error score is sensitive to concussive injury and represents a reliable and valid clinical measure.[19,27,28] We observed a difference only between baseline and postpractice scores but not between baseline and prepractice measures or between prepractice and postpractice measures. Thus, dehydration alone, without an accompanying practice, did not change balance performance. However, our data do suggest that combined weight-cutting tactics and participation in sport-specific practice did affect BESS performance. Clinically, these differences between baseline and postpractice mimic a possible dual competition in which a wrestler cuts weight to compete and then sustains a potential concussion during the match. Thus, clinicians need to be mindful of potential influences that weight-cutting tactics may have on clinical measures commonly used to evaluate concussion. Although we support a conservative approach to managing concussion, we acknowledge that deficits on clinical measures of concussion may not always reflect a concussion. However, until a concussion diagnosis can be adequately ruled out, we support removing an athlete who is suspected of suffering from head trauma from competition. Based on previous work, we waited for 20 minutes after practice ended before administering the BESS.[25,26] In another study,[12] fluid restriction and an active dehydration task did not affect BESS performance.

Some explanations for the differences between studies can be offered. Patel et al studied 24 healthy and physically active males who became dehydrated through restriction of fluids and foods high in fluid content for 15 hours before a 45-minute bicycle ergometer exercise task. In contrast, we assessed 32 Division I collegiate wrestlers who practiced 2 to 3 hours per day for as many as 6 days per week. Our participants also completed a practice that was more closely related to actual training than to a bicycle exercise task. They could also have been practicing weight-cutting tactics for up to 36 hours. The mean percentage change in body mass between baseline and postpractice was close to 5%, whereas individuals in the Patel et al[12] study experienced body mass changes only between 1.71% and 4.15%.

GSC Severity Score and Total Number of Symptoms Reported

Total symptom severity score and total number of symptoms reported differed across all 3 evaluation points (baseline, prepractice, and postpractice). Thus, weight-cutting tactics strongly affected symptom severity reporting, and symptom severity was further intensified by practice. Similar to other authors who have used a GSC, we observed high standard deviations. This finding supports the inclusion of a baseline symptom inventory. Our work agrees with Patel et al,[12] who demonstrated a higher total symptom severity score and total number of symptoms reported after dehydration than in a euhydrated state. Participants also reported higher ratings for balance difficulties, dizziness, feeling slowed down, and feeling in a fog after the dehydrated condition. Participants dehydrated by a factor of 1% to 3% of their body mass reported headache, tiredness, and difficulty concentrating.[29] We did not analyze the severity of each symptom individually in the GSC.

Standardized Assessment of Concussion and Simple Reaction Time

Weight-cutting tactics did not appear to influence the mental status or simple reaction time of Division I collegiate wrestlers. Clinically, any deficits postinjury compared with baseline on these measures are likely due to injury and not to weight-cutting practices employed by collegiate wrestlers. Patel et al[12] also did not identify differences in SAC or SRT after dehydration compared with a euhydrated state.[12] However, visual memory and sleep are known to be impaired in dehydrated individuals versus those who are euhydrated.[12] We did not use other modules of the ANAM battery because the SRT detects deterioration in injured participants between baseline and the first testing interval, whereas no difference was seen in other subtests.[21]

Wrestling research[30] has previously identified impairments in cognitive function after rapid weight loss in the digit span and story recall tests. However, Choma et al[30] did not find this to be true for the Letter Cancellation, Digit Symbol, and Trail Making A and B tests. Interestingly, when the participants were rehydrated, their performance approached baseline measures; therefore, adequate rehydration may be necessary to accurately interpret the clinical outcome of these measures before rendering an informed concussion diagnosis.

Sport Concussion Assessment Tool 2

The SCAT2 is a relatively new clinical concussion tool developed after the Third International Conference on Concussion in Sport.[31] To date, no authors have looked at how dehydration may affect the outcomes measured on the SCAT2. Further, because athletes participating in all sports may experience dehydration, the implications of this study may extend to other sports. Although the SCAT2 encompasses several common clinical measures of concussion (eg, SAC, symptom inventory, BESS), our data demonstrate that differences in SCAT2 total score were driven by the total number of symptoms reported across time sessions. We acknowledge that we were selective in analyzing only those individual components of the SCAT2 that have traditionally been used as independent clinical tools, such as the SAC, GSC, and BESS. Other components were not relevant to analyze in the context of our uninjured sample. For example, all participants received the highest possible point values for the Glasgow Coma Scale, Physical Signs, and Coordination Examination. In light of these subcomponent findings, we submit that the SCAT2 total score differences we observed were driven in large part by the total number of symptoms reported at each time point.

Weight-Cutting Tactics

Our participants practiced weight-cutting tactics commonly used by collegiate wrestlers. The National Collegiate Athletics Association allows tactics such as restricting food and fluid, exercising excessively, and wearing sweat suits. Although our participants filled out a questionnaire identifying which weight-cutting tactics they practiced, there is always the possibility that they used saunas or vapor-impermeable clothing (both banned) but did not tell us. Our findings also show that weight class did not appear to affect clinical concussion measures. This means that no 1 weight-class grouping (lightweight, middleweight, or heavyweight) influenced outcome measures more than any other weight class. Performing a study with an equal number of participants per weight class may be helpful to further investigate how weight-cutting tactics affect concussion-assessment tools. It may be also fortuitous to explore the long-term effects of weight-cutting tactics on athlete performance (eg, across an entire competitive season or competitive career).

We focused on Division I collegiate wrestlers, but many wrestlers begin practicing weight-cutting tactics at the high school level. In contrast to the 10 weight classes at the collegiate level, high school scholastic wrestling has 14 weight classes. An overall concussion rate of 0.18 per 1000 AEs has been reported at the high school level.[6,32] This rate is lower than the overall collegiate level concussion rate of 0.42 per 1000 AEs yet is still higher than volleyball, boys' basketball, baseball, and softball high school rates.[32] It is also important to note that high school wrestlers practice extreme weight-cutting tactics, too. In 1 study,[33] 33% of participants competed during the season at less than their *minimum wrestling weight*, which was defined as a body fat measurement of 5% or less.[33] Our findings cannot be generalized to the high school population, and further research in the high school setting might provide more insight into the effects of weight-cutting tactics on concussion measures in this younger population.

Limitations

Due to logistical considerations, we could not perform the study on actual competition days; however, we were able to successfully simulate the weight-cutting tactics that would be practiced leading up to a competition. Participants weighed in on Tuesday, even though no data were collected, and had to be within 5 lb (2 kg) of flat weight. This procedure was followed to give the participants a goal and reinforce compliance. Retrospectively, we realize that it might have been beneficial to perform the entire study test battery on Tuesday to provide a comparison of time points once participants achieved their target weights. Future authors, therefore, should study the lasting effects of weight-cutting tactics in collegiate wrestlers. Also, we did not fully control what the participants ate or drank, which could have led to some variability in our results. This may be a perceived limitation, but we feel that, by allowing the athletes freedom in this regard, we were better able to realistically capture the effects of individualized weight-cutting tactics used by our sample and, thus, provide stronger external validity of our data. We did not ask athletes to identify on the restriction logs the volume or quantity of foods and fluids they consumed. As a result, we were unable to compute the specific effects of protein-, carbohydrate-, and fat-restricted diets on our outcome measures. In addition, we did not collect or analyze participants' previous history of concussion. This factor would have been interesting to analyze, yet our study was a within-subject design; therefore, this factor likely would not have affected our findings. We did not assess relative humidity and acknowledge this would have enhanced our monitoring of the training area's environmental consistency across practice sessions. Finally, specific gravity was used to assess hydration status because it is a cost-effective clinical tool commonly used in wrestling. However, we acknowledge that plasma osmolality tracks changes in hydration status more accurately than urine specific gravity and urine osmolality.[24,34] Notwithstanding these limitations, we believe that our study yields valuable clinical implications regarding weight-cutting tactics in collegiate wrestlers on clinical concussion measures.

Conclusions

The results of clinical concussion tests conducted on wrestlers who are cutting weight may be difficult to interpret. In the absence of an obvious deteriorating condition warranting prompt emergency medical care, we recommend evaluating athletes with a suspected concussion only after they have been properly rehydrated. Wrestling is still a unique sport for clinicians in that injury time during matches at the college level is only 1 minute and 30 seconds. In this scenario, the clinician is less likely to rely on objective measures of concussion and instead focuses on the observable signs and reported symptoms. Our findings indicate that the wrestler who has practiced weight-cutting tactics and is dehydrated will have a greater number of symptoms endorsed and greater symptom severity, even in the absence of injury. As a result, we submit that clinicians should pursue the conservative management of suspected concussions. The important clinical consideration is the concussion, but we provide evidence that weight-cutting tactics commonly used by collegiate wrestlers may interfere with this decision-making process.

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