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*Original Research*

# Nutrient Intake, Performance, and Body Composition of Preseason Wrestlers

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ABSTRACT

***International Journal of Exercise Science 17(2): 517-530, 2024.*** College athletes, especially in weight class sports, often experience energy deficits. Athletes competing in weight class sports such as wrestling are at greatest risk for deficiencies and little is known about the relationships between body composition, nutrient intake, and performance in these athletes. The purposes of this study were to (1) quantify macronutrient and micronutrient intake of pre-season male collegiate wrestlers and compare to estimated needs, and (2) examine relationships among nutritional intakes, body composition, and performance measurements of strength and anaerobic capacity. Male Division I wrestlers ($n$ = 11, age: 21.3 ± 1.7 years, wrestling experience: 14.9 ± 2.5 years) were recruited during pre-season. Nutrient intake was collected from a 3-day food diary. A 7-site skinfold assessment determined fat-free mass (FFM) to estimate total daily energy expenditure (eTEE). Isokinetic and isometric strength were evaluated by a Biodex dynamometer. Anaerobic capacity was tested on a stationary cycle ergometer. Eight of eleven wrestlers were energy deficient based on estimated needs. Mean intake of four micronutrients fell below the Recommended Dietary Allowances (RDA). Significant correlations were found between dietary intake, strength and anaerobic performance variables ($r$ = 0.603 – 0.902, $p$ = 0.0001 – 0.05). However, after accounting for FFM, these relationships were no longer significant. Nutrient intake in tandem with body composition affects performance for weight class athletes. Achieving high FFM during the preseason may be advantageous for wrestling performance. Nutrient intake and body composition should be monitored so coaches and health professionals can create individualized recommendations to help athletes optimize performance.

KEY WORDS: Athletic performance, diet quality, macronutrients, nutrient adequacy, sports nutrition

## INTRODUCTION

Many collegiate and elite athletes are found to have a negative energy balance (37, 41). Athletes' failure to meet nutritional needs may be due to lack of knowledge regarding their energy needs and intake levels. Jagim et al., reported that NCAA Division III athletes significantly underestimate daily energy, carbohydrate, and fat needs ($p \leq 0.01$) (19). Among Division I athletes, diet quality is particularly low during the off-season, when nutritional support is not available, with the lowest diet quality found in wrestlers who have a high intake of convenience foods containing high fat and sodium (20). In addition, previous studies report low vitamin D status in wrestlers (2, 13), as well as insufficient biotin (34.9% of RDA), zinc (79% of RDA), and iodine (13.85% of RDA) intake (13). These findings indicate that wrestlers may be at risk for energy, macronutrient, and micronutrient deficiencies. Determining wrestlers' nutritional intake and how it relates to body composition and performance during the preseason may help identify the prevalence of poor dietary patterns and may create solutions for this population to improve their body composition and performance during the competition season.

A major nutritional concern with wrestling is that it is a weight class sport, meaning many athletes engage in rapid weight loss (RWL) behaviors prior to a competition. While the exact methods of RWL vary depending on the athlete, the most common behaviors include dieting, increased exercise, and dehydration (32). Techniques for RWL have been reported to result in physiological symptoms such as lack of urine and tears, fatigue, and confusion, as well as influencing mood of wrestlers and taekwondo athletes (8). It is not well known how dietary-based RWL techniques affect performance, although previous research has indicated that RWL can potentially be achieved in a non-harmful way (21, 29). However, a baseline for wrestlers' intake, at a time not influenced by RWL, such as the preseason, must be established before recommendations for RWL can be made.

Another gap in the literature is associating nutrient intake with physiological performance of wrestlers, despite the importance of nutrition to this weight class sport. Several early studies in wrestlers examined anaerobic and aerobic capacity (6, 15, 16, 31, 39), as well as strength (6, 25), and flexibility (6), to provide a physiological profile that may be useful to evaluate wrestling performance. While these studies provide a foundation for expectations of wrestling performance, few studies have compared body composition and performance variables, despite evidence that body composition influences performance measurements in wrestlers (39). Many athletes, including wrestlers, may wish to lower their total body mass, while preserving fat-free mass (FFM) to optimize their body composition for performance. This highlights the need to examine relationships between body composition and performance measurements at different phases of the season and determine how nutrition may be related to these markers. Optimizing body composition and performance during the preseason may establish an ideal baseline for competition season.

Many athletes choose to use the pre-season to adjust their nutritional intake and lose weight to be closer to their chosen weight class. If done optimally, this can set athletes up for a successful competition season; however, without nutritional guidance, it is likely that nutritional requirements for competition season, body composition, and performance goals are not being met. In order to provide recommendations to best fit the physiological demands of the sport of wrestling, more research on the nutrient intake of these athletes is needed. Determining how nutrient intake is related to performance and body composition measurements is a necessary step to understand how diet can be utilized to impact performance and body composition based on the needs of the sport. Therefore, the aims of this study are to (1) quantify macronutrient and micronutrient intake of pre-season male collegiate wrestlers and compare to estimated needs, and (2) examine relationships among nutritional intakes, body composition, and performance measurements of strength and anaerobic capacity. We hypothesize that overall, collegiate wrestlers will not meet recommendations for macronutrient distribution and micronutrient intake but will have adequate energy intake. Additionally, we hypothesize that there will be positive relationships between nutritional intake and measurements of body composition and performance.

## METHODS

*Participants*

A power analysis conducted with G*POWER 3.1 (Universität Kiel, Germany) for correlation analyses determined that 7 participants were needed in the present study for a correlation of 0.87, power of 0.80, and α = 0.05 (24). Division I collegiate wrestlers ($n$ = 11) from a top fifteen team participated in this study (age = 21.3 ± 1.7 years, height = 174.9 ± 8.5 cm, weight = 82.1 ± 18.2 kg, wrestling experience = 14.9 ± 2.5 years). The participants included at least one athlete competing in every weight class with the exception of the 157 pound class. Participants were at the end of their pre-season training cycle. This team focuses on resistance training and aerobic exercise, with a training schedule of 6 days per week for approximately 2 hours per day. Participants are not expected to have been engaging in RWL, as this practice is typically only done in the week prior to a competition. All participants signed a written informed consent and completed a physical activity readiness questionnaire (PAR-Q) (40) and questionnaire over health history, wrestling experience, and current eating and training habits prior to data collection. This study was approved by the university Institutional Review Board (approval #2209012-EXP,). This research was carried out fully in accordance to the ethical standards of the International Journal of Exercise Science (28).

*Protocol*

This was a cross-sectional study analyzing the nutrient intake, body composition, and performance values, including strength, and anaerobic measures of collegiate wrestlers. Two visits were conducted during the wrestlers' pre-season (late September- early October) within a 7-day time period. Body composition data was gathered from skinfold thickness. An isokinetic dynamometer was used to evaluate hamstring and quadricep muscle strength. Anaerobic capacity was tested on a stationary cycle ergometer. Additional data about each participant's medical history and current training habits were collected from a health status questionnaire.

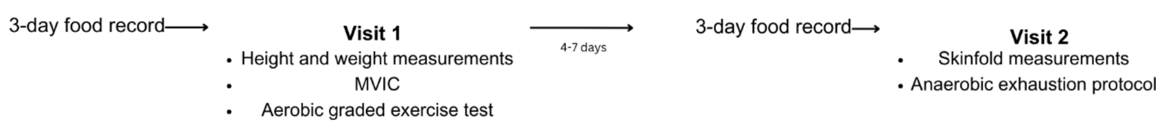


**Figure 1.** Study Design. Food records were completed on the three days immediately preceding each visit. MVIC, maximal voluntary isometric contraction.

A 3-day food record collected information on nutrient intake prior to each test visit. Participants were asked to record everything consumed on the three days leading up to each test visit. The research team, which included a Registered Dietitian, instructed participants on the proper way

to complete the food record and reviewed the record with participants for accuracy upon collection. Data were entered into the PeopleOneHealth food tracker (45) and Cronometer food diary (43) to analyze macronutrient and micronutrient composition.
During the first visit, height and body mass were collected using a standing stadiometer, and digital scale (Seca gmbh & Co.kg Hamburg, Germany), respectively. Isometric torque of participants' right leg was measured using a Biodex System 4 Quick-Set isokinetic dynamometer (Biodex Medical Systems, Inc., Shirley, NY). Participants were seated with pelvis, trunk, and contralateral thigh restrained. The lateral condyle of the femur was aligned with the axis of rotation of the leg extension device. During the first visit, maximum voluntary isometric contractions (MVIC) of the hamstring and quadriceps were taken. Isometric tests were performed with a flexion angle of 60º below the horizontal plane. Each participant completed two warmup leg extension and leg flexion muscle actions at approximately 50% and 75% of perceived effort and one practice attempt of leg extension and flexion MVICs. Each participant then completed two, 4-second leg extension and flexion MVICs in which participants were instructed to push or pull against the lever arm as hard as possible for extension and flexion, respectively. Peak torque was then recorded.

After approximately 5 minutes of rest, participants completed a graded exercise test on an electronically braked, calibrated cycle ergometer (Velotron, Sram LLC, Chicago, IL). The testing protocol began at 100 W and increased every minute by 25 W until participants reached volitional exhaustion, defined by a pedal cadence below 70 RPMs. This was conducted to determine maximal power in order to calculate the appropriate resistance for each participant to perform a high-intensity anaerobic test on the second visit. Based on the maximal power achieved ($W_{max}$), 80%, 95%, and 110% was calculated for each participant. This protocol was identified to be a reliable method of determining high-intensity cycling capacity (35).

During the second visit, body composition was obtained using skinfold measurements taken with a Lange caliper (Model 68902, Cambridge Scientific Industries, Inc, Cambridge, MD) on the right side of the body, utilizing male 7-site skinfolds of the chest, midaxillary, triceps, subscapular, abdomen, suprailiac, and thigh. Each skinfold measurement was taken twice at each site and a third measurement was taken if the difference exceeded 2 mm. The average of two measurements within 2 mm was recorded. Recorded measurements were used to calculate body density (18) and estimate fat mass (FM) (kg), FFM (kg), and body fat % (BF%) (3). FFM estimates were then used to estimate resting metabolic rate (eRMR, kcals) using the Cunningham Equation (11).

$$Resting\ metabolic\ rate = 500 + 22(FFM)$$

The eRMR was then multiplied by an activity factor of 1.8 to calculate estimated total daily energy expenditure (eTEE).

After approximately 10 minutes of rest, participants performed the anaerobic exhaustion protocol on a calibrated cycle ergometer. This consisted of a five-minute warmup at 100 W, followed by five minutes of rest. The seat was adjusted so that each participants' legs were nearly fully extended on each revolution, and toe clips were used to maintain pedal contact throughout the test. The test effort was then incremented with the first 15 seconds being at 80 % $W_{max}$, the next 15 seconds being 95% $W_{max}$, then increasing to 110% $W_{max}$ until volitional exhaustion was reached. Participants were instructed to pedal at a self-selected, constant pace. When participant's pace dropped by 20 RPMs, volitional exhaustion was reached, and participants were instructed to stop pedaling. The time to exhaustion (TTE, s) and total work done (TWD, kJ) were the recorded measures for each participant (35).

*Statistical Analysis*

Means and standard deviations (SD) for body composition, performance measurements, and macronutrient and micronutrient intakes, were calculated in a spreadsheet software program (Microsoft Excel 2022, version 2208). A Pearson product moment correlation analysis was performed among macronutrient and micronutrient intakes from the second dietary record, body composition variables, peak torque, TWD, and TTE. For significant collinear relationships among dietary intakes, body composition, and performance measurements, first-order partial correlations ($r_{xyz}$) were calculated to partial out collinear influences. Reliability statistics were performed for the two dietary records. All statistical analyses were performed using IBM SPSS Statistics for Macintosh, Version 28 (IBM Corp., Chicago, IL, USA.). Statistically significant data is defined as all correlations and comparisons with an alpha of $p \leq 0.05$. A correlation coefficient of 0.9 to 1.0 (-0.9 to -1.0) denotes very high positive (negative) correlation, correlation coefficient of 0.7 to 0.9 (-0.7 to -0.9) denotes high positive (negative) correlation, 0.5 to 0.7 (-0.5 to -0.7) denotes moderate positive (negative) correlation, 0.3 to 0.5 (-0.3 to -0.5) denotes low positive (negative) correlation, and 0.0 to 0.3 (0.0 to -0.3) denotes negligible positive (negative) correlation (27).

## RESULTS

Table 1 reports means ± SD for the body composition variables (height, body mass, BMI, FFM, FM, BF%, eRMR, and eTEE), and performance measurements (Extension Peak Torque, Flexion Peak Torque, $W_{max}$, TTE, and TWD).

Table 2 reports the means ± SD for energy and macronutrient intakes while Table 3 reports intake of select vitamins and minerals pertinent to athletic performance. Intraclass correlation coefficients (ICCs), standard error of the measurement (SEM), coefficients of variation (CVs), and minimum detectable changes (MDCs) between means of dietary intakes of the two separate 3-day dietary records are reported in Tables 2 and 3. There were no significant differences between the mean values from Record 1 and Record 2 ($p$ = 0.110 – 0.793). For energy and macronutrients, ICCs and CVs ranged from 0.668 – 0.871 and 19.45% - 27.45%, respectively. For micronutrients, ICCs and CVs ranged from -0.006 – 0.998 and 10.86% - 102.39%, respectively (Table 3). Table 4 reports the mean ± SD energy and macronutrient intake relative to body mass ($g \cdot kg^{-1}$), compared to general recommendations for athletes undergoing similar training (38).

**Table 1.** Body composition and performance variables for male collegiate wrestlers (*n* = 11).

| Body Composition/ Performance Measurements | Mean ± SD |
|---|---|
| Height (cm) | 174.9 ± 8.5 |
| Body Mass (kg) | 82.1 ± 18.7 |
| Body Mass Index | 26.5 ± 3.4 |
| Fat-Free Mass (kg) | 73.9 ± 11.9 |
| Fat Mass (kg) | 8.1 ± 7.6 |
| Body Fat % | 8.8 ± 5.7 |
| eRMR (kcal) | 2,127 ± 262 |
| eTEE (kcal) | 3,828 ± 471 |
| Extension Peak Torque ($Nm \cdot kg^{-1}$) | 2.8 ± 0.4 |
| Flexion Peak Torque ($Nm \cdot kg^{-1}$) | 1.6 ± 0.2 |
| Power Max (W) | 318.2 ± 38.9 |
| Time to Exhaustion (s) | 107.6 ± 47.4 |
| Total Work Done (KJ) | 158.9 ± 74.0 |

Data are presented as means ± standard deviations (SD).

**Table 2.** Energy and macronutrient intakes of male collegiate wrestlers (*n* = 11). Records 1 and 2 were separated by 4-7 days for each participant.

| | Record 1 | Record 2 | *p* - value | $ICC_{2,1}$ | SEM | CV (%) | MDC |
|---|---|---|---|---|---|---|---|
| Energy Intake (kcal) | 2,911 ± 1,185 | 2,601 ± 1,332 | 0.239 | 0.780 | 579.2 | 21.0 | 1605.6 |
| Carbohydrate (g) | 282 ± 81 | 257 ± 160 | 0.461 | 0.668 | 74.1 | 27.5 | 205.3 |
| Protein (g) | 172 ± 89 | 149 ± 87 | 0.110 | 0.871 | 31.2 | 19.5 | 86.5 |
| Fat (g) | 122 ± 122 | 105 ± 57 | 0.191 | 0.733 | 28.5 | 25.0 | 78.9 |

Data are presented as means ± standard deviations (SD).

**Table 3**. Vitamin and mineral intakes of male collegiate wrestlers (*n* = 11). Mean values were compared to the Recommended Daily Allowance (44). Records 1 and 2 were separated by 4-7 days for each participant.

| | Record 1 | % RDA | Record 2 | % RDA | *p* - value | $ICC_{2,1}$ | SEM | CV (%) | MDC |
|---|---|---|---|---|---|---|---|---|---|
| Vitamin A (mcg) | 612.4 ± 826.3 | 68 | 860.5 ± 843.5 | 96 | 0.458 | 0.190 | 754.1 | 102.4 | 2,090.1 |
| Thiamin (mg) | 1.6 ± 0.7 | 137 | 1.5 ± 1.0 | 127 | 0.739 | 0.130 | 0.8 | 50.8 | 2.2 |
| Riboflavin (mg) | 2.5 ± 1.2 | 195 | 2.3 ± 0.9 | 179 | 0.593 | 0.355 | 0.9 | 35.8 | 2.4 |
| Niacin (mg) | 47.2 ± 41.4 | 295 | 34.0 ± 12.4 | 212 | 0.335 | -0.006 | 30.6 | 75.5 | 84.9 |
| Vitamin B6 (mg) | 4.1 ± 4.5 | 314 | 3.1 ± 1.7 | 235 | 0.483 | 0.023 | 3.3 | 93.6 | 9.3 |
| Folate (mcg) | 387.0 ± 209.8 | 97 | 416.2 ± 194.5 | 104 | 0.692 | 0.325 | 168.3 | 41.9 | 466.4 |
| Vitamin B12 (mcg) | 20.8 ± 28.0 | 867 | 11.2 ± 13.8 | 467 | 0.252 | 0.288 | 18.5 | 115.5 | 51.2 |
| Vitamin D (IU) | 1,148.8 ± 3007.1 | 191 | 1,220.4 ± 3013.1 | 203 | 0.221 | 0.998 | 128.7 | 10.9 | 356.7 |
| Vitamin E (mg) | 12.4 ± 8.3 | 83 | 11.0 ± 5.5 | 74 | 0.521 | 0.516 | 5.0 | 42.2 | 13.7 |
| Calcium (mg) | 1,281.4 ± 1,209.6 | 128 | 1,349.5 ± 1,189.9 | 135 | 0.699 | 0.896 | 402 | 30.5 | 1,113.1 |
| Iron (mg) | 20.1 ± 9.7 | 251 | 17.4 ± 10.1 | 217 | 0.301 | 0.638 | 5.9 | 31.6 | 16.4 |
| Phosphorus (mg) | 1,701.6 ± 964.0 | 213 | 1,710.2 ± 855.5 | 214 | 0.966 | 0.767 | 455.7 | 26.7 | 1,263.2 |
| Potassium (mg) | 3,476.6 ± 2,084.5 | 102 | 3,352.6 ± 1,361.5 | 99 | 0.809 | 0.578 | 1,172.7 | 34.3 | 3,250.5 |
| Sodium (mg) | 3,616.3 ± 1098.4 | 151 | 3,593.8 ± 2,206.0 | 150 | 0.968 | 0.469 | 1297.7 | 35.0 | 3,597.0 |

Data are presented as means ± Standard deviations (SD).

**Table 4.** Energy and macronutrient intake relative to body mass of male collegiate wrestlers ($n$ = 11). Mean values are compared to general recommendations for athletes (38).

| | Record 1 | Record 2 | Recommendation [a] |
|---|---|---|---|
| Energy Intake (kcal $\cdot$kg$^{-1}$) | 34.5 ± 8.5 | 30.3 ± 11.1 | 40-45 |
| Carbohydrate (g $\cdot$kg$^{-1}$) | 3.4 ± 0.6 | 3.0 ± 1.6 | 6.0-10.0 |
| Protein (g $\cdot$kg$^{-1}$) | 2.0 ± 1.0 | 1.7 ± 0.8 | 2.0-2.5 |
| Fat (g $\cdot$kg$^{-1}$) | 1.5 ± 0.7 | 1.2 ± 0.5 | 0.5-1.0 |

Data are presented as means ± Standard deviations (SD); [a] Recommendations based on guidelines set by Thomas et al. (38).

A total of eight out of eleven participants (73%) had an energy intake below their eTEE, eight participants (73%) did not meet recommended carbohydrate intake, four out of eleven participants (36%) did not meet recommended fat intake, and eight participants did not meet recommended protein intake. Intakes for vitamin A, vitamin E, vitamin D, and potassium were below the RDA in at least five out of eleven wrestlers (45%). Calcium intake was below the recommended value for athletes in a caloric deficit (38) for nine out of eleven participants (82%) and was below the RDA for 4 out of 11 participants (36%).

Table 5 reports correlations for body composition, nutrient intake, and performance. In general, body composition variables show positive high to very high intercorrelations ($p < 0.0001 – 0.002$). Energy, macronutrient, and mineral intake were also intercorrelated with positive moderate to very high intercorrelation ($p < 0.0001 – 0.044$); however, vitamin intakes in general were not intercorrelated with other dietary intakes ($p \geq 0.05$). Performance variables show positive moderate to high intercorrelations ($p = 0.0002 – 0.041$). In general, macronutrient intake and body composition variables demonstrated positive moderate to very high correlation ($p < 0.000 – 0.050$). Mineral intake and body composition similarly demonstrated positive moderate to high correlation ($p = 0.0004 – 0.042$). Conversely, vitamin intake and body composition variables show no significant correlations ($p > 0.05$), with the exception of a negative correlation between vitamin A intake and age ($p = 0.036$). Body composition demonstrated moderate to high positive correlations with specific performance variables ($p = 0.0002 – 0.033$). In general, moderate to high correlations were observed between nutrient intakes and performance variables ($p = 0.0003 – 0.049$), with a negative correlation between vitamin A intake and extension peak torque (PT) normalized for body weight ($p = 0.013$).

For the significant relationships between nutrient intake and athletic performance, partial correlations were calculated to remove the influence of concurrently related body composition variables. No correlations remained significant after partialing out FFM and eRMR ($p > 0.05$). Only the correlation between fat intake and total work remained significant when weight was partialed out ($|r_{\text{Fat,Total Work.weight}}| = 0.640$, $p = 0.046$). Four correlations remained significant when height was partialed out: carbohydrate intake and total work ($|r_{\text{Carbohydrate Intake,Total Work.Height}}| = 0.734$, $p = 0.16$), energy intake and total work ($|r_{\text{Energy Intake,Total Work.Height}}| = 0.693$, $p = 0.026$), fat intake and total work ($|r_{\text{Fat Intake,Total Work.Height}}| = 0.729$, $p = 0.017$), and iron intake and extension PT ($|r_{\text{Iron Intake,EXT\_PT.Height}}| = 0.692$, $p = 0.027$).

**Table 5.** Correlations between nutrient intake, body composition, and performance.

| | Fat Free Mass | Estimated TEE | Estimated RMR | Energy | Carbohydrate | Protein | Fat | Calcium | Iron | Postassium | Sodium | Extension Peak Torque | Flexion Peak Torque | Max Power | Total Work |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Fat Free Mass | 1.00 | 1.00 | 1.00 | 0.89 | 0.72 | 0.65 | 0.89 | 0.71 | 0.69 | 0.83 | 0.87 | 0.81 | 0.87 | 0.68 | 0.86 |
| Estimated TEE | 1.00 | 1.00 | 1.00 | 0.89 | 0.72 | 0.65 | 0.89 | 0.71 | 0.69 | 0.83 | 0.87 | 0.81 | 0.87 | 0.68 | 0.86 |
| Estimated RMR | 1.00 | 1.00 | 1.00 | 0.89 | 0.72 | 0.65 | 0.89 | 0.71 | 0.69 | 0.83 | 0.87 | 0.81 | 0.87 | 0.68 | 0.86 |
| Energy | 0.89 | 0.89 | 0.89 | 1.00 | 0.91 | 0.70 | 0.97 | 0.80 | 0.86 | 0.87 | 0.95 | 0.84 | 0.81 | 0.68 | 0.88 |
| Carbohydrate | 0.72 | 0.72 | 0.72 | 0.91 | 1.00 | 0.41 | 0.89 | 0.61 | 0.72 | 0.63 | 0.93 | 0.73 | 0.76 | 0.58 | 0.82 |
| Protein | 0.65 | 0.65 | 0.65 | 0.70 | 0.41 | 1.00 | 0.58 | 0.92 | 0.88 | 0.82 | 0.53 | 0.65 | 0.49 | 0.44 | 0.49 |
| Fat | 0.89 | 0.89 | 0.89 | 0.97 | 0.89 | 0.58 | 1.00 | 0.65 | 0.75 | 0.87 | 0.95 | 0.76 | 0.80 | 0.75 | 0.90 |
| Calcium | 0.71 | 0.71 | 0.71 | 0.80 | 0.61 | 0.92 | 0.65 | 1.00 | 0.90 | 0.74 | 0.63 | 0.76 | 0.66 | 0.43 | 0.67 |
| Iron | 0.69 | 0.69 | 0.69 | 0.86 | 0.72 | 0.88 | 0.75 | 0.90 | 1.00 | 0.83 | 0.77 | 0.74 | 0.64 | 0.55 | 0.63 |
| Postassium | 0.83 | 0.83 | 0.83 | 0.87 | 0.63 | 0.82 | 0.87 | 0.74 | 0.83 | 1.00 | 0.78 | 0.70 | 0.65 | 0.65 | 0.74 |
| Sodium | 0.87 | 0.87 | 0.87 | 0.95 | 0.93 | 0.53 | 0.95 | 0.63 | 0.77 | 0.78 | 1.00 | 0.74 | 0.83 | 0.70 | 0.82 |
| Extension Peak Torque | 0.81 | 0.81 | 0.81 | 0.84 | 0.73 | 0.65 | 0.76 | 0.76 | 0.74 | 0.70 | 0.74 | 1.00 | 0.74 | 0.68 | 0.76 |
| Flexion Peak Torque | 0.87 | 0.87 | 0.87 | 0.81 | 0.76 | 0.49 | 0.80 | 0.66 | 0.64 | 0.65 | 0.83 | 0.74 | 1.00 | 0.42 | 0.88 |
| Max Power | 0.68 | 0.68 | 0.68 | 0.68 | 0.58 | 0.44 | 0.75 | 0.43 | 0.55 | 0.65 | 0.70 | 0.68 | 0.42 | 1.00 | 0.56 |
| Total Work | 0.86 | 0.86 | 0.86 | 0.88 | 0.82 | 0.49 | 0.90 | 0.67 | 0.63 | 0.74 | 0.82 | 0.76 | 0.88 | 0.56 | 1.00 |

## DISCUSSION

This study presents a nutritional and physiological profile of NCAA Division I male wrestlers. Additionally, this is the first study to our knowledge to perform a dietary analysis of Division I wrestlers. The mean energy intake was 2,601 kcal, with eight out of eleven participants not meeting eTEE (12). Additionally, all participants failed to meet general recommendations for at least one macronutrient (38). These findings partially conflict with the first hypothesis since the wrestlers in this study were deficient in both energy and macronutrients. Macronutrient and mineral intakes were positively correlated with body composition and performance, despite intake being inadequate. However, FFM accounted for most of the significance of these relationships, indicating that body composition in conjunction with nutrition may have a large influence on wrestling performance. This would suggest that achieving high FFM with adequate intake during the preseason may be beneficial for maintaining performance when a weight and energy deficit is necessary for weight cutting.

In general, the athletes in this study failed to meet recommendations for nutrient intake. Energy intake was about 1,200 kcal·day$^{-1}$ lower than the eTEE. Specifically, eight out of eleven participants (73%) had energy intakes below calculated eTEE, while five athletes (45%) had energy intakes lower than eRMR (Table 2). Additionally, mean carbohydrate intake was 257 g, or about 3.1 g·kg$^{-1}$, whereas mean protein intake was 149 g, or about 1.8 g·kg$^{-1}$. These findings are similar to the results reported by Lingor and Olson (22) evaluating dietary intake of Division III collegiate athletes with a mean energy intake of 2,000 kcal·day$^{-1}$ and 2,387 kcal·day$^{-1}$ during two separate weeks and eTEE of 3,140 kcal·day$^{-1}$. Similarly, mean carbohydrate and protein intakes were low based on general recommendations for athletes (38). A carbohydrate intake of 3.0 g·kg$^{-1}$ has been suggested as the minimum daily intake required for athletes of low-intensity, skill based sports (5). While the participants of the current study are meeting this minimum intake, for optimal performance, wrestlers likely need an intake closer to the 6-10 g·kg$^{-1}$ suggested for training consisting of moderate to high intensity exercise of 1-3 hours a day (5). A protein intake of 1.8 g·kg$^{-1}$ may be adequate with proper energy intake; however, a higher protein intake of 2.3-2.5 g·kg$^{-1}$ is suggested to benefit FFM maintenance for athletes in an energy deficit (23, 26). If the current energy deficits observed are sustained, these athletes may be at risk of losing FFM, or potentially developing relative energy deficiency, which can be negative for performance as well as a wide array of general health factors (17).

While energy deficits are concerning, these dietary records were purposely taken in the pre-season as the athletes were preparing for the competition season. Thus, most of the participants, excluding two heavyweights and one injured wrestler, were aiming to lower their body mass, which should be considered when evaluating dietary intake. Their focus at this stage would be to reduce FM while maintaining FFM, as opposed to RWL practices done in the days prior to a competition, when the goal is to temporarily lower body mass through primarily total body water volume, and gut residue. However, the wide differences in macronutrient distribution between each participant highlights the lack of recommendations for optimal strategies for this population to attain this goal. In the present study, carbohydrate intake ranged from 18% to 54% of total calories, protein intake ranged from 15% to 38%, and fat intake ranged from 28% to 41%. This reinforces that more research is needed to establish nutritional recommendations for safe and effective weight loss prior to competition season. Furthermore, with more insight into the dietary practices of wrestlers during the competition season, recommendations for each stage of the weight cycle may be identified.

Additional goals during preseason typically include increasing muscular strength and aerobic capacity, while anaerobic capacity remains a focus throughout the year. The wrestlers in the current study had a mean MVIC extension PT of 2.78 Nm·kg$^{-1}$, which is similar to values reported for other Division I wrestlers (4). Isokinetic extension and flexion PT (2.50 Nm·kg$^{-1}$ and 1.29 Nm·kg$^{-1}$, respectively) were lower than values reported for American football players (2.90 Nm·kg$^{-1}$ and 1.94 Nm·kg$^{-1}$, respectively) (42) and professional soccer players (3.17 Nm·kg$^{-1}$ and

1.77 Nm·kg$^{-1}$, respectively) (30). While lower body strength is important for wrestlers, these athletes must attain a balance between upper and lower body strength rather than focus on raw strength (36). While this balance is also important for other sports such as American football and soccer, these sports likely rely more on lower body strength, lending to the higher reported values.

Anaerobic power is particularly important for wrestling performance considering a wrestling match consists of 2-3 minute high intensity bouts with short periods of rest in between. This indicates that anaerobic development may be a better predictor of wrestling success than aerobic capacity. Due to differences in methodology, comparisons to previous research performed in wrestlers are difficult. Previous studies have reported mean and peak power achieved during specific anaerobic tests (6, 9, 14, 15, 31, 33, 39), while the current study measured TTE and TW. The test utilized in this study allowed participants to reach exhaustion and was meant to simulate a two- or three-minute wrestling period, which may be more applicable than a 30 second Wingate. Although direct comparisons are difficult, it is interesting to consider how performance may be affected by these athletes' overall energy and macronutrient intake. Since there were high positive correlations between TW and energy, carbohydrate, and fat intake, it seems likely, and not surprising, that higher nutrient intake would result in better anaerobic performance. While conclusions cannot be drawn from this single study, it is possible that higher strength or anaerobic measures could be attained at a timepoint when these athletes are not attempting to lose weight, which should be evaluated in future studies that examine performance and nutrition assessments throughout the wrestling season.

The mean BF% calculated for the wrestlers in this study was 8.83%, which is similar to reported BF% for collegiate and senior level wrestlers (6, 9, 14, 31, 33) and athletes of other combat sports (1, 7, 34). There is less agreement with previous studies for lean mass, possibly due to differences in methodology, as previous studies have reported FFM, lean mass, or muscle mass as a marker of body composition. Additionally, the individual nature of a weight class sport can largely influence FFM composition in athletes, with the potential for variation throughout the different stages of a season, making comparisons across studies difficult. Nevertheless, reported BF% is similar among wrestlers at multiple levels, reinforcing the foundational importance of body composition to the sport of wrestling. Additionally, previous studies have reported positive associations between fat free mass and anaerobic peak power ($r = 0.75$) (24) and indications of the detrimental effect of higher body fat on performance, including a negative relationship between BF% and peak power ($r = -0.36$) (24), and a positive relationship between BF% and 300-yard shuttle time ($r = 0.69$) (10). Since wrestling is a dynamic sport that relies on a balance between numerous performance factors, monitoring all of these factors, along with nutrition is important for wrestling success. Nutrition strategies focused on maintaining adequate intake, while keeping low BF% and high FFM measurements, may help optimize wrestlers' performance throughout the season while still allowing them to participate in weight cutting.

The main strength of this study is the dietary analysis of Division I wrestlers, as the current literature on wrestlers' nutrient intake is lacking. Additionally, this study provides a robust profile of wrestlers, giving insight on body composition, nutrition, strength, and anaerobic ability during pre-season, which is highly influential for competition season preparation. The main limitation of this study is the potential for error with self-reported intake, even with proper instruction. Additionally, the eRMR and eTEE may not represent the actual values of resting metabolic rate and total daily energy expenditure of these athletes since these are estimations based on calculations that have errors associated with them. Minimization of error was attempted by choosing an equation that utilized FFM to try to be as accurate as possible. Finally, the current participants were all from one university and may not be representative of all wrestlers, especially of different competitive levels or ethnicities.

This study demonstrates that wrestlers are likely in an energy deficit leading up to the competition season. Although an energy deficit is likely necessary for these athletes to make weight, it may lead to macro- or micronutrient deficiencies which could negatively influence performance, as well as health. Additionally, maintaining high FFM may be advantageous for wrestling performance, particularly while striving to make weight. While many wrestlers have already achieved high FFM and low BF% measurements, a prolonged energy deficit throughout the season can lead to loss of FFM. Despite the importance of nutrient intake to the sport, wrestlers lack an optimal strategy that allows them to maximize performance while managing their weight. In order to establish nutrition recommendations, future research should evaluate the impact of different long- and short-term weight cutting techniques on performance and body composition, including assessments evaluating changes over a complete cycle of the competitive season. This may provide the foundation needed to develop optimal nutrition recommendations and strategies to make weight and manipulate body composition while maintaining performance and general health. Additionally, monitoring nutrient intake and performance outcomes can allow coaches and health professionals to create individualized recommendations for athletes to optimize performance while managing weight cutting phases.

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