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The Relationship of Anthropometric and Physical Performance Characteristics on Competitive Success in Amateur, Elite, and Professional Rodeo Athletes

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Abstract

Oranchuk, DJ, Gullett, LK, Kicia, M, Thome, B, and Game, A. The relationship of anthropometric and physical performance characteristics on competitive success in amateur, elite, and professional rodeo athletes. *J Strength Cond Res* XX(X): 000–000, 2022—Reference anthropometric and physical performance qualities can improve understanding of sporting needs and streamline preparation and rehabilitation programs. However, these data and their relationships with competitive success are absent in rodeo athletes. We hypothesized that riding performance would be most correlated with hip adductor, neck, and grip strength, whereas jump, reactive strength index (RSI), and change of direction abilities would best predict bull-fighting performance. Forty-three amateur ($n = 9$), professional ($n = 23$), or internationally ranked ($n = 11$) male rodeo athletes (bareback = 9, bull riders = 16, saddle bronc = 7, bullfighters = 11) (26.8 ± 5.6 years) volunteered for this study. Anthropometrics included body mass, height, and body fat percentage. Performance measures included isometric hip adduction and abduction, neck flexion and extension, handgrip strength, squat and countermovement jump heights, eccentric utilization ratio, reactive strength index, change of direction, bike sprints, and several pneumatic power measures. Bullfighters were taller and heavier than bull riders (effect size [ES] = 0.84–0.87, p = 0.008–0.017). Bull riders were leaner than bullfighters (ES = 0.74, $p = 0.012$). Fighters had greater RSI than riders (ES = 0.73–1.47, $p < 0.001$–0.030). Competitive level of rodeo riders ($n = 32$) correlated with age, rodeo experience ($\rho = 0.37$–0.43, p = 0.013–0.049), bent-leg abduction ($\rho = 0.43$, $p = 0.014$), straight-leg hip adduction and abduction ($\rho = 0.49$–0.56, $p <$ 0.001–0.005), neck flexion force ($\rho = 0.43$, $p = 0.016$), and rotational power ($\rho = 0.50$, $p = 0.004$). The competitive level of the fighters correlated with age ($\rho = 0.64$, $p = 0.036$) and time trial performance ($\rho = -0.76$, $p = 0.006$). This is the first study providing normative and correlational strength and power performance data in a rodeo population. These data highlight the need for more event-specific physical preparation. Riders should focus their physical preparation on hip and neck strength and rotational power. Bullfighters should prioritize stiffness and anaerobic power.

Key Words: bull riding, concussion, cowboy, power, rough stock, strength

Introduction

Rodeo comprises several strength-focused and power-focused events, including but not limited to calf roping, steer wrestling, team roping, barrel racing, bullfighting, and the "rough-stock" events of bull, bareback, and saddle bronc riding (27). Rodeo athletes run the gambit of body sizes and require different skills to excel in their chosen event (27). Anecdotally, riding events require special techniques and strong hip adductors, neck muscles, and handgrip to remain on the animal successfully and consistently for 8 seconds (5,27,32). Conversely, bullfighters need to be agile, with rapid reaction times to maintain proper position relative to the bulls to keep the riders as safe as possible.

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Although rodeo athletes require many physical and psychological qualities to succeed (27), hip and hand strength appear valuable to maintain position (27), with neck strength potentially vital to vestibular balance and avoiding neck strains and concussions (44). Indeed, hip adductor strains are common injuries in riders (7,26,37,38). Although little exists regarding hip strength in rodeo athletes, many studies have examined isometric adduction and abduction strength in hockey, soccer, and rugby athletes (12,29,30,33). In addition, neck strength has an inverse relationship with head kinematics, possibly reducing head and neck injuries (10,17,19). Similarly, metrics such as the reactive strength index (18), jump height, eccentric utilization ratio (24), and change of direction tests (11,22,34) have demonstrated beneficial relationships to performance in a wide variety of sports. However, although several logic-derived physical preparation paradigms have been proposed (5,32,40), the relationship between the aforementioned physical qualities with riding and bullfighting performance is presently lacking.

Although rodeo events are most popular in the central United States and Canada, the sport has rapidly grown in Australia and

Brazil and is expanding internationally. In addition, several American universities include rodeo in their intercollegiate sports, often with scholarships on the line (28,35). However, sports science in rodeo has not developed by a sizeable magnitude because nearly all published studies have focused on injury rates and recovery protocols (7,26,37,38,44), with the lone performance study primarily reporting metabolic and reaction time characteristics (25). Thus, publicly available normative data are hard to come by, leaving rodeo athletes and strength and conditioning professionals to use anecdotal reports or data from their own, likely limited pool of athletes, to guide training. Therefore, this study aimed to provide normative anthropometric and performance data across several rodeo events and highlight actionable insights regarding strength and conditioning. We hypothesized that riding performance would be most correlated with experience, and hip adductor, neck, and grip strength measures, whereas jump, reactive strength index (RSI), and change-of-direction abilities would best predict bullfighting performance.

Methods

Experimental Approach to the Problem

A cross-sectional study was used whereby high-performing rodeo athletes' anthropometric profile and strength and power qualities were compared between events (bareback riders [bareback], bull riders, saddle bronc riders [saddle bronc], bullfighters [fighters]) and competition levels (amateur, low-professional [bottom one-third of national rankings], medium-professional [middle one-third of national rankings], high-professional [top one-third of national ranking], internationally ranked professional). General and anthropometric data included age, years of experience, height, body mass, body mass index (BMI), and body fat percentage. Strength measures included isometric hip adduction and abduction, neck flexion and extension, and handgrip dynamometry. Jump measures included squat jump (SJ) and countermovement jump (CMJ) vertical height, eccentric utilization ratio (EUR), RSI, and pneumatic resisted lateral jump power. Upper-body power was assessed through pneumatic resisted chest press and rotational push-pull tests. Change of direction and anaerobic power were assessed by pro-agility, and air bike sprint tests, respectively. Analysis of variance (ANOVA), standardized differences, and correlational analyses were used.

Subjects

Forty-three amateur ($n = 9$), national ($n = 23$), or internationally ($n = 11$) ranked adult male rodeo athletes (26.8 ± 5.6 years, range = 18–38) volunteered for this study. Subjects consisted of 9 bareback riders, 16 bull riders, 7 saddle bronc riders, and 11 fighters. All subjects were from Alberta or Saskatchewan, Canada. Written consent was read, signed, and collected from each athlete. The study was approved by the University of Alberta Ethics Committee and was conducted according to the Declaration of Helsinki.

Procedures

Measurement ReliabilityAll tests without preexisting publications describing intrasession and intersession reliability were examined during pilot testing with a group ($N = 8$) of similarly aged (29.1 ± 4.8 years) male sports medicine professionals. Intrasession reliability was determined by performing each test (except for anaerobic power) 3 times per session, with intersession reliability assessed over 2 sessions, 6–8 days apart. Reliability was considered acceptable when intraclass correlation coefficient (ICC) of >0.67 and coefficient of variation (CV) of <10% (31); 95% confidence limits (95% CL) are provided in [square brackets].

Testing for each subject was completed on a single day, in a private clinic and athlete performance facility. All testing took place between 8 AM and 3 PM and followed the same testing order for each subject. Most subjects were assessed during 1 of 4 testing combines between May 2021 and March 2022. The following testing procedures followed concussion (SCAT-3), ocular-motor, psychological, and general medical screening.

Body Composition. Height was measured to the nearest 1 mm using a stadiometer, whereas a portable scale measured body mass to the nearest 0.1 kg (both measurements taken barefoot). All skinfold landmarks were measured and denoted by an ISAK level-2–certified anthropometrist with a low typical error (CV = 2.8%). The 3-site (pectoral, abdominal, thigh) measurements were performed on all subjects 3 times, in revolving order from one spot to the next. Harpenden calipers (Baty Intl, West Sussex, United Kingdom) with a 0.1-cm precision were used to quantify skinfold thickness. The average of the 3 measures was recorded and entered the Jackson-Pollock equation (equation 1) to determine body density converted to body fat percentage using the Siri's formula (equation 2).

$$\text{Body Density} = 1.10938 - (0.0008267 \times \text{Sum of skinfolds}) + (0.0000016 \times \text{Square of the sum of skinfolds}) - (0.0002574 \times \text{age}) \quad (1)$$

$$\text{Body Fat Percentage}(\%) = (495/\text{Body Density}) - 450 \quad (2)$$

A previous study determined that no significant difference ($p = 0.38$) existed in body fat estimates between 3 and 7 site testing (4). In addition, Loenneke et al. (21) reported strong reliabilities (ICC = 0.992) for the Jackson-Pollock 3-site estimate.

Warm-up. Before the performance tests, all subjects performed a general warm-up consisting of forward and backward jogging, side shuffles, arm swings, lunges, hops, and groin squeezes. Each subject completed the following evaluations post warm-up, with approximately 5 minutes of rest between the tests.

Isometric Performance. Specific warm-ups for all 6 isometric tests detailed below consisted of performing contractions of 50 and 80% of perceived maximal effort for 5 seconds with 30 seconds of rest between the contractions. Isometric hip adduction and abduction were measured in 2 supine positions using the ForceFrame (Vald Performance, Albion, Australia) sampling at 400 Hz. First, the athletes lay supine with their hips and knees flexed to 45° and 90° (bent leg), respectfully, with the medial and lateral condyles of the knees between the load cells (Figure 1A). Arms and feet were required to be flat on the ground, with the head resting on a pad. Subjects were instructed to apply light pressure to the load cells after the warm-up. They were given a countdown of "3, 2, 1, squeeze, squeeze, squeeze!" or "3, 2, 1, push, push, push!" for adduction and abductions, respectively. Maximal adduction and abduction contractions were performed twice, with 60 seconds of passive rest between each effort. A third contraction was allowed if the force of the second contraction exceeded the first by more than 10%. After a 2-minute rest, the same procedures were repeated with the knees and hips extended to 0° (straight leg) and subjects

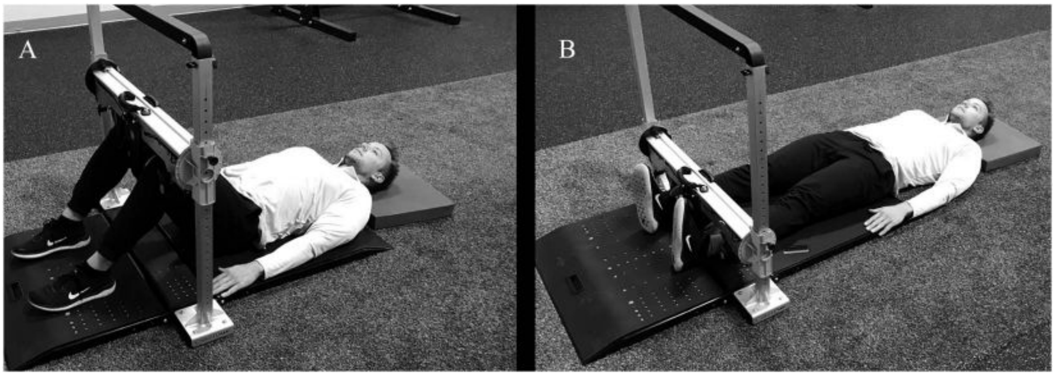

Figure 1. Testing positions for bent-leg (panel A) and straight-leg (panel B) hip adduction and abduction.

squeezing and pushing from the medial and lateral malleolus, respectively (Figure 1B). For subsequent analysis, the highest force output (newtons) from each limb was recorded. Previous studies have determined assessments of peak hip strength using this equipment to be highly reliable (ICC = 0.82–0.85) (12), (CV = 4.9–9.0% (33)).

Isometric neck extension and flexion strength were also assessed using the ForceFrame. The athletes assumed a quadruped position for neck extension with their hands placed directly under their heads with elbows locked and the occipital protuberance pressed against a load cell (Figure 2A). Following the specific warm-up, subjects applied light pressure to the load cells and were given a countdown of "3, 2, 1, push, push, push!". Maximal contractions were performed twice, with 60 seconds of passive rest. A third contraction was allowed if the second force exceeded the first by >10%. After a 2-minute rest, the same procedures were repeated for neck flexion, where the subjects lay supine with the load cell placed minimally above their forehead (Figure 2B).

Isometric grip strength was evaluated with the subjects seated upright with hips and knees at 90°. The hand dynamometer (Baseline Hydraulic, Fabrication Enterprises Inc., White Plains, NY) was set to "0" for consistency and held with the elbow at 90° and the humorous abducted 15° from the torso. Each subject was given one practice squeeze for each hand before performing 2 maximal efforts per hand, alternatingly with 30 seconds of rest between the efforts. The highest force (in kilograms) from each hand was recorded and analyzed. Previous studies have determined handgrip dynamometry to be highly reliable in both healthy athletic (ICC = 0.94–0.98) (16) and injured populations (ICC = 0.936–0.974) (3), regardless of hand preference.

Dynamic Performance. Jump heights were determined by a contact mat (Just Jump, Probotics Inc., Huntsville, AL), which measures flight time to derive jump height (height = $g \cdot t_{fligth}/2$, where g is the acceleration because of gravity). Despite systematically overestimating vertical jump height, contact mats have been found to have nearly perfect correlations to motion capture (r = 0.97) and force plates (r = 0.99) (20). Subjects performed 3 SJs and 3 CMJs with 30 seconds of rest between each jump. For the SJ, the athlete descended to a knee angle of approximately 90°. This position was held for 3 seconds before a verbal command to jump was given. An SJ was considered successful if the athlete gave a maximal effort and there was no visible countermovement. The CMJ was performed with a rapid descent to a self-selected depth, immediately followed by a maximal ascent. Subjects were instructed not to tuck their legs and land flat footed during both SJ and CMJ assessments. The highest of each jump type was used for further analysis. The EUR was also calculated by dividing CMJ height by SJ height (24).

The RSI' 10/5' was measured through a wearable accelerometer (PUSH Inc., Toronto, ON, Canada), sampling at 200 Hz, and was automatically derived from the equation: $9.81/8 \times \text{flight-time}^2$. The accelerometer was placed in the manufacturer-provided waist belt and attached to the subjects so that the accelerometer was immediately above the sacrum. The subjects were instructed to have their hands-on-hips and perform 10 vertical jumps in rapid succession. The subjects were told to keep

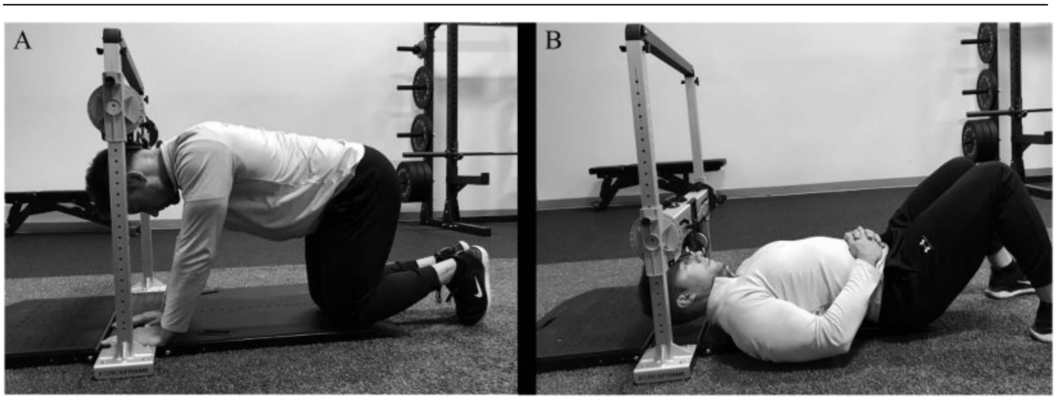

Figure 2. Testing positions for isometric neck extension (panel A) and flexion (panel B).

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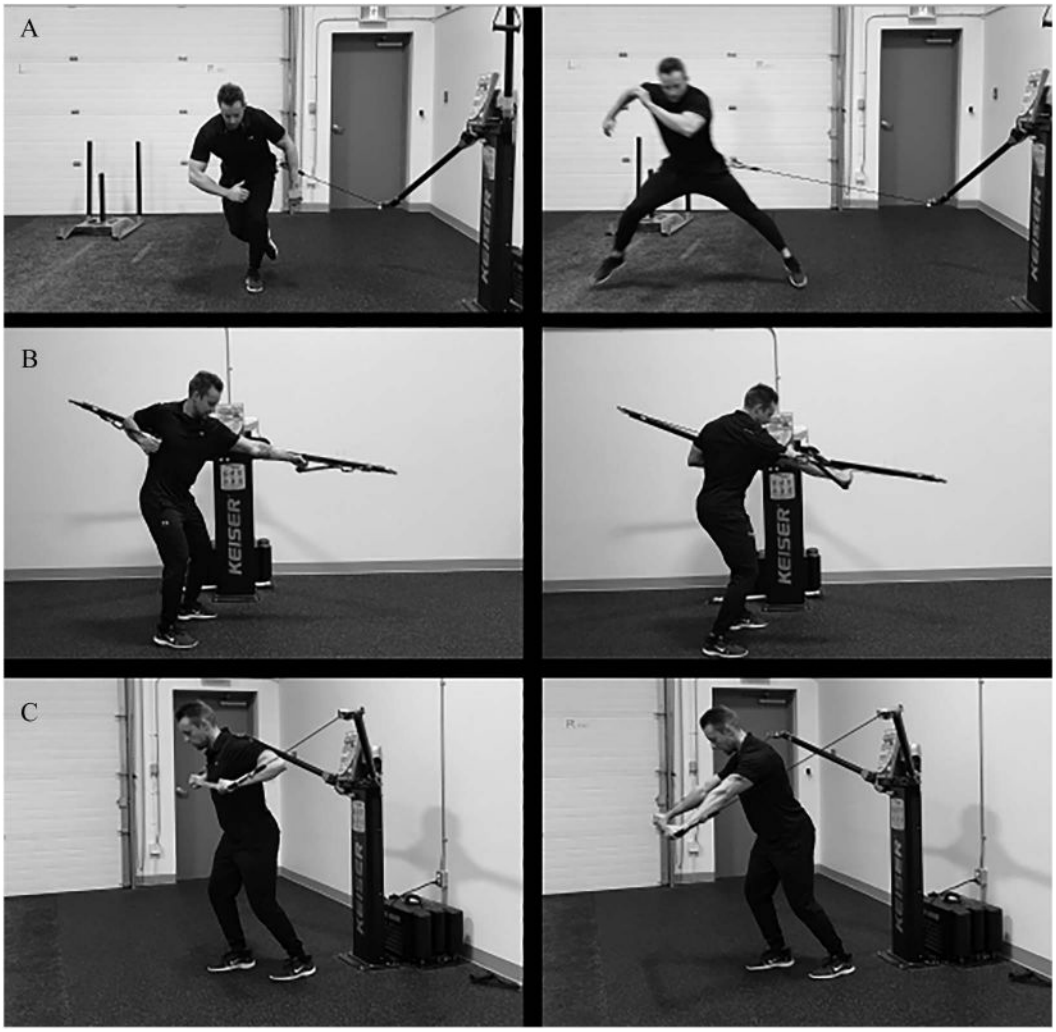

Figure 3. Start and ending positions for the lateral jump (panel A), push-pull (panel B), and chest-press (panel C) power tests.

their legs relatively straight and "jump as high and fast as possible." Similar to previously examined drop jump RSI (42), our pilot testing determined the RSI 10-5 testing procedure to hold acceptable intrasession (ICC = 0.97 [0.89–0.99], CV = 6.2% [4.5–11.6]) and intersession (ICC = 0.97 [0.86–0.99], CV = 6.0% [4.0–12.7]) reliabilities.

A pneumatic cable station (Model 3020; Keiser, Fresno, CA) was used to measure power during the lateral jump, rotational push-pull, and chest-press performances, as illustrated in Figure 3A–C, respectively. The pneumatic cable station was chosen to assess several measures of general athletic performance while maximizing space and time efficiency during the collection periods. Resistance was set to 1.52 kilopascals (kPa) per kilogram of body mass (i.e., 20 psi for a 200 lbs individual) for all pneumatic tests. The order of sides for the lateral jump and push-pull tests were allocated randomly. The subjects were secured to a cable at the "4" height setting with a waist belt and carabiner for the lateral jump. The subjects were instructed to balance on the leg closest to the station while standing perpendicular. They then bent at the hips and knees, letting the far leg dip behind the down leg before rapidly jumping as far as possible from the cable station (Figure 3A). The athletes could land on 1 or 2 legs as they preferred. Two practice jumps were allowed before each limb's 3 maximal efforts were completed with approximately 15 seconds between the jumps and 60 seconds between the limbs. Two minutes later, the subjects completed the push-pull rotational power assessment (Figure 3B). For the push-pull test, the pushing and pulling handles were set to "8" and "6," respectively. The athlete began in a semisquat position before rapidly and simultaneously pushing and pulling on the respective handles. Three practice repetitions were required, followed by 3 maximal efforts with approximately 10 seconds of rest between the repetitions. The process was repeated on the opposite side following a 60-second break. After 2 minutes of passive rest, the Keiser's arms were put to a height of "8" with the "chop bar" attached to both cables for the chest press. The athletes assumed a split stance to aid balance and were instructed to grasp the bar with both hands, palms down, and shoulder width apart. They then were asked to rapidly press the bar away from their chests (Figure 3C). Subjects were given 3 practice repetitions before a passive rest of 60 seconds. They then performed 3 maximal repetitions with approximately 10 seconds of rest between the repetitions. The highest peak power output (watts) for each test was recorded for future analyses. Acceptable reliabilities were found for all tests:

- Lateral jump (intra: ICC = 0.94 [0.72–0.99], CV = 3.9% [2.6–9.2]; inter: ICC = 0.95 [0.76–0.99], CV = 3.9% [2.5–8.2%]).
- Push-pull (intra: ICC = 0.91 [0.67–0.98], CV = 4.9% [2.9–9.4%]; inter: ICC = 0.94 [0.76–0.99], CV = 4.2% [2.7–9.1%]).
- Chest press (intra: ICC = 0.93 [0.68–0.99], CV = 4.4% [2.8–9.1%]; inter: ICC = 0.94 [0.73–0.99], CV = 3.9% [2.6–8.1%]).

Change of direction ability was evaluated using the pro-agility test (39). A 2-m-wide lane of cones was laid out 5 m apart on an artificial turf surface. Lines between the cones were applied with athletic tape so that the subjects had something to touch during the test. Laser-based timing gaits (Brower Timing Systems, Draper, UT) were set up over the middle cones, 0.75 m above ground height. Subjects were instructed to face one of the lasers perpendicular to the running direction, and on their own time, sprint to one side, touch the line with one hand while changing direction, and sprinting to the far cone. After touching the distant line, the subjects would sprint through the center cones, tripping the timing gates and ending the test. Subjects performed 2 practice trials at 50 and 75% of perceived maximal effort in each direction. Two maximal trials were then conducted in each direction, in alternating order, with 60 seconds of passive rest between the attempts. The fastest time from each direction was recorded for analysis. The pro-agility test is moderate to highly reliable in male team sport athletes (CV = 2.5%, ICC = 0.67) (39).

Testing was concluded with a maximal effort sprint on an air bike (TYDAX, Edmonton, Canada). Subjects rode with hands and feet cycling simultaneously. The bike was set to record the time taken to burn 10 calories (kcal). Subjects rode the bike at 50% of perceived maximal effort for 60 seconds before a 60-second rest. A researcher then gave a countdown of "3, 2, 1, GO!" before the subject exerted maximal effort until 10 kcal were registered. Pilot testing determined the anaerobic power test to hold acceptable intersession reliability (ICC = 0.85 [0.65–0.99], CV = 4.9% [3.2–10.2%]).

Statistical Analysis

Jeffrey's Amazing Statistics Program (JASP) software (version 0.16, Amsterdam, the Netherlands) was used for all statistical analyses. Results were analyzed for the entire group and each event (bareback, bull riders, saddle bronc, fighters) using an ANOVA, with Welch's homogeneity correction, for each primary variable. Dunn's post hoc comparisons were used to quantify pairwise comparisons. Qualitative descriptors of standardized Cohen's *d* effect sizes (ES) with 95% CL were assessed and reported using these criteria: trivial <0.2, small 0.2–0.49, moderate 0.5–0.79, and large >0.8 (14). Because of the limited sample size, results were interpreted as potentially meaningful when ES was ≥0.50. *p* Values are provided to express the precision of the mean estimated difference between the events (41). At the same time, statistical significance was accepted when $p < 0.05$. Omega squared (ω^2) was used to characterize the effect size of each ANOVA (14). Both magnitude and precision of the estimated difference (i.e., ES and *p*-values) were used to interpret the results.

Spearman's Rho (ρ) assessed relationships between the testing variables and competitive level (1 = amateur, 2 = low professional, 3 = medium professional, 4 = high professional, 5 = international professional). Pearson's correlation (*r*) coefficient assessed relationships between anthropometric and performance variables. Spearman's correlations were performed for all riders ($n = 32$) pooled, whereas fighters ($n = 11$) were analyzed separately. All correlations were interpreted as follows: = ±0 to 0.1 trivial, ±0.1 to 0.3 small, ±0.3 to 0.5 moderate, ±0.5 to 0.7 large, ±0.7 to 0.9 very large, and <−0.9 or >0.9 nearly perfect. In addition, 95% CL were calculated for the correlational data by simulating 1,000 bootstrapped samples. Moderate results were interpreted as potentially meaningful.

Normative data are reported as mean ± *SD* in tables, whereas medians, interquartile ranges, and minimum and maximum values are presented in box plot form because of instances of nonnormally distributed data. Individual data points and distributions were included to provide further transparency (2,43). Asymmetry percentages are provided for all unilateral performance measures. Because of many possible comparisons, only significant or potentially meaningful results are reported in the text. Similarly, superfluous correlations (e.g., BMI/body fat %, CMJ height/nondominant grip strength) are not reported in text.

Results

Total group and event-specific age, experience, and anthropometric characteristics, isometric performance data, and dynamic performance data are summarized in Tables 1–3, respectively.

Between-Event Differences

No significant interaction effects ($F = 0.338$, $p = 0.798$, $\omega^2 < 0.001$) or pairwise comparisons (ES ≤ 0.47, $p \geq 0.15$, ≤24%) were detected for competitive level (Figure 4).

Anthropometrics. Individual age, experience, and anthropometric characteristics are illustrated in Figure 5. No significant interaction effects were detected ($F = 1.21$–3.05, $p = 0.057$–0.335, $\omega^2 < 0.001$–0.097) for age, experience, or any anthropometric

Table 1

Anthropometric characteristics by rodeo event.*

Event	Age (y) Mean ± *SD*	Total rodeo experience (y) Mean ± *SD*	Experience in current event (y) Mean ± *SD*	Height (cm) Mean ± *SD*	Body Mass (kg) Mean ± *SD*	BMI (km·m^{-2}) Mean ± *SD*	Body fat (%) Mean ± *SD*
Bareback ($n = 9$)	26.6 ± 6.8	12.4 ± 9.8	11.3 ± 6.9	177.2 ± 6.1	78.2 ± 6.7	24.9 ± 2.4	9.1 ± 5.5
Bull riders ($n = 16$)	24.3 ± 4.4	13.0 ± 6.5	9.3 ± 4.7	174.8 ± 4.3	70.8 ± 8.2	23.1 ± 2.3	7.5 ± 4.9
Saddle bronc ($n = 7$)	29.7 ± 5.4	19.4 ± 4.9	14.2 ± 4.7	175.7 ± 7.8	75.7 ± 15.9	24.2 ± 4.9	10.5 ± 7.5
All riders ($n = 32$)	26.1 ± 5.6	13.9 ± 7.5	10.7 ± 5.5	175.7 ± 5.6	74.0 ± 10.2	23.9 ± 3.0	8.6 ± 5.7
Bullfighters ($n = 11$)	28.9 ± 5.9	14.6 ± 4.9	10.0 ± 6.0	179.8 ± 5.0	78.3 ± 4.7	24.3 ± 1.6	13.6 ± 5.1
Total ($N = 43$)	26.8 ± 5.3	14.1 ± 6.9	10.5 ± 5.6	176.6 ± 5.6	75.0 ± 9.3	24.0 ± 2.8	9.3 ± 5.5

*BMI = body mass index; body fat % = Jackson and Pollock 3-site estimate.

Table 2
Isometric performance characteristics.*

Test	Bareback ($n = 9$) Mean ± *SD*	Bull riders ($n = 16$) Mean ± *SD*	Saddle bronc ($n = 7$) Mean ± *SD*	All riders ($n = 32$) Mean ± *SD*	Bullfighters ($n = 11$) Mean ± *SD*	Total ($N = 43$) Mean ± *SD*
Hip (N)						
Bent-leg adduction (average)	484 ± 81	464 ± 96	459 ± 107	469 ± 92	502 ± 65	476 ± 87
Average asymmetry (%)	4.1 ± 1.8	7.3 ± 5.7	5.2 ± 4.8	6.2 ± 4.8	7.7 ± 6.5	6.5 ± 5.3
Bent-leg abduction (average)	457 ± 74	392 ± 67	380 ± 92	408 ± 79	403.7 ± 68	407 ± 76
Average asymmetry (%)	4.1 ± 2.4	5.7 ± 4.0	5.7 ± 4.6	5.2 ± 3.7	5.1 ± 2.3	5.1 ± 3.4
Adduction: abduction (% diff)	6.5 ± 18.5	17.3 ± 19.5	24.9 ± 29.1	15.6 ± 21.3	25.9 ± 16.9	18.5 ± 20.3
Straight-leg adduction (average)	219 ± 59	224 ± 48	230 ± 53	224 ± 51	237 ± 61	227 ± 53
Average asymmetry (%)	5.1 ± 2.6	5.3 ± 4.2	6.7 ± 3.9	5.5 ± 3.7	8.3 ± 7.9	6.2 ± 4.8
Straight-leg abduction (average)	210 ± 62	191 ± 47	198 ± 42	198 ± 50	185 ± 45	195 ± 48
Average asymmetry (%)	7.3 ± 7.4	3.8 ± 4.9	3.6 ± 2.4	4.8 ± 5.5	6.5 ± 5.4	5.1 ± 5.5
Adduction: abduction (% diff)	6.7 ± 18.0	21.0 ± 26.4	23.8 ± 18.8	17.4 ± 23.4	28.1 ± 19.9	20.3 ± 22.3
Bent-leg: straight-leg diff						
Adduction (%)	139 ± 53.8	109 ± 35.7	89.7 ± 25.6	113.6 ± 42.6	121 ± 43.4	116 ± 41.6
Abduction (%)	135 ± 32.9	116 ± 52.8	89.0 ± 12.5	117 ± 44.6	123 ± 34.8	119 ± 41.2
Neck (N)						
Flexion	169 ± 36	182 ± 75	168 ± 43	175 ± 58	157 ± 60	171 ± 58
Extension	321 ± 76	340 ± 76	278 ± 55	320 ± 73	315 ± 94	319 ± 78
Flexion: extension (% diff)	46.0 ± 9.9	44.8 ± 22	43.1 ± 12.7	44.8 ± 17.2	50.7 ± 11.4	46.4 ± 16.0
Grip (kg)						
Mean	54.4 ± 13.0	52.6 ± 9.4	55.9 ± 5.8	53.8 ± 9.7	54.3 ± 9.2	55.0 ± 9.1
Dominant	55.9 ± 12.7	54.5 ± 9.3	56.5 ± 5.9	55.1 ± 9.5	54.8 ± 8.4	53.0 ± 10.5
Nondominant	53.0 ± 14.5	50.8 ± 10.8	55.5 ± 7.0	52.5 ± 11.1	54.4 ± 8.6	53.9 ± 9.5
Average asymmetry (%)	11.7 ± 13	10.8 ± 11.3	2.5 ± 3.1	9.8 ± 11.2	2.9 ± 3.2	7.8 ± 10.1

*N = newtons; kg = kilograms.

variables. However, Dunn's post hoc analysis also found that fighters (ES = 0.87 [−0.25 to 2.00], $p = 0.013$, 17.3%) and saddle bronc (ES = 1.02 [−0.28 to 2.32], $p = 0.012$, 20.0%) athletes were older than the bull riders. Post hoc determined that saddle bronc riders had more years of rodeo experience than bareback riders (ES = 1.04 [−0.59 to 2.67], $p = 0.036$, 44.2%) and bull riders (ES = 0.95 [−0.52 to 2.40], $p = 0.033$, 39.5%). Similarly, saddle bronc riders had greater event experience than the bull riders (ES = 0.89 [−0.57 to 2.35], $p = 0.027$, 42.2%). Post hoc comparisons also determined that fighters were taller than saddle bronc (ES = 0.71 [−0.68 to 2.10], $p = 0.037$, 2.2%) and bull riders (ES = 0.87 [−0.28 to 2.03], $p = 0.008$, 2.7%), whereas bull riders were lighter than bareback riders (ES = 0.83 [−0.36 to 2.02], $p = 0.018$, 10.0%) and fighters (ES = 0.84 [−0.32 to 1.99], $p = 0.017$, 10.1%). Finally, bull riders had lower body-fat percentage than the fighters (ES = 0.74 [−0.41 to 1.88], $p = 0.012$, 42.2%).

Isometric Performance. Individual isometric performance data are illustrated in Figure 6. No significant interaction effects were detected ($F = 0.043$–1.73, $p = 0.200$–0.988, $\omega^2 <$ 0.001–0.064) for any isometric variables. However, Dunn's

Table 3
Dynamic performance characteristics.*

Test	Bareback ($n = 9$) Mean ± *SD*	Bull riders ($n = 16$) Mean ± *SD*	Saddle bronc ($n = 7$) Mean ± *SD*	All riders ($n = 32$) Mean ± *SD*	Bullfighters ($n = 11$) Mean ± *SD*	Total ($N = 43$) Mean ± *SD*
Vertical jump						
CMJ (cm)	57.9 ± 3.8	60.0 ± 8.9	57.7 ± 4.8	58.9 ± 6.9	58.8 ± 4.3	58.8 ± 6.4
SJ (cm)	48.8 ± 8.5	47.3 ± 7.5	47.6 ± 6.0	47.8 ± 7.3	48.6 ± 2.1	48.0 ± 6.5
% Difference	13.7 ± 17	18.9 ± 6.2	18.1 ± 10.4	17.3 ± 10.8	17.0 ± 4.7	16.9 ± 9.6
EUR	1.22 ± 0.20	1.24 ± 0.10	1.24 ± 0.13	1.23 ± 0.14	1.21 ± 0.07	1.23 ± 0.12
RSI 10-5	1.12 ± 0.37	1.18 ± 0.56	0.85 ± 0.43	1.09 ± 0.49	1.50 ± 0.29	1.19 ± 0.48
Pneumatic power (W)						
Lateral bound (average)	201 ± 26.3	188 ± 25.3	190 ± 26.6	192 ± 25.9	201 ± 23.3	194 ± 25.0
Average asymmetry (%)	4.7 ± 3.2	6.7 ± 5.0	6.6 ± 7.0	6.1 ± 4.9	4.6 ± 2.3	5.8 ± 4.4
Push-pull (average)	911 ± 156	864 ± 154	831 ± 109	870 ± 144	903 ± 146	878 ± 143
Average asymmetry (%)	10.0 ± 4.8	11.0 ± 11	3.9 ± 2.9	9.3 ± 8.7	5.9 ± 6.3	8.4 ± 8.2
Chest press	632 ± 110	630 ± 113	586 ± 193	621 ± 130	618 ± 75.4	621 ± 117
COD (s)						
Pro-agility (average)	5.07 ± 0.36	5.00 ± 0.49	5.32 ± 0.26	5.07 ± 0.42	4.95 ± 0.37	5.04 ± 0.41
Average asymmetry (%)	2.5 ± 1.3	2.5 ± 2.4	3.9 ± 4.0	2.8 ± 2.5	2.9 ± 1.8	2.8 ± 2.3
Anaerobic power						
10 kcal air bike (s)	15.1 ± 2.4	16.7 ± 3.1	15.3 ± 3.1	16.0 ± 2.9	15.1 ± 1.7	15.6 ± 2.7

*CMJ = countermovement jump; SJ = squat jump; EUR = eccentric utilization ratio; cm = centimeters; W = watts; RSI = reactive strength index; COD = change of direction.

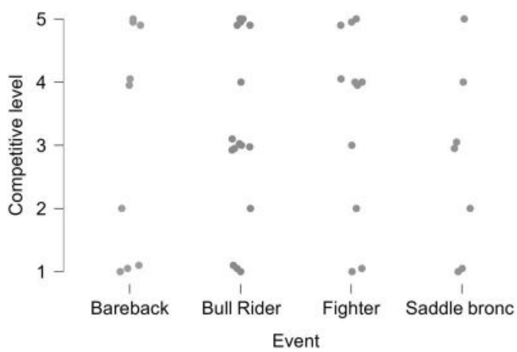

Figure 4. Jitter plot of competitive level between rodeo events. 1 = amature, 2 = low national, 3 = medium national, 4 = high national, 5 = internationally ranked.

post hoc comparisons showed that bareback riders had higher bent-leg hip abduction when compared with saddle bronc (ES = 1.06 [−0.39 to 2.50], $p = 0.026$, 18.5%) and bull riders (ES = 0.89 [−0.30 to 2.09], $p = 0.019$, 15.4%). Post hoc analysis also determined that bull riders had greater neck extension strength than the saddle bronc riders (ES = 0.79 [−0.51 to 2.10], $p = 0.040$, 20.0%). Straight-leg hip abduction was meaningfully higher in bareback riders when compared with fighters (ES = 0.51 [−0.78 to 1.80], $p = 0.184$, 12.6%). Neck extension was also meaningfully higher in bareback when compared with saddle bronc riders (ES = 0.56 [−0.86 to 1.97], $p = 0.127$, 14.4%).

Dynamic Performance. Individual dynamic performance data are illustrated in Figure 7. A significant interaction was detected for RSI ($F = 4.83$, $p = 0.012$, $\omega^2 = 0.136$) with post hoc analysis determining that fighters had greater RSI when compared with bareback (ES = 0.86 [−0.42 to 2.14], $p = 0.014$, 29.3%), saddle bronc (ES = 1.47 [−0.05 to 2.89], $p < 0.001$, 55.7%), or bull riders (ES = 0.73 [−0.38 to 1.85], $p = 0.030$, 24.5%). Dunn's post hoc analysis determined found that bareback riders had meaningfully greater RSI than saddle bronc riders (ES = 0.61 [−0.81 to 2.02], $p = 0.162$, 27.7%).

No significant interaction effects were detected ($F = 0.113–0.894$, $p = 0.204–0.951$, $\omega^2 < 0.001–0.021$) for any other dynamic variable. Post hoc comparisons also detected meaningfully lower lateral bound power for the bull riders when compared with bareback riders (ES = 0.51 [−0.66 to 1.69], $p = 0.077$, 6.6%) and fighters (ES = 0.55 [−0.58 to 1.69], $p = 0.086$, 9.1%). Likewise, saddle bronc had lower push-pull power than the bareback riders (ES = 0.55 [−0.87 to 1.97], $p = 0.088$, 9.2%). Agility time was significantly or meaningfully slower for saddle bronc riders than fighters (ES = 0.88 [−0.71 to 2.48], $p = 0.020$, 7.1%), bull riders (ES = 0.78 [−0.70 to 2.25], $p = 0.022$, 6.2%), or bareback (ES = 0.60 [−1.02 to 2.21], $p = 0.110$, 4.7%). Finally, bull riders had slower 10 kcal time trials than fighters (ES = 0.73 [−0.41 to 1.86], $p = 0.049$, 12.4%), bareback riders (ES = 0.57 [−0.72 to 1.86], $p = 0.144$, 9.6%), or saddle bronc riders (ES = 0.52 [−0.77 to 1.81], $p = 0.129$, 8.6%).

Correlations

Heatmaps of Spearman's correlations for riders ($n = 32$) and fighters ($n = 11$) are provided in Supplemental Digital Content (see Figure 1, http://links.lww.com/JSCR/A366) and Supplemental Digital Content (see Figure 2, http://links.lww.com/JSCR/A367), respectively.

Competitive Level

Riders. Scatter plots of significant ($p < 0.05$) correlations between anthropometric and performance tests, and competitive riding level (bareback riders, bull riders, saddlebow riders pooled) are provided in Figure 8. The competitive level of rodeo riders was moderately correlated with age (ρ = 0.43 [0.09–0.71], $p = 0.013$) and rodeo experience (ρ = 0.37 [−0.02 to 0.71], $p = 0.050$). Bent-leg abduction (ρ = 0.43 [0.08–0.67], $p = 0.014$) and straight-leg adduction (ρ = 0.56 [0.25–0.76], $p < 0.001$) and abduction (ρ = 0.49 [0.12–0.73], $p = 0.005$) forces moderately correlated with competitive level. Similarly, isometric neck flexion force moderately correlated with competitive level (ρ = 0.43 [0.10–0.68], $p = 0.016$). The competitive level of the riders also moderately correlated with rotational push-pull power (ρ = 0.50 [0.17–0.74], $p = 0.004$).

Nonsignificant, but possibly meaningful, correlations were found between riding level and current event experience (ρ = 0.30 [−0.07 to 0.63], $p = 0.112$), bent-leg hip adduction (ρ = 0.33 [−0.02 to 0.62], $p = 0.063$), and lateral bound power (ρ = 0.34 [0.01–0.61], $p = 0.058$).

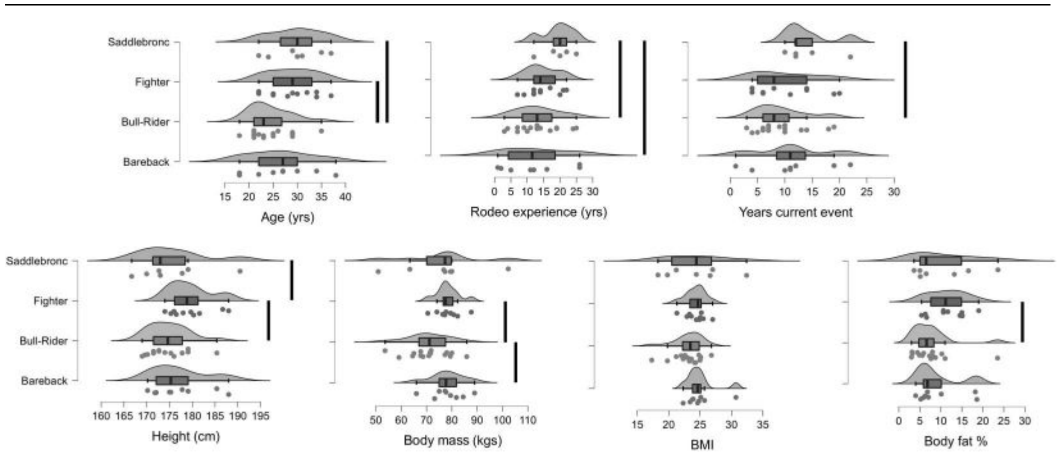

Figure 5. Raincloud plots of individual age, experience, and anthropometric data between rodeo events. Box plots illustrate the median, interquartile range, and minimum and maximum values. Individual data points beyond the whiskers are considered outliers (quartile ± 1.5 × interquartile range). Black bars = significant pairwise difference ($p < 0.05$).

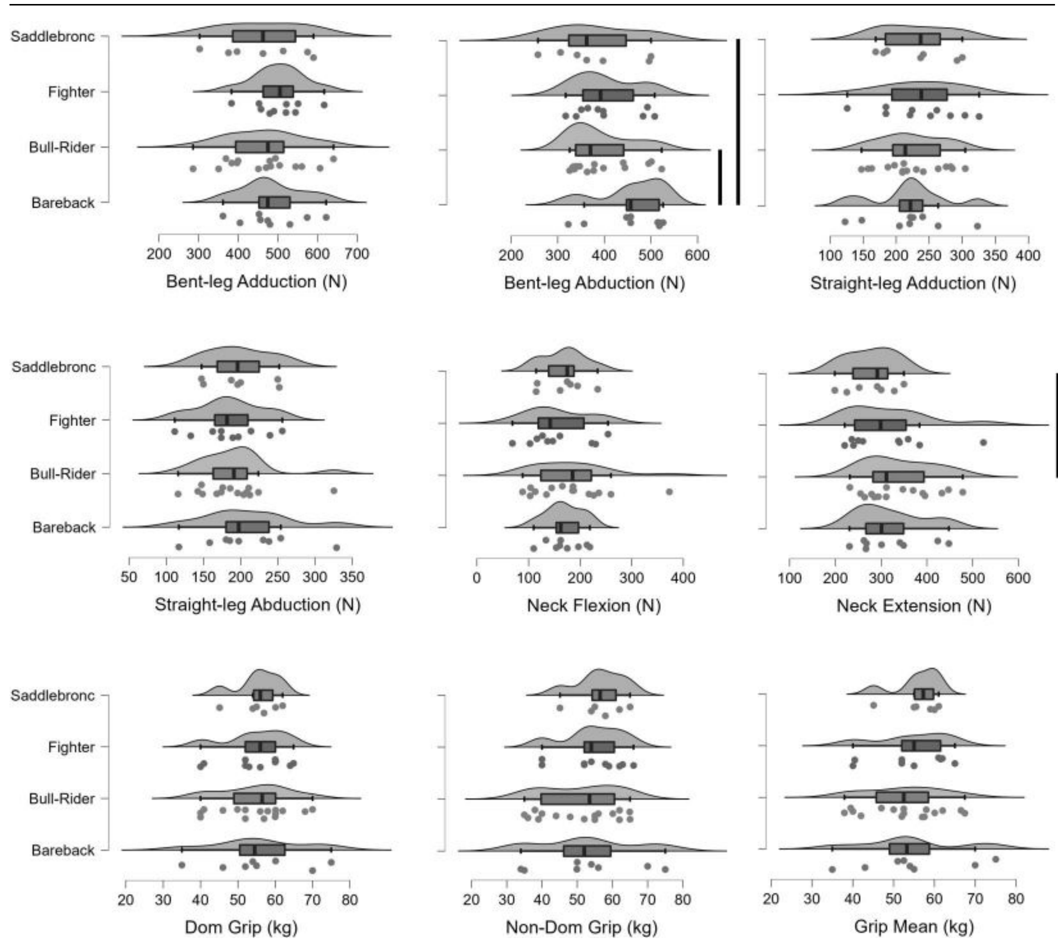

Figure 6. Raincloud plots of isometric performance data between rodeo events. Box plots illustrate the median, interquartile range, and minimum and maximum values. Individual data points beyond the whiskers are considered outliers (quartile ± 1.5 × interquartile range). Black bars = significant pairwise difference ($p < 0.05$).

Fighters. Scatter plots of significant ($p < 0.05$) correlations between anthropometric and performance tests, and competitive fighting level are provided in Figure 9. Competitive fighting level moderately correlated with age (ρ = 0.64 [0.11–0.90], p = 0.036) and largely correlated with 10 kcal time trial performance (ρ = −0.739 [−0.96 to −0.15], p = 0.009).

Nonsignificant, but potentially meaningful, correlations were found between fighting level and rodeo experience (ρ = 0.37 [−0.36 to 0.88], p = 0.261) and current event experience (ρ = 0.41 [−0.35 to 0.92], p = 0.216). Potentially meaningful correlations were also found between competitive level and bent-leg adduction (ρ = 0.50 [−0.13 to 0.90], p = 0.14) and abduction (ρ = 0.35 [−0.36 to 0.92], p = 0.35), and straight-leg adduction (ρ = 0.56 [−0.10 to 0.94], p = 0.090) and abduction (ρ = 0.40 [−0.33 to 0.93], p = 0.25). Squat jump (ρ = 0.45 [−0.27 to 0.89], p = 0.23), RSI (ρ = 0.39 [−0.34 to 0.84], p = 0.24), and chest press (ρ = 0.47 [−0.11 to 0.88], p = 0.144) also held potentially meaningful correlations with fighting level.

Performance Testing Relationships

Heatmaps of Pearson's correlations between all anthropometric and performance variables for all riders and fighters pooled (N = 43) are provided in Supplemental Digital Content (see Figure 3, http://links.lww.com/JSCR/A368).

Discussion

The purpose of the present investigation was to develop the first normative anthropometric and physical performance data for seldom-studied rodeo athletes. We also aimed to determine which age, experience, anthropometric, and performance characteristics relate to rodeo performance level. The key findings were that age, total rodeo experience, event experience, hip and neck flexion strength, and rotational power were related to riding performance. By contrast, age and anaerobic power were associated with bullfighting performance. In addition, fighters had greater RSIs than riding athletes. The potential cultural, physiological, and biomechanical explanations for our findings and implications for practitioners and researchers are discussed herewith.

Of the riders, bull riders were the youngest, with the least rodeo and event experience, followed by bareback riders and saddle bronc riders, respectively. This finding perfectly aligns with longitudinal findings on between-event injury rates reporting that bull riders suffered the most injuries, followed by bareback and saddle bronc athletes (37). Likewise, fighters were also older and more experienced than bull riders, lending credence to anecdotes that fighters are commonly former riders who wish to remain active in the rodeo community. Therefore, it is plausible that bull riders have shorter careers or eventually shift to events with lower injury risk.

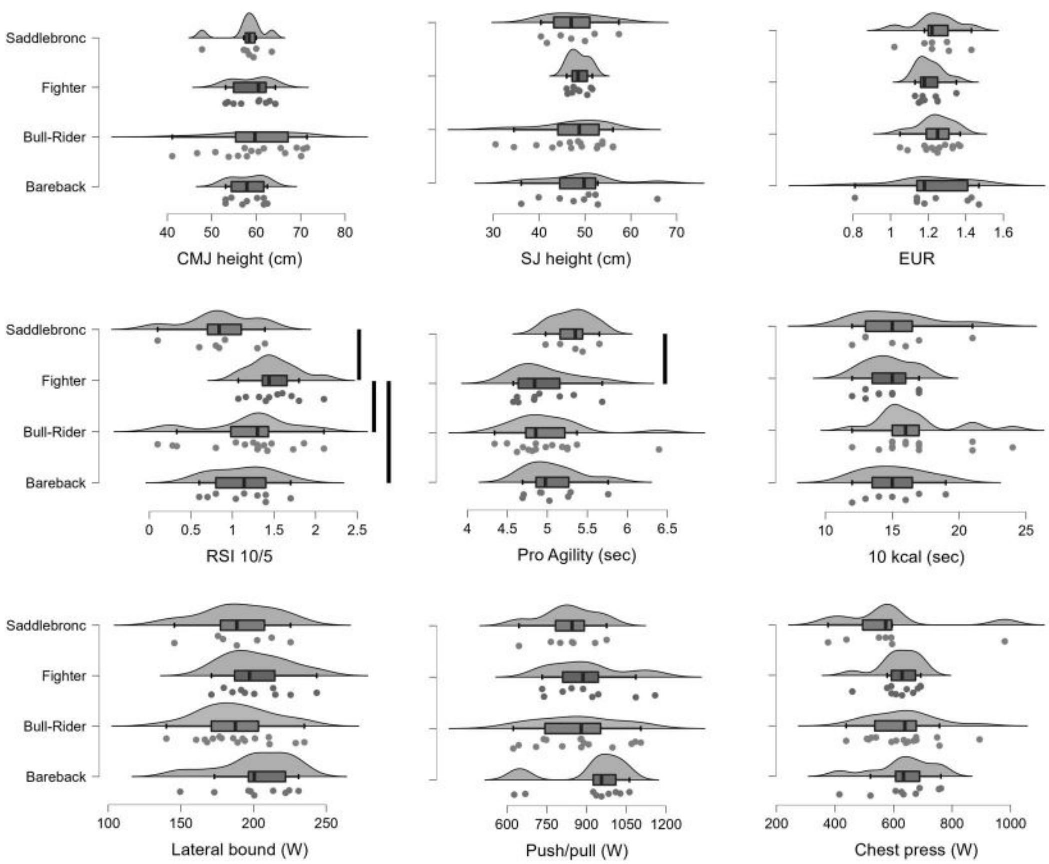

Figure 7. Raincloud plots of dynamic performance data between rodeo events. Box plots illustrate the median, interquartile range, and minimum and maximum values. Individual data points beyond the whiskers are considered outliers (quartile ± 1.5 × interquartile range). Black bars = significant pairwise difference ($p < 0.05$).

The most consistent between-event findings were between bull riders and fighters, with the bull riders being shorter, lighter, and leaner than the fighters. Bareback athletes were also heavier than the bull riders. Because of the greater twisting and turning in bull vs. saddle bronc or bareback riding, being shorter and lighter may be advantageous as rotational inertia would be lesser when compared with taller or heavier athletes. However, this theory would have to be confirmed through motion capture or inertial measurement units. Height, body mass, and body fat percentage did not correlate to riding performance for any subgroup or pooled for all riders, suggesting the importance of firm cutoffs instead of linear relationships.

Although we hypothesized the importance of adductor strength, all isometric hip adduction and abduction force measures were significantly or moderately correlated with riding (but not fighting) performance, with minimal between-event differences. This finding could be the result of several factors, including agonist-antagonist neural inhibition and coactivation (9,23), or simply that hip adduction and abduction strength are highly associated ($r = 0.45–0.67$, all $p < 0.01$, see Figure 3, Supplemental Digital Content, http://links.lww.com/JSCR/A368). Regardless, combined with previous research determining the prevalence of hip injuries (38), our findings suggest that it is wise for riders to focus on building and maintaining hip strength. However, it is beyond the scope of this study to determine whether building hip strength will directly affect performance or injury risk. Neck strength is another potentially important quality for rodeo athletes because concussions and head injuries are among the most commonly suffered (8). Our data show that better riders tend to have stronger neck flexors, and previous studies have determined the beneficial effects of neck strength on head kinematics (6,19) and concussion occurrence (10,17). However, like hip strength, the relationship between neck strength and concussion risk remains to be determined in a rodeo context. Contrary to our hypothesis, grip strength did not correlate with riding level, suggesting a minimum threshold for performance that is not improved with greater strength. Therefore, riders may not need to prioritize grip training outside of individual circumstances. However, the assessed arm position and dynamometer diameter are substantially different than the gripping position and task during riding events, potentially challenging the test's specificity.

Although 6 of the 9 dynamic performance measures found no between-event differences, lateral bound and upper-body rotational power did correlate with riding performance. Although not specific to riding, the lateral bound heavily uses the hip musculature, which is essential for riding performance and may be a better test for assessing rapid force production. Conversely, the relationship between rotational power and riding performance is more straightforward. This is the result of the rotational forces that must constantly be resisted to maintain position on an animal, especially with one hand secured to a rope, with the other held above the riders' center of mass (5). Thus, it is likely that riders should prioritize rotational power and antirotation-focused exercises in their physical preparation.

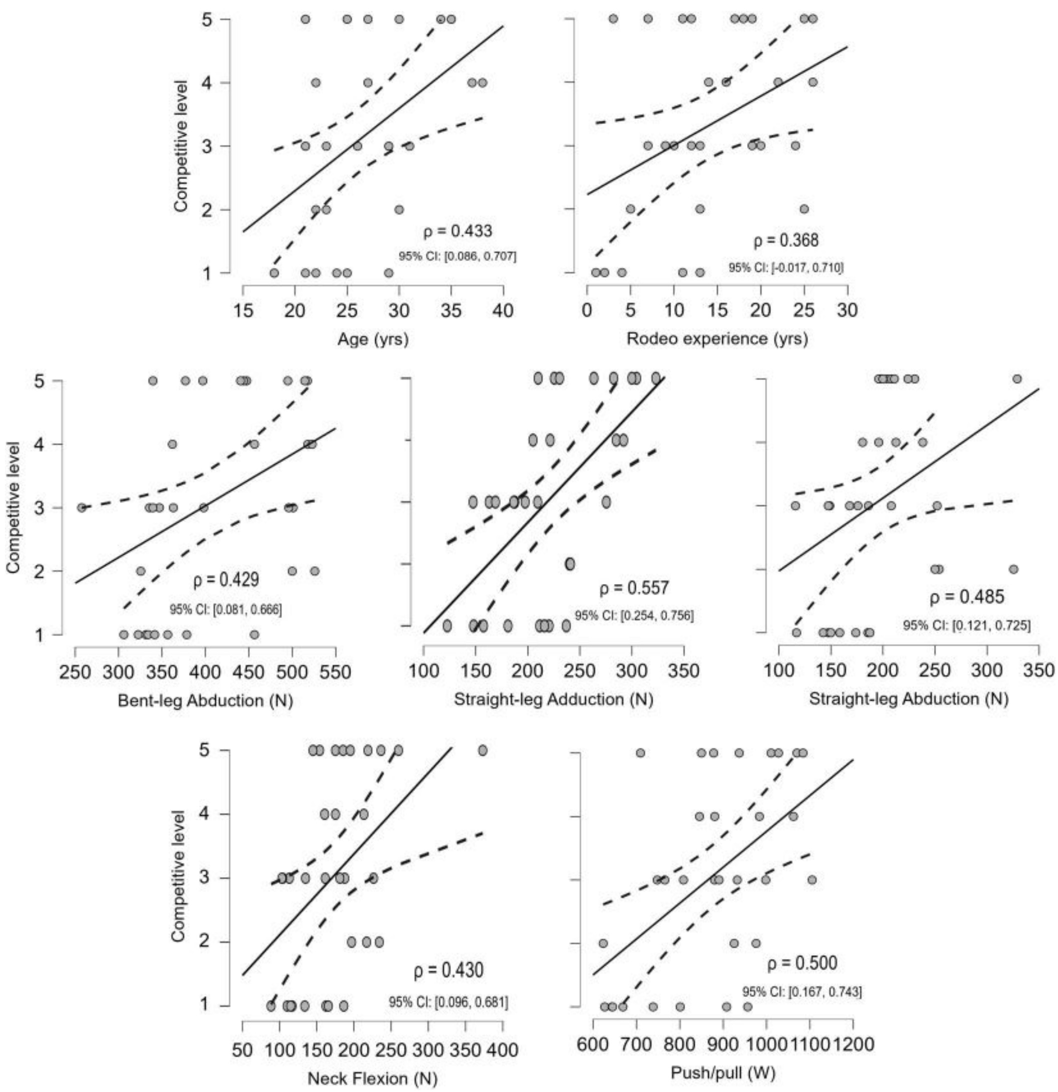

Figure 8. Statistically significant ($p < 0.05$) Spearman's correlations (ρ) between competitive level, and anthropometric and performance characteristics of the pooled riders ($n = 29$).

Fighters had significantly greater RSIs and completed the pro-agility and time-trial tests in the shortest times. The RSI and pro-agility results are easily explainable because of specificity because the fighters are the only rodeo event examined who perform on their feet, rapidly changing directions. Therefore, long-term musculotendinous and neural adaptations from rodeo-specific

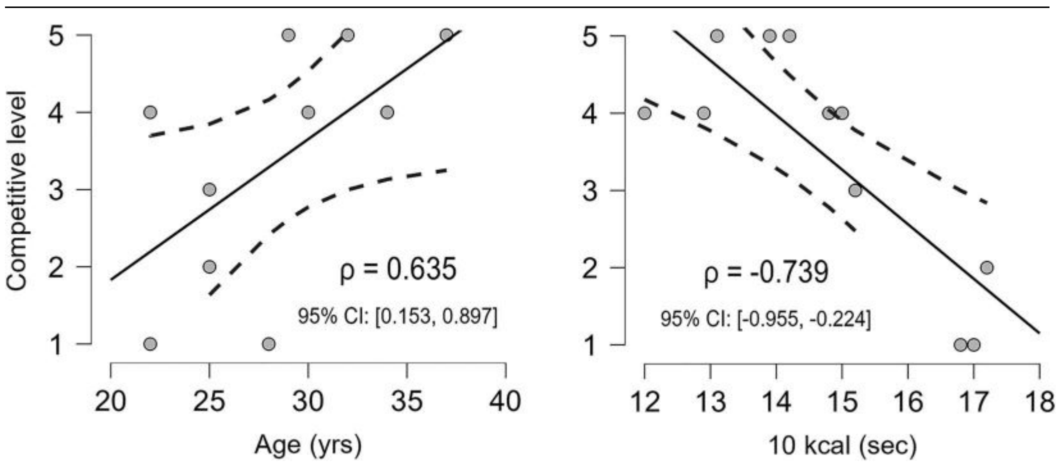

Figure 9. Statistically significant ($p < 0.05$) Spearman's correlations (ρ) between competitive level, and anthropometric and performance characteristics of the bullfighters ($n = 11$).

training may be at play. However, neither jump heights nor EUR favored the fighters, suggesting that potential musculotendinous differences may exist predominantly in the triceps surae complex (1). Reactive strength index, pro-agility, and air bike tests were also the only ones in the testing battery that required repeated contractions or efforts. Therefore, the long rest periods afforded to riders during competition, in contrast with the fighters performing nearly nonstop, may have underpinned the present results. Regardless of the between-group differences, only time trial performance correlated with fighting competitive level. Although challenging to rationalize fully, it is plausible that fighters with greater anaerobic fitness can perform crowd-pleasing stunts regularly, making themselves more likely to be invited to higher-level rodeos.

Although the primary purpose of the investigation was accomplished, there are several limitations and future research directions of which to be aware. We could not directly measure riding performance, and fighting performance is highly subjective. Therefore, we used competitive status to delineate the abilities of the subjects. Similarly, we did not quantify the current training practices of the subjects. It is, therefore, plausible that prize-winning and highly sponsored athletes have more time and resources to invest in specific physical preparation. Conversely, lower-achieving rodeo athletes may have to rely on physical labor for income, potentially negatively impacting performance.

Although challenging to recruit high-level rodeo athletes, our limited individual event sample sizes for bareback ($n = 9$) and saddle bronc- ($n = 7$) riders made some between-event analyses questionable. This observation is clear because a single outlier could have a large impact, as visually apparent in Figures 5–7 and demonstrated by frequently large confidence limits. For example, trivial values are included in the 95%CLs for correlations between riding performance and current event experience, bent-leg adduction, and neck flexion. Also, the physical characteristics of youth and female rodeo athletes and other events such as barrel racing, calf roping, and steer wrestling require examination. Although we report our intersession and intrasession reliability data for previously unpublished tests, our sample size for these data was relatively small ($N = 8$). Therefore, more extensive studies are required to investigate the validity and reliability of the accelerometer-derived RSI 10-5 stiffness, pneumatic power, and 10 kcal time trial tests.

The pneumatic cable station could only be adjusted in large increments (15°, height: 18.8 ± 7.7 cm [range: 5–27 cm] at the distal attachment points), making personalization based on height difficult. Therefore, readers should know that relative between-subject cable positions were not uniform. Other tests, including strength endurance or reaction times, may unveil additional findings. Likewise, we did not include any direct measures of core stability (e.g., plank test) or glenohumeral strength that could be critical to riding performance. A lack of range of motion assessment was a similar oversight and warrants investigation. Longitudinal investigations are required to understand how performance characteristics relate to injury and recovery rates. Also, training studies are needed to elucidate the cause-and-effect relationship between physical traits and rodeo performance.

Practical Applications

Although previous articles have reported injury (26) or cardiovascular and metabolic data (25) in rodeo athletes, this study is the first to report normative and correlational strength and power performance data in a rodeo population. From our data, hip strength and upper-body rotational power seem vital for bareback riders, bull riders, and saddle bronc riders. Therefore, strength and conditioning coaches should consider including hip adduction and abduction–focused exercises like Copenhagen planks, banded adductions, and lateral slide adductions (36). Rotational exercises, such as medicine ball throws, may also belong to a physical preparation program (13). Neck flexion strength, likely trained through manual isometrics and bridges (15), also seem crucial. Conversely, high anaerobic power and RSI were the most apparent qualities of interest for bullfighters. These data highlight the likely need for greater foci on event-specific physical preparation to maximize performance. Sports medicine professionals can use the normative data when working with rodeo athletes in return-to-sport contexts. Finally, the normative data may increase motivation and facilitate goal setting. We hope that this study encourages other groups to examine rodeo athletes and bring sports science to this often-forgotten sport.

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