Workday Habits and Fatigue of American Jockeys

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Objective: The study aims to characterize the workday habits of American jockeys and evaluate the relationship between workday habits and fatigue through changes in postural stability (balance) across their workday. **Methods:** Thirty-seven jockeys participated in prerace and postrace day testing. Jockeys completed questionnaires on workday habits and a 2-minute balance test with triaxial accelerometers on the unstable surface and sacrum. **Results:** The median caloric intake during their workday was 263.8 kcal. Wilcoxon signed rank tests reported no significant changes in balance across the workday. Statistically significant ($P < 0.05$) correlations existed between sleep ($\tau = -0.41$) and number of races ridden ($\tau = 0.37$) with balance variables. **Conclusions:** American jockeys exhibit weight-cycling behaviors, primarily restricted caloric and fluid intake. No changes were evaluated in balance across the workday. Future research should focus on evaluating other fatigue mechanisms involving abdominal muscle fatigue and cognitive fatigue.

Keywords: accelerometer, horse racing, postural stability

LEARNING OUTCOMES

- Characterize workday habits of American jockeys, including sleep, caloric and fluid intake, and sauna use.
- Compare postural stability using an occupation-specific stability test across American jockeys' workday to evaluate for peripheral fatigue.
- Identify relationships between workday habits and changes in postural stability across the workday.

Thoroughbred jockeys are nonstandard independent contractors whom trainers hire to exercise and race young racehorses. Jockeys are at a high risk of falling due to a multitude of factors such as the unpredictability of young horses and racing in a field with several other horses.[1–5] American jockeys have the highest reported rate of injuries worldwide, at 4.5 per 1000 mounts with other countries reporting rates between 0.6 and 1.8 injuries per 1000 mounts.[1–5] Jockeys are at 203 greater odds of experiencing a musculoskeletal injury if they fall off their horse than if they do not.[5] Legg and colleagues identified that the incidence rate of injuries increased with the number of races a jockey rode in a day and during the summer, suggesting fatigue as a possible contributor to fall risk.[6] Fatigue could arise from various pathways, including muscular fatigue, age, and lifestyle factors.[7–9] Addressing fatigue is a common pathway to decrease workplace and sport-related errors and injuries.[10–12] Therefore, understanding workday fatigue and potential ways to combat fatigue in jockeys is critical to reduce injuries in this unique population.

Elite athletes develop sports expertise specific to their sports demands that includes refined technical skills, motor development and control, tactical understanding, and psychological preparedness.[13–15] Jockeys' distinctive riding position requires them to develop sports expertise to maintain balance while controlling the horse. Their riding position, known as the Martini-glass position, is recognized as the most unstable posture in all equestrian sports.[16] This position requires the jockeys to crouch over the saddle with their back parallel to the ground and only their toes in the stirrups.[16,17] Jockeys maintain this position while simultaneously navigating their horse around a track at speeds up to 40 mph and coordinating their movement cycle with those of the horse to optimize performance.[18] These demands require the jockey to have strong postural control to maintain their center of mass (COM) over the base of support—their stirrups. For jockeys to maintain their balance or postural stability while racing (ie, competition) and exercising (ie, conditioning or practice) horses, they must synthesize information from the somatosensory, visual, and vestibular systems efficiently and effectively.[19] The central nervous system (CNS) integrates this feedback with information from the environment to provide the musculoskeletal system information to maintain postural stability.[9] For jockeys, maintaining postural stability while simultaneously navigating their horse around a track with up to 19 other horses is critical to staying safely on top of the horse.

Postural stability and control can deteriorate across a workday from fatigue, increasing the risk for making an error that can lead to injury. Fatigue is complex and can be impacted by physical, mental, and emotional stress.[20,21] Lifestyle factors and overall health can contribute to how the body handles stress and fatigue, and occupational demands often shape an individual's lifestyle habits.[22,23] Such lifestyle demands for jockeys include having a translocational lifestyle, moving from one race meet to another throughout the year. A race meet is a series of horse races that take place over a set period at a specific racetrack. In the United States, a meet lasts anywhere between 6 days and 5 months, and there are various meets that occur simultaneously across the country. Racing occurs year-round, leaving no "off-season."[1] As jockeys become more successful, defined by winning more races and races with higher prize money, they often travel more frequently and greater distances. These demands can include traveling across the region and the country within a short period for various races with higher prize money (stake races) and to ride better horses (mounts). Depending on the demand for a jockey from various trainers and owners, jockeys may ride 1 to 12 races in a day. However,

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Data availability: The data that support the findings of this study are available on request from the corresponding author, Michaela M. Keener, PhD. The data are not publicly available as our informed consent only allows for the sharing of deidentified data for secondary analysis upon request.
Ethical considerations: This study was approved through the University of Kentucky's institutional review board (protocol number: 61443). Participants were given time to read the consent, ask questions, and then the choice to sign the informed consent. The informed consent was signed by all participants prior to any data collection.
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to the authors' knowledge, no data have been published on the frequency of this travel or the average number of mounts a jockey riders per day in the United States. In addition to this translocational lifestyle, jockeys must meet strict weight allowances.

Jockeys are required to weigh in before and following each ride, at a predetermined weight for each horse and race. These weights range from 116 to 128 lb, which varies based on physical location and local jurisdiction requirements.[1] Previous studies have identified that to meet these weight restrictions, jockeys often utilize weight-cycling habits, including restricted caloric and fluid intake, sitting in saunas, working out in sweat suits, and flipping (making themselves throw up).[24–30] Previous research highlights that poor sleep quality, dehydration, and low caloric intake can contribute to fatigue in young, healthy adult males.[7–9] Based on past studies, many of the jockeys meet these potential lifestyle variables that can increase fatigue. Therefore, it is important to evaluate jockeys' fatigue across the workday while considering their occupational-specific position and their workday habits.

Evaluating postural stability using accelerometers is becoming more common and has been used to evaluate fatigue, and predict performance.[31,32] Using triaxial accelerometers to quantitate the COM movement during static and dynamic postural stability tasks in research settings demonstrates excellent test-retest reliability, the ability to differentiate between static and dynamic tasks, and provides high correlations between it and gold standard assessments.[32–35] Postural sway is always present, regardless of body position, as muscles cannot maintain constant tension, requiring constant small changes in COM.[36] Therefore, the amount of sway of the COM provides information on fatigue and the level of fatigue.[37] The reliability of triaxial accelerometry and ease of use allows for field analysis of fatigue, including in occupational settings with transient populations, such as jockeys. Cullen and colleagues who utilized the Y-balance test in jockeys suggested the need for a jockey-specific balance test in future research.[38] Legg and colleagues used a jockey-specific timed test on a fixed sawhorse where riders had to maintain their position for up to 3 minutes (2023). For the current study, we wanted to evaluate jockey's postural stability in their position on an unstable surface without the ability to grip a horse or sawhorse with their knees to aid in balance. Therefore, an occupational-specific postural dynamic stability test for jockeys using triaxial accelerometers was designed to evaluate jockey fatigue.

To the authors' knowledge, no prior study has evaluated workday fatigue and its relationships to lifestyle habits in American jockeys. Therefore, the purpose of this study was two-fold. The first purpose was to characterize the workday habits of American jockeys through self-reported questionnaires completed at the beginning and end of their race day to determine if American jockeys utilize similar weight-cycling behavior to jockeys in other countries. It was hypothesized that, like jockeys in other countries, American jockeys would utilize weight-cycling habits, including restricted caloric and fluid intake. The second purpose was to evaluate the relationship between weight-cycling habits and the change in postural stability measurements with an occupation-specific test. First, it was hypothesized that measures of postural stability across their workday would decrease, characterized by more movement in their position at the end of their workday compared with the start of their workday. Second, we hypothesized that as jockeys utilized weight-cycling behaviors more (decreased sleep, caloric and fluid intake, and increased sauna use), they would experience greater negative changes in postural stability across the workday. Third, we hypothesized that jockeys that perceived less energy, more thirst, and more hunger at the end of the day would experience larger negative changes in postural stability across the workday. Finally, we hypothesized that jockeys who rode more races would show more significant negative changes in postural stability variables across their workday. By establishing these workday habits and their potential influence on postural control, we can provide more insight into future interventions to mitigate fall and injury risks.

METHODS

Study Design, Population, and Sampling

The data presented in this manuscript were initially collected, analyzed, and presented as part of the first author's doctoral dissertation at the University of Kentucky.[39] The research team adhered to STROBE Guidelines (Supplementary 1, http://links.lww.com/JOM/B798). The research team recruited American jockeys across a single race meet at a racetrack in Kentucky during April 2021. Participants were recruited through word-of-mouth during the race meet. Eligibility criteria included the following: (1) aged 18 years or older; (2) riding at least one Thoroughbred race on the day of testing; and (3) had not experienced a lower extremity injury in the past 6 months that kept them from work for longer than a week. This study was approved through the University of Kentucky's Institutional Review Board (protocol number: 61443), and participants completed and signed informed consent prior to any data collection.

This study used a repeated-measures study design where jockeys were asked to engage in testing prior to riding any races for the day, and to return after their final race of the day to complete the protocol. Data collection occurred across 5 days over a 20-day race meet. Although jockeys were encouraged to return on multiple days during the meet, the postural stability analysis for this study only included data from each jockey's first day.

This study represents the research team's initial effort to engage with the jockey community in a field setting. To encourage repeated participation, the research team focused on relationship building in the community. As such a convenience sample was used in this study, and no power analysis was completed prior to data collection.

Questionnaire

Jockeys were asked a series of questions by the research team in English during prerace and postrace day testing sessions (see Table 1). To help with assessing fluid intake, the same 24 fl oz travel mug was used for jockeys to use as a visual. Data including the jockeys' required race weight(s), number of races ridden that day, and distance of race were retrieved from publicly available racing cards.

Occupation-Specific Postural Stability Test

The Equestrian Athlete Initiative, housed in the Sports Medicine Research Institute, developed a novel postural stability test for jockeys. The test is conducted in the rider's occupation-specific position on a Bosu Balance Ball (BOSU HEDSTROM Fitness, LLC, San Diego, CA) turned so the ball is facing downward and the flat platform is facing upward (see Fig. 1), making an unstable surface. To evaluate postural stability, we used two Xsens triaxial accelerometers (Xsens Technologies B.V., Enschede, the Netherlands). One was placed on the center of the balance ball's platform, and another was placed on the jockey's L5. The L5 is the most used location for triaxial accelerometer location in postural stability assessments, as it is believed to be closest to the COM.[40–43] Both accelerometers were secured with tape. The accelerometers collected data at 60 Hz and streamed the data directly to an iPad over Bluetooth.

To evaluate position of the jockeys throughout their test, an iPad equipped with MyDartfish Pro (Dartfish, Fribourg, Switzerland) was set up 2 m to the right of the Bosu Balance Ball to capture sagittal plane biomechanics. Prior to the jockeys stepping onto the unstable platform, the research team explained that the jockey's would squat down into their own race position once on the platform. Jockeys were assisted in stepping onto the platform, and then were instructed to squat down into their jockey position, and to hold as still as possible for 2 minutes. The research team did not want to interfere with what the jockey felt their own position was, as each jockey's position is unique to their own anthropometric measurements. Therefore, the

TABLE 1. Questions the Research Team Asked the Jockeys During Prerace and Postrace Day Testing Sessions

Prerace Day Session Questions	Postrace Day Session
1. How many hours of sleep did you get last night?	1. Did you take a nap today? If yes, how long?
2. Have you traveled outside of the state in the past 48 hours? If so, where to, and how did you get there (ie, car or fly)?	2. Did you spend any time in the sauna today? If yes, how long?[a]
3. Have you had an injury in the past 6 months, or since we last saw you?	3. Have you had any food since we saw you earlier today? If yes, what and how much?
4. Have you had a concussion in the past 6 months, or since we last saw you?	4. Have you had any water since we saw you earlier today? If yes, how much?
5. Did you exercise horses this morning? If yes, how many?	5. Have you drank anything else besides water since we saw you earlier today? If yes, what, and how much?
6. Have you had anything to eat today? If yes, what, and how much?	6. On a scale from 1 being starving, to 5 being full, how do you rate your hunger?
7. Have you had any water today? If yes, how much?	7. On a scale from 1 being extremely thirsty to 5 experiencing no thirst, how do you rate your thirst?
8. Have you had any other drink besides water today? If yes, what, and how much?	8. On a scale from 1 being extremely tired, to 5 being extremely well rested, how do you rate your energy?
9. On a scale from 1 being starving, to 5 being full, how do you rate your hunger?	
10. On a scale from 1 being extremely thirsty to 5 experiencing no thirst, how do you rate your thirst?	
11. On a scale from 1 being extremely tired, to 5 being extremely well rested, how do you rate your energy?	

[a]Indicates a question added to the IRB with a modification review after the first day of data collection following feedback provided by the jockeys.

research team did not require jockeys to hold a specific knee or hip angle during the testing. After the 2-minute hold, the research team assisted the jockeys off the stability ball.

Data Processing

The accelerometer data were extracted from the accelerometers using XSens Dot software. Extracted data included free acceleration and gyroscope data in x, y, and z directions. The data were then processed in a custom Matlab (The Mathworks Inc, Natick, MA) code written by the research team. The code calculated a resultant (R) vector using the magnitude of acceleration in all three directions and smoothed the data with a fourth-order Butterworth filter with a lowpass of 10 Hz and cutoff frequency of half of the sampling frequency (30 Hz). The code then calculated the root mean square (RMS) for x, y, z, and R. Data from the z axis were excluded from the analysis, as it primarily capture vertical motion, which remained constant due to gravitational forces throughout the test and jockeys remaining steady in this axis. Direction of each the three main axes (x, y, and z) for each accelerometer is in Figure 1. Three frames (5 seconds in, 60 seconds in, and 5 seconds from the end of the 2-minute test) were extracted from the sagittal plane Dartfish videos. Sagittal ball tilt from the front of the ball, ankle, knee, hip, and trunk angles was measured in the three extracted frames.

Caloric intake was estimated using the WebMD Food calculator based on the self-reported food and fluid intake during the pretest and posttest.[44] For jockeys who participated multiple days, the median answer for their daily questionnaire characteristics (sleep, travel, caloric intake, fluid intake, and time in sauna) was calculated and used for analysis.

Statistical Analysis

All data from accelerometer data, daily questionnaires, and the online racing database were combined into a single file. Data were then imported into SAS (SAS Institute Inc, Cary, NC) for analysis. To evaluate change in postural stability across the day, only the IMU data from the first day a jockey participated were included in the analysis. The first day of participation in the study was used for analysis as this was our largest sample size. Additionally, analyses of changes across the days for jockeys who returned multiple days showed no significant differences using a Kruskal-Wallis test as data were nonparametric. To evaluate workday habits, the median of all the days a jockey participated in data collection (up to 5 days) was calculated and used for the workday characteristics.

Tests for normality were run for all numerical variables using Shapiro-Wilk testing. All variables were nonnormally distributed. To evaluate changes in accelerometer and gyroscope data, the difference between predata and postdata was calculated for all variables by subtracting the prevalues from the postvalues. If there were missing data from one of the accelerometers, that participant was excluded from this portion of the analysis. To evaluate if there were changes in the jockeys' positions between the pretrial and posttrial, the values extracted from each test were averaged, and the prevalues were subtracted from the postvalues. Wilcoxon signed rank tests were used to evaluate for positional differences, with alpha set to 0.05.

Wilcoxon signed rank tests were used to test the hypotheses for changes in postural stability across the workday. Kruskal-Wallis H tests were used to evaluate the effects of age and caffeine intake on postural stability. A Bonferroni-adjusted P value was manually set to 0.0083 as there were six variables to evaluate a change in the dependent variable for both the ball and the jockey. Median, interquartile range, minimum, and maximum values were calculated for workday characteristics. Kendall tau correlation coefficients were calculated for numerical workday characteristics. Spearman correlation coefficients were calculated for categorical variables of perceived energy, thirst, and hunger. For all correlation, scatterplots were used to evaluate linearity. Statistical significance for all correlation coefficients was set at a threshold of $P < 0.05$. All statistical analyses were completed with RMS IMU data for the full 2-minute postural stability test, and the final minute of the postural stability test. Sensitivity analyses were not performed in this study due to the exploratory nature of the research and small sample size.

RESULTS

Thirty-seven race riders completed the testing protocol. Three of the participants were apprentice jockeys while the other 34 were licensed jockeys. Two participants were female while the remaining were males. Forty-six percent of the race riders were Hispanic. Of the race riders, 27% were 18–30 years old, 56.8% were 31–40 years old, and 16.2% were 41 years or older.

Median age and workday habit characteristics are in Table 2. Among jockeys included in the workday habit medians, 51.4% participated on a second day, 27.0% on a third day, 13.5% on a fourth day, and 8.1% on a fifth day during the 5-day period the research team was present at the track, for a total of 74 data points ($n = 37$). Eight race riders (21.6%) had traveled in the past 48 hours, with a median time of 4 hours of travel. Half of the reported travel was by car and the other half was by plane. Three race riders (8.1%) had fallen off a horse in the past 30 days and reported no injuries from their falls. No race riders reported experiencing a concussion in the past 30 days. Only 32 of 37 jockeys were asked about sitting in the hot box (sauna) as this variable

FIGURE 1. A jockey holding their position during the occupation-specific postural stability test with accelerometers on the low back at L5 (black circle) and the center of the Bosu ball (red circle) with the directions of axes for both accelerometer placement.

was not in the original IRB protocol and was added with a modification request following feedback from the jockeys. Approximately one third (34.4%) of the 32 jockeys reported using the sauna. Finally, 59.5% exercised horses in the morning prior to starting their race day.

Across the 74 data points of workday habits, 25.7% of the time participants reported not eating anything before their race day began. Breakfast sandwiches or equivalent with eggs, breakfast meat and toast (18.9%), eggs without toast (10.8%), and yogurt parfaits (5.1%) were the most common food that race riders consumed before their race day began. Other than water (56.8%), the most common fluids consumed before their race day began were coffee (70.3%), sugar-free energy drinks (10.8%), and orange juice (9.5%). Sixty percent of the jockeys ate between their pretesting and posttesting session, with 59% of them only reporting eating candy. For those who consumed fluids between their pretesting and posttesting session, the most common choices were water (50.0%), electrolyte drinks (Gatorade, Powerade, Pedialyte) (12.2%), soda (10.8%), sugar-free energy drinks (10.8%), and coffee (8.1%).

Due to issues with the IMU data streaming to the iPad via Bluetooth, only 27 complete preball and postball IMU data sets were used for analysis of postural stability across the first workday. Considering the Bonferroni-adjusted P value was set to 0.0083, there were no significant changes in any of the accelerometer and gyroscope data between the preday and postday stability scores for the full test or the final minute of the test (see Table 3). Age had no significant effect on any of the postural stability variables based on the results of the Kruskal-Wallis H tests. There were no significant differences in position between the pre-2D and post-2D data.

Kendall tau coefficients of numerical workday habits were used to evaluate workday habits relationship with other workday habits and postural stability outcomes (Table 4). There was a negative moderate correlation ($\tau = -0.41$) between sleep and change in Jockey RMS ML Acceleration ($P < 0.05$). This finding indicates that less sleep correlated with a greater change in the left to right (ML) acceleration, reflecting decreased stability throughout the workday in the ML plane. There were no significant correlations between perceived thirst, hunger and energy, and postural stability variables.

DISCUSSION

This study is the first to evaluate workday habits and postural stability in American jockeys to the authors' knowledge. This study successfully sampled a diverse American jockey population to assess workday habits and fatigue. The current study had two purposes. The first purpose was to characterize the workday habits of American jockeys and determine if American jockeys utilize similar weight-cycling behavior to jockeys in other countries. It was hypothesized that, like jockeys in other countries, American jockeys would utilize weight-cycling habits, including restricted caloric, fluid intake, and sauna use. This hypothesis was partially supported as jockeys reported most often using restricted caloric and fluid intake, but do not utilize the sauna as often as jockeys in other countries.[24–26,28,45–47] The second purpose was to evaluate the relationship between weight-cycling habits and fatigue across the workday utilizing an occupation-specific postural stability test. It was hypothesized that measures of postural stability would decrease, characterized by more movement in their position at the end of their workday compared with the beginning. This hypothesis was not supported. Second, we hypothesized that as jockeys utilized weight-cycling behaviors more (decreased sleep, caloric and fluid intake, and increased sauna use), they would experience greater changes in postural stability across the workday. This hypothesis was only partially supported as statistically significant correlations ($P < 0.05$) were found but the strength of these correlations were weak. Third, we hypothesized that jockeys that perceived less energy, more thirst, and more hunger at the end of the day would experience larger changes in postural stability across the workday. This hypothesis was not supported as there were no significant correlations between these perceptions and changes in accelerometer data across the workday. Finally, we hypothesized that jockeys who rode more races would show greater changes in postural stability across their workday. This

TABLE 2. Median, Interquartile Range (IQR), and Ranges of Workday Habits Self-Reported by the Jockeys

Variable (Unit)	Median	IQR	Range	
Age (yr)	33.0	9.0	22.0	55.0
Sleep (hr)	7.0	1.3	3.0	8.0
Distance traveled in past 48 hours (hr)	4.0	2.0	3.0	8.0
Prehunger (Likert scale 1–5)[a]	4.9	1.8	2.0	5.0
Prethirst (Likert scale 1–5)[a]	4.0	1.5	2.0	5.0
Pre-energy (Likert scale 1–5)[a]	4.5	1.3	2.0	5.0
Pre amount of water consumed (L)	0.2	0.4	0.0	1.4
Preamount of fluid (excluding water) consumed (L)	0.2	0.2	0.0	0.9
Calories consumed before the race day (kcal)	200.0	146.3	0.0	437.5
Posthunger (Likert scale 1–5)[a]	4.0	1.5	1.0	5.0
Postthirst (Likert scale 1–5)[a]	3.3	2.0	1.0	5.0
Postenergy (Likert scale 1–5)[a]	4.0	1.5	1.0	5.0
Postamount of water consumed (L)	0.1	0.2	0.0	0.6
Postamount of fluid (excluding water) consumed (L)	0.0	0.1	0.0	0.5
Time in sauna (min)	30.0	20.0	5.0	120.0
Calories consumed during race day (kcal)	14.2	111.7	0.0	200.0
Total calories consumed across workday (kcal)	263.8	150.0	75.0	472.5
Total water consumed during workday (L)	0.4	0.5	0.0	1.8
Total fluids (including water) consumed during workday (L)	0.8	0.5	0.2	2.2
Races ridden (n)	2.0	2.5	1.0	6.0
Days since last day off of racing (n)[x]	1.0	1.5	1.0	4.0
Days since last win (n)	7.5	10.1	1.0	36.5
Total distance ridden in races (km)[y]	2.9	3.2	0.9	8.7

[a]Likert scales are so that 1 represents being starving, extremely thirsty, and extremely tired, while 5 represents being full, experiencing no thirst, and being extremely well rested for the respective scales.

[x]Days since last day off from racing does not account for the number of days it has been since they had a day off from riding, as public records were not available to state if jockeys were exercising horses on days off from racing or not.

[y]Total distance ridden in races only includes the race distance, and not any distance ridden warming up before the race, after the race, or in morning workouts.

hypothesis was partially supported as there was statistical significance ($P < 0.05$) between the number of races ridden and changes in accelerometer data throughout the workday, but this correlation was weak. The data presented in the current study provide valuable insights into jockeys' workday habits and postural control, highlighting patterns that may inform targeted strategies for enhancing their well-being, and guiding future research regarding workday fatigue.

The current study found that the American jockeys' intake was a median of 263.8 calories during their approximated 12-hour workday. The 12-hour workday approximation was based on 46% of the jockeys participating in the last or second to last race of the day, with 64.7% of those jockeys also exercising horses that morning. At the time of the study, tracks in the region open at 5:30 AM for exercising horses, and the final race of each workday occurred between 5 and 6 PM. Accounting for the median sleep of 7 hours in this sample, this indicates a jockey's workday could account for approximately 71% of their waking hours. Jockeys' caloric intake in other countries for their entire day, not just their workday, reports ranges from 1360–1786 calories a day.[17,25,46,48,49] The median of the current study accounts for approximately 14%–19% of the average daily caloric intake reported in other studies for jockeys globally. When evaluating the estimated caloric intake from the current study and subtracting an estimated 43.0 kcal per race ridden, 20% of the jockeys had negative values indicating a caloric deficit.[17] This estimate did not account for additional calories for resting metabolic rate, or other activities, including those expended during exercising horses, as we did not ask the number of horses ridden, type of exercise session, or time spent exercising horses. For jockeys in this study, we considered that the percentage of calories

TABLE 3. Medians, Interquartile Range (IQR), Variance, and Results of Wilcoxon Signed Rank Test for Change From Prerace to Postrace Workday Inertial Measuring Unit (IMU) Root Mean Square (RMS) Data From the Center of the Bosu Ball and the Jockey's Sacrum, Split into the Whole 2-Minute Test and Only the Final Minute of the Test

	Full 2-Minute Test				Final Minute of the Test			
Calculated Change over the Day (Post-Pre)	Median	IQR	Variance	P	Median	IQR	Variance	P
R Acceleration Ball (m/s^2)	−0.11	0.31	1.42	0.26	−0.02	0.26	0.16	0.61
X Acceleration Ball (m/s^2)	−0.07	0.23	0.79	0.18	−0.04	0.22	0.07	0.49
Y Acceleration Ball (m/s^2)	−0.05	0.26	0.48	0.27	0.01	0.18	0.07	0.98
R Gyroscope Ball (rad/s)	−1.08	4.14	77.37	0.23	−0.58	3.38	12.95	0.42
X Gyroscope Ball (rad/s)	−0.77	3.15	22.41	0.13	−0.31	2.32	6.08	0.27
Y Gyroscope Ball (rad/s)	−0.82	3.63	56.26	0.60	−0.63	2.38	7.04	0.48
R Acceleration Jockey (m/s^2)	0.01	0.17	0.24	0.79	0.03	0.14	0.02	0.12
X Acceleration Jockey (m/s^2)	0.00	0.08	0.08	0.99	0.01	0.06	0.00	0.14
Y Acceleration Jockey (m/s^2)	−0.02	2.38	7.04	0.48	0.00	0.09	0.01	0.59
R Gyroscope Jockey (rad/s)	0.12	3.03	134.4	0.69	0.42	2.53	3.33	0.47
X Gyroscope Jockey (rad/s)	−0.28	1.85	84.22	0.12	−0.18	1.44	1.48	0.45
Y Gyroscope Jockey (rad/s)	0.58	1.76	41.22	0.28	0.63	1.39	1.89	0.03

TABLE 4. Kendall Tau Correlation Coefficients for Numerical Workday Habits and Root Mean Square (RMS) Data From IMUs Located on the Jockey and the Bosu Ball, Split Between Analysis of the Whole Test and the Final Minute of the Stability Test

	IMU Data From Full 2-Minute Test						IMU Data From Final Minute of the Test					
	Age	Sleep	Caloric Intake	Fluid Intake	Races Ridden	Time in Sauna	Age	Sleep	Caloric Intake	Fluid Intake	Races Ridden	Time in Sauna
Ball R Acceleration	−0.21	−0.19	−0.03	0.18	0.23	0.08	−0.08	−0.21	−0.10	0.00	0.20	0.08
Ball AP Acceleration	−0.19	−0.18	−0.03	0.15	0.26	0.12	−0.07	−0.18	−0.16	0.01	0.22	0.14
Ball ML Acceleration	−0.30	−0.20	0.00	0.20	0.21	0.08	−0.04	−0.17	−0.09	0.01	0.08	0.03
Ball R Gyroscope	−0.13	−0.09	0.03	0.19	0.31	0.02	0.03	−0.10	−0.10	−0.01	0.23	0.05
Ball AP Gyroscope	−0.18	−0.09	0.06	0.21	0.28	0.04	0.07	−0.14	−0.05	0.01	0.21	0.05
Ball ML Gyroscope	0.01	0.00	0.03	0.22	0.29	0.05	−0.01	−0.10	−0.13	−0.03	0.21	0.00
Jockey R Acceleration	−0.22	**−0.32**[a]	−0.01	0.16	0.28	−0.12	−0.11	**−0.32**[a]	−0.01	0.04	0.22	0.02
Jockey AP Acceleration	−0.18	−0.25	−0.10	0.16	0.26	0.00	−0.09	−0.22	0.14	0.08	0.16	0.10
Jockey ML Acceleration	−0.23	**−0.37**[a]	−0.10	0.14	**0.37**[a]	−0.05	−0.26	**−0.41**[a]	−0.03	0.03	0.30	0.07
Jockey R Gyroscope	−0.22	−0.16	0.02	0.21	**0.31**[a]	−0.02	−0.26	−0.30	−0.01	0.08	0.25	0.09
Jockey AP Gyroscope	−0.26	−0.04	0.06	0.17	0.25	−0.08	−0.24	−0.23	0.16	0.07	0.23	−0.06
Jockey ML Gyroscope	−0.28	−0.20	−0.02	**0.29**[a]	0.26	0.02	−0.22	−0.26	0.01	**0.28**[a]	0.25	0.15

[a]Bolded values mark statistically significant correlations with P values <0.05. R: Resultant, AP: Anterior-Posterior, ML: Mediolateral. All IMU data (Acceleration and Gyroscope) are calculated changes in the data across the workday as post-pre values.

consumed relative to the average daily intake (14%–19%), and the proportion of waking hours spent working (71%), combined with an estimated 20% of jockeys being in a caloric deficit from their races alone, to suggest that American jockeys are likely using restricted caloric intake throughout the workday as a weight-cycling strategy. These strategies indicated inadequate fueling for the exercise level engaged in throughout an estimated 12-hour workday.

American jockeys reported using a sauna lower than what has been reported for jockeys in other jurisdictions. Literature reports sauna use ranging from 17% to 86% of jockeys.[24–26,28,45–47] Only 34.4% of the current sample reported using the sauna, with a median time of 30 minutes and range of 5–120 minutes. Many of the jockeys who reported using the sauna often commented that they were using it to warm up before going out for a race, or after returning from a race on cold days during the spring season. Based on these comments and a median at the lower end of the previously reported range, the current sample does not utilize the sauna as frequently as other jockey communities to make weight based on previous research in racing jurisdictions around the world. However, since some of these studies that previously reported sauna uses by jockeys, there has been movement to reduce risk for the jockeys. Thus, some racing jurisdictions have identified saunas as a risk factor and subsequently have closed saunas at racetracks.[50]

Previous research supports testing elite athletes in task-specific positions to evaluate postural stability as they develop the motors skills and control related to their sport.[13,15,51,52] The only study to date to evaluate postural stability in jockeys suggested the need for an occupation-specific test for this population.[38] The current study used a novel occupation-specific postural stability test to evaluate fatigue. Legg and colleagues' findings of injury rate ratios suggest that fatigue could affect the safety of the rider; however, there are different types of fatigue to evaluate: central and peripheral.[6] Peripheral fatigue refers to fatigue arising at the neuromuscular level, including metabolic changes, decrease in actional potential, and disruption of excitation-contraction coupling.[53–55] Peripheral fatigue affects movement velocity and range of motion, which can deteriorate postural stability.[9,56] Central fatigue originates from the CNS and leads to reduced voluntary muscle activation. This reduction in muscle activity manifests as a lower frequency and coordination of muscle contractions, impacting postural stability.[9,57,58] Central fatigue is linked to increased cognitive fatigue, anxiety, stress, and decreased sleep and perceived energy.[58–61] The current study focuses on evaluating postural stability, which can be impacted by peripheral and central fatigue, and showed no significant changes across the workday. We reported that the median number of races ridden per day was relatively low (two races per day) and jockeys had recently had a day off from racing. However, the days off considers a day off to be from race competition, but not from morning exercise work. Thus, we suggest that future research should evaluate multiple workdays with jockeys riding in differing numbers of races, as well as days off from racing, to deepen the understanding of how race day and nonrace days impact fatigue.

The duration of horse races in the United States, where jockeys maintain their riding posture, is generally brief. Most races, including renowned ones like the Kentucky Derby, last under 2 minutes, with the Belmont Stakes, the longest of the Triple Crown, averaging 2:28.[62] Jockeys typically participate in 1 to 12 races daily, based on their schedule and demand. Despite the short duration of these races, jockeys face considerable physical demands to sustain postural stability while riding. Legg and colleagues observed that during live races, jockeys' muscle activity is mainly concentrated in the lower limbs, with about 50% in the quadriceps, hamstrings, and gluteal muscles.[63] They also noted a decrease in abdominal muscle activity and an increase in hamstring activity over multiple races, indicating a tendency toward abdominal rather than lower extremity fatigue, which might not have been captured with the stability test used for the current study.[63] Moreover, jockeys usually have a minimum recovery period of 20–45 minutes between consecutive races, which provides adequate time for short term recovery for these trained individuals when evaluating them in a task-specific to their expertise.[64,65] Following the final race of the day, jockeys were encouraged to return for postday follow-up immediately, but also had to talk to owners and trainers, and sometimes had to wait for other jockeys to complete the test. This delay in postday testing could result in jockeys having sufficient time to recover prior to the postworkday stability test.

Moving forward, postural stability tests in the jockey population should add a dual task approach to the current protocol to evaluate central fatigue and performance. Dual tasks could include reaction time, answering questions, or visual and auditory stimuli that mimics racing environments. Although we did not see differences across the workday in postural stability, that gives cogency for future use of this novel occupation-specific postural stability test to assess changes following injury or an incident in which a concussion is of concern. Additionally, these data provide a foundational sample to understand the normative fluctuations in postural control performance using this occupation-specific task. Future research should investigate how factors such as high-volume racing, sauna use, or injury may impact postural control now that a normative range can be established. Finally, based on the results of Legg and colleagues indicating abdominal fatigue over lower extremity and the results of the current study, future research should evaluate abdominal strength fatigue across the workday.

As part of the second purpose, we also hypothesized that an increase in negative workday habits and increased age would have detrimental effects on fatigue across a race day. Age was not a significant factor that affected postural stability. This result could be due to a small number of jockeys in the current study being over 50 years old. However, it is also likely that the long-term training and expertise of working as a jockey provides them with a strong foundation to continue to maintain postural stability in their position across their career.[66–68] Additionally, there may be bias that the older jockeys that continue to be successful in this sport have developed the sports expertise to maintain a higher level of performance that may be reflected in this task.

There were also no significant correlations between caloric intake and postural stability variables. This finding could be reflective of an overall low intake; a median intake ranging from 0–437.5 calories across their whole workday. Future studies should consider evaluating caloric intake and postural stability on race days and nonrace days. Sleep during the workday also had a significant correlation with jockey changes in resultant and mediolateral RMS acceleration across the workday. Although significant, these were still weak correlations and needs further research to understand the relationship between sleep and stability variables for practical application.

Finally, we hypothesized that as the number of races ridden across the workday increased, there would be a significant change in postural stability variables. This hypothesis was supported by moderate positive correlations between changes in postural stability variables and the number of races ridden. These correlations between races ridden and jockey resultant RMS acceleration, resultant RMS gyroscope, and mediolateral RMS gyroscope data taken in consideration with the results of Legg and colleagues' study on muscle fatigue in race riders suggest changes to the jockeys COM during postural stability may come more from abdominal fatigue rather than leg fatigue.[63] Based on the combined results of the current study and the study by Legg et al, future research should consider evaluating abdominal fatigue across the workday and workday habits.

The limitations of the current study size include a small convenience sample of elite jockeys at a single track during one fall season. Despite this limitation, the current sample of jockeys provide valuable documentation as elite American jockeys at top tier track with a large value in purse winnings. Future research should evaluate jockeys from various tracks and meets. Representation of females was limited in this study. Previous research suggests there might be differences in peripheral and central fatigue in females when compared with males.[69,70] This study's sample is representative of the American Jockey population, which is predominately male and a high percentage of Hispanic individuals but should not be generalized to female jockeys due to the small sample of females who participated in this study.[71] Evaluating the reliability and validity of this occupation-specific postural stability test in equestrian populations during both competitive and noncompetitive days is an important next step. Lastly, most participating jockeys were observed on days when they had fewer races to ride, as indicated by the median of 2 races and a range of 1–6 races during the data collection period. As a convenience, jockeys preferred more time to partake in the data protocol without a perceived disruption or distraction in their daily schedule. This limits the interpretation of the results of this study to the impact of the describe number of races. Future research should try to capture performance following a higher volume race schedule.

CONCLUSIONS

To the authors' knowledge, this study is the first to evaluate American jockeys' workday habits and postural stability across a race day. While American jockeys engage in weight-cycling behaviors such as restricted caloric and fluid intake, they do not rely heavily on sauna use. No significant changes in postural stability were observed across the workday, though there were weak correlations between sleep, fluid intake, and changes in postural stability. With nonsignificant changes in the IMU postural stability data across the workday, this 2-minute occupation-specific test might effectively assess postural stability postinjury or after a concussive event. An estimated 20% of jockeys in the current study were in a caloric deficit over the course of their workday when considering only the energy they expended during race-related activities and not resting metabolic rate, exercising horses, or other physical activity. This finding underscores the need for future research to assess jockeys' workday fueling practices, resting metabolic rate, and workday energy expenditure in the United States. Future research should explore various mechanisms and covariates of fatigue, including central fatigue, chronic fatigue across race meets, race volume, abdominal strength, and differences between race and nonrace day postural stability to gain further insights into jockey health, performance, and safety.

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