

Demographic Predictors of Chronic Pain in American Equestrians: A Secondary Analysis

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Abstract

Equestrians report a high rate of chronic pain (CP), which can disrupt horse-rider movement patterns, communication, and safety. Equestrian-related risk factors (i.e., participation level) for reporting CP are well established, while demographic predictors remain underexamined in American equestrians. The purpose of this study was to examine demographic predictors of self-reported CP in American equestrians. This study was a secondary analysis of cross-sectional survey data from adult American equestrians ($n = 1,968$) that included self-reported CP status (no formal definition or diagnosis) and demographic variables. All variables were categorical. Chi-square tests ($P < 0.25$) informed forward-selection binary logistic regressions to estimate odds (ORs) of reporting CP across demographic variables, with significance set at $P < 0.05$. Approximately 45% of the sample reported general CP. The sample was predominantly female (96%). Participation level was a significant predictor of reporting general CP and chronic back, pelvic, and lower leg pain, with professionals having 1.71–1.95 greater odds ($P < 0.05$) than recreational equestrians, and 1.39–1.80 greater odds than amateur equestrians ($P < 0.05$). Body mass predicted general CP and chronic back pain, with riders weighing <91 kg having lower odds of reporting general and back CP (ORs = 0.45–0.60, $P < 0.05$). Model discrimination was modest across analyses (c-statistics: 0.58–0.63). Participation level remains significantly associated with reporting. Body mass emerged as a potential predictor, while other demographic predictors (e.g., age and sex) remain uncertain with regard to reporting CP in American equestrians. Future research should examine body mass, riding biomechanics, and joint-specific load distribution across disciplines with consideration of horse and human health.

Keywords

Horseback riding; body mass; risk factors; human-animal interactions; pain prevalence

1. Introduction

Equestrian activities provide a unique form of lifelong physical engagement across a variety of disciplines, each with distinct rules and performance objectives. They are considered an "early-start" and "late-specialization" sport, which supports participation across the lifespan, including childhood development and later career and family phases [1–4]. Equestrian activities are highly inclusive, with males and females competing together across all levels of participation (e.g., recreational, amateur, and professional) [2,3]. Successful riding relies on a high degree of biomechanical

coordination between the horse and rider, such that the rider's posture, balance, and movement directly influence the horse's gait and movement patterns [5–8]. Beyond the physical demands of the sport, participation also involves a human-animal bond that contributes to improved mental, social, and physical well-being [9–11].

Participation in equestrian activities is associated with several benefits, including improved balance, strength, physical well-being, mood, self-esteem, and social connectedness [12–19]. These benefits often coexist with a high risk of acute

and overuse injuries. Horses, as large sentient animals, are responsive to environmental and human stimuli and can behave unpredictably, increasing the risk of injury during riding and handling [20–22]. Equestrians are also susceptible to overuse injuries due to the accumulation of musculoskeletal strain over time from repetitive biomechanical forces during riding and routine barn work [23–28]. The accumulation of repetitive forces and the high risk of acute injuries can lead to long-term health consequences for equestrians.

Such injuries may progress to chronic pain (CP), defined as pain that persists or recurs for more than half of the days per week for three months or longer [29]. CP imposes a substantial societal burden when considering the cost of disability, medical losses, and decreased productivity [30,31]. In the general population, risk factors for CP include age, sedentariness, obesity, manual labor, low socioeconomic status, sleep disturbances, and psychosocial strain [32,33]. One of the most prominent risk factors for chronic musculoskeletal pain is sedentariness (i.e., prolonged waking time spent sitting or reclining), coupled with low engagement in moderate-to-vigorous physical activity (i.e., not meeting physical activity guidelines) [34]. Together, these factors can facilitate weight gain, which is a concern, as obesity also significantly increases the risk of developing chronic musculoskeletal pain [34,35]. Finally, patterns of older-aged individuals and females experiencing a higher prevalence of musculoskeletal pain have surfaced within current literature [33].

Previous studies reveal that 24–87% of equestrians report experiencing CP, with low back pain being the most prevalent [36–43]. This high rate of CP in equestrians is not only concerning from a human health perspective, but also from a horse welfare and safety standpoint. Balance and coordinated movement patterns are essential for communication between the horse and rider [44–48]. Equestrians experiencing CP may adopt compensatory movement patterns that alter posture and loading on the horse's back, which could negatively impact equine movement and welfare [49]. Therefore, understanding potential risk factors that increase the rate of CP in equestrians is critical to both horses and humans.

Studies have identified that participation level, discipline, hours spent riding, barn chores, and saddle fit are related to overuse injuries, acute pain, and CP in equestrians [26,36–41,43,50,51]. Across the literature, participation levels consistently emerge as a strong and reliable factor relating to acute pain and CP, with professionals reporting a higher frequency of pain than recreational and amateur riders [43,52,53]. While participation level and other equestrian-related risk factors provide important context, identifying demographic patterns of CP is a critical step that remains underdeveloped in the equestrian literature.

Previous work has yielded inconsistent findings regarding demographic risk factors for reports of pain in equestrians. With respect to age, one study identified younger riders at greater risk of reporting low back pain, while others have reported a higher risk among older riders [53,54]. Two studies specifically report that riders over 35 years old are most likely to report experiencing pain [37,39]. In contrast, one study reported no association between age and pain [38]. While

studies report varying findings, the balance of evidence suggests a trend toward greater reporting of pain with increasing age, similar to that observed in the general population.

Evidence regarding sex differences is similarly mixed. Lewis and Baldwin [37] reported that female event riders were more likely than males to report pain, a pattern echoed in later work showing that females were more likely to have experienced pain in the previous two years than their male counterparts [37,39]. Another study also found a higher risk of low back pain among females [55], whereas Ferrante *et al.* [53] reported no association between sex and low back pain. Despite some inconsistency, findings more commonly indicate higher pain reporting among female equestrians.

Anthropometric characteristics (e.g., height, body mass, and body mass index (BMI)) have likewise produced contradictory findings. Some studies have found no associations between anthropometric variables and reporting pain and pain-related functional limitations [25,53,54,56,57]. However, other studies have reported that higher BMI and body mass are associated with greater pain-related disability and an increased risk of low back pain across the lifespan [53,54,56,57]. Taken together, there is some evidence to suggest that greater body mass may be associated with increased pain risk. Considering these inconsistencies, which are derived predominantly from European samples, it is critical to examine demographic factors associated with reporting CP in American equestrians.

The general American population exhibits higher obesity rates, lower physical activity engagement, and worsening mental health trends compared to many European countries [58,59]. In this context, understanding how demographic risk factors relate to self-reported CP in American equestrians is crucial for identifying targets for prevention and early intervention to decrease CP rates. American equestrians represent a wide range of individuals across the lifespan. Identifying demographic factors associated with CP is a critical step toward improving long-term participation, safety, and overall well-being. Therefore, the purpose of this study was to examine demographic predictors of self-reported CP in American equestrians. We hypothesized that (1) participation level would be significantly associated with reporting CP, with professionals at greater risk of reporting general and regional CP, and (2) equestrians with higher body mass, who were female, and were of older age would be at greater risk of reporting general and regional CP.

2. Methods

2.1. Study Design and Data Source

Data collected and stored from a cross-sectional survey in 2020–2021 were leveraged for a secondary analysis of demographic variables and their associations with self-reported CP. The original dataset was used to evaluate physical activity across participation level [17] and to assess the relationships between self-reported acute injury and CP status across participation level [43]. The data have also been used to evaluate relationships between physical activity engagement and reporting CP in equestrians [60]. These data analyses were approved by the University of Kentucky's Institutional Review Board under protocol number 56488.

2.2. Dataset Inclusion and Validation

The current study used a new set of inclusion criteria compared to the previous studies [17,43,60]: included responses were from (1) active equestrians 18 years or older, (2) who completed the CP section of the survey, and (3) provided definitive answers for demographic and CP questions (e.g., not "prefer not to answer").

2.3. Questionnaire Details

All variables extracted for the secondary analysis were categorical. Questions included general demographics that determined sex, height, body mass, region of the United States (US), race, and age. Questions regarding equestrian participation included the participation level (professional, amateur, and recreational), number of years spent participating in equestrian activities, how often they engaged in equestrian activities in the 6 months prior to taking the survey (monthly, 1–2 days/week, 3–4 days/week, 5–6 days/week, or daily), and if they participate year-round (Y/N). Professional equestrians were defined as individuals receiving payment for riding/training/grooming. Amateur equestrians were defined as individuals who are competitive but do not receive financial compensation. Recreational equestrians were defined as individuals who engage in noncompetitive activities [17]. If they selected "no" to whether they participated year-round, branching logic asked them to select which seasons they engaged in equestrian activities. Finally, individuals were asked if they currently experience any CP (Y/N) without a formal definition or diagnosis. If they selected "yes", then they were asked to select all the anatomical regions they experience pain in, with the options including head/face, neck, chest, back, breasts, abdomen, arms, hands, pelvis, genitals, upper leg, lower leg, and feet.

2.4. Data Cleaning

Data cleaning and analysis were completed in SAS 9.4. The original dataset comprised 2,579 initiated responses. Based on the inclusion criteria, data from 115 minors (younger than 18 years old) were excluded, 416 individuals were excluded for not completing the CP section, and 79 were excluded for not providing definitive responses to key items (including missing data). Following data cleaning, data were examined for duplicates ($n = 0$) and response validity, which included checking for implausible values, such as participants reporting years of experience in equestrian activities greater than their age ($n = 1$). The final dataset for this analysis included 1,968 responses.

To address categories with sparse counts, response categories were generally collapsed to preserve ordinal structure and to satisfy standard assumptions for contingency analyses (i.e., ensuring that at least 5% of the sample contributed to each combined category). Two variables warranted exceptions to this 5% rule. For height, collapsing all categories with fewer than 5% of responses would have reduced six levels to only two, eliminating meaningful distinctions and limiting interpretability. Instead, we collapsed low-frequency categories at the shortest and tallest ends of the distribution, acknowledging that the resulting categories still did not reach the 5% threshold. Similarly, for years of equestrian experience, there were low frequencies in the two categories representing ≤ 5 years of experience. Rather than combining these

with a third category and creating an overly broad grouping of <10 years of experience, we collapsed only the two categories to retain a more meaningful distinction for early years of equestrian activity. **Table 1** presents the frequencies and percentages for each category before and after collapsing.

For individuals who did not report riding year-round, a variable was created by summing the number of seasons in which they reported riding (range: 1–3). Participants who indicated riding in all four seasons were reclassified into the "yes" (participates in equestrian activities year-round) category.

Table 1: Frequency and percentage of responses in categories before and following collapsing.

Pre-collapsing categories			Post-collapsing categories		
	n	%		n	%
Age (y)					
18–24	283	14.3	18–24	283	14.3
25–29	227	11.4	25–29	226	11.4
30–34	222	11.2	30–34	222	11.2
35–39	216	10.9	35–39	215	10.9
40–44	161	8.1	40–44	161	8.1
45–49	120	6.0	45–49	120	6.1
50–54	146	7.4	50–54	146	7.4
55–59	146	7.4	55–59	146	7.4
60–64	204	10.3	60–64	204	10.3
65–69	147	7.4	65–69	146	7.4
70–74 ^A	88	4.4	≥70 ^A	112	5.7
≥75 ^A	26	1.3			
Height (cm)					
<137 ^A	5	0.3	<152 ^A	33	1.7
137–150 ^A	28	1.4	152–165	1010	51.0
152–165	1011	50.9	168–180	877	44.3
168–180	878	44.2	≥181 ^B	61	3.1
183–196 ^B	61	3.1			
≥197 ^B	3	0.2			
Body mass(kg)					
<45 ^A	9	0.5	<57 ^A	264	13.3
45–56 ^A	256	12.9	57–68	618	31.2
57–68	618	31.1	68–79	533	26.9
68–79	533	26.8	79–90	319	16.1
79–90	320	16.1	91–102	146	7.4
91–102	148	7.5	≥103 ^B	101	5.1
103–113 ^B	55	2.8			
114–124 ^B	20	1.0			
125–136 ^B	17	0.9			
≥137 ^B	10	0.5			

Pre-collapsing categories			Post-collapsing categories		
	n	%		n	%
Years of experience in equestrian activities (y)					
<1 ^A	5	0.3	<5 ^B	52	2.6
1–4 ^A	48	2.4	5–9	125	6.3
5–9	125	6.3	10–14	203	10.3
10–14	203	10.2	15–19	263	13.3
15–19	263	13.2	20–24	255	12.9
20–24	256	12.9	25–29	218	11.0
25–29	218	11.0	30–34	221	11.2
30–34	221	11.1	35–39	128	6.5
35–39	128	6.5	40–44	103	5.2
40–44	104	5.2	45–49	100	5.1
45–49	100	5.0	≥50	313	15.8
≥50	315	15.9			

Superscript letters (A, B) demonstrate categories combined from the pre-collapsing categories and their respective post-collapsing categories.

2.5. Statistical Analysis

All analyses were conducted in SAS 9.4. Statistical significance was defined as $P < 0.05$. Frequencies and descriptive statistics were calculated for all variables. Correlations among ordinal variables were evaluated using Kendall's Tau correlation coefficients.

Associations between demographic variables and (1) participation level, (2) reporting any CP (general CP), and (3) reporting CP in specific anatomical regions (regional CP) were examined using chi-square tests. Chi-square analyses were conducted only when at least 80% of cells had expected counts of ≥ 5 . Using this criterion, regional CP analyses were only completed for the back, pelvis, neck, upper leg, and lower leg, while the other eight regions did not have high enough counts to run analyses. These regional analyses evaluated reporting CP (Yes/No) across demographic variables. All demographic variables (including collapsed variables) met chi-square assumptions except for race and the number of seasons ridden if not riding year-round.

For general CP and the five regional CP outcomes, variables with $P < 0.25$ in chi-square analyses were entered into the forward-selection binary logistic regression models, consistent with purposeful selection approaches [61]. Variable retention for models was set at $P < 0.05$. The dependent variable in each model was reporting CP (general or regional), coded with "yes, experiencing CP" as the reference category so that odds ratios (ORs) reflect the increased or decreased likelihood of reporting CP. Model results are reported as ORs with 95% confidence intervals (95% CIs) and P -values for retained variables, along with the c-statistic (area under the receiver operating characteristic curve).

The Akaike Information Criterion (AIC) provides a measurement of overall model fit while penalizing the complexity of the predictor variables added. AIC is dataset-specific and does not provide interpretable results without comparison to other models from the same dataset. Therefore, we provide AIC_{Reduction} (AIC_R), which provides a value comparing the models with added variables relative to the null model, defined as $AIC_R = AIC_{null} - AIC_{model}$. The values of AIC_R should be interpreted such that larger positive values indicate greater improvement over the null model, while 0 indicates no improvement, and negative values indicate worse fit compared to the null model. To aid interpretation, we also present ORs from significant models using alternative reference groups, as specified in the results.

3. Results

The final dataset included 1,968 American adult equestrians. The sample was predominantly female (96.0%) and Caucasian (94.0%), with representation across all adult age ranges and regions of the US. Professionals comprised 20.1% of the sample, while amateur (39.1%) and recreational (40.8%) equestrians were evenly represented. Most participants (87.7%) engaged in equestrian activities on a year-round basis. Among those who did not ride year-round, 91.4% reported participating in three seasons per year, with the majority indicating they did not participate during the winter. Regarding riding frequency in the past 6 months, 17.5% of participants reported riding inconsistently (only riding monthly), while the remaining 82.5% reported riding each week consistently. Nearly half of the sample (44.9%) self-reported experiencing general CP, and the most frequently reported region of CP was the back (27.1%), followed by the pelvis (10.1%), lower leg (9.2%), neck (9.1%), and upper leg (7.2%). No other region had a percentage greater than 5% of the sample, and therefore, no other models were run for these regions. Among the 884 individuals reporting CP, 49.5% reported experiencing CP in one anatomical region, 26.7% in two regions, 12.8% in three regions, and 11.0% in four or more regions. **Table 2** presents the frequencies and counts for sex, age, height, body mass, equestrian engagement, and general and regional CP by participation level with chi-square results.

Kendall Tau correlations revealed only three significantly correlated ordinal variables with a $|\tau| \geq 0.20$. Age had a weak negative correlation with participation level of $\tau = -0.21$, $P < 0.001$, meaning that as age increased, the level of participation decreased from professional (3) to recreational (1). Age also had a strong positive correlation with years of equestrian experience, with $\tau = 0.55$, $P < 0.001$. Body mass and height showed a weak positive correlation, with $\tau = 0.30$, $P < 0.001$.

3.1. Chronic Pain Models

For general CP, participation level ($P = 0.0001$), body mass ($P = 0.0002$), sex ($P = 0.161$), experience in equestrian activities ($P = 0.249$), and year-round participation ($P = 0.106$) fell within the $P < 0.25$ cutoff used in the binary logistic regression. The final binary logistic regression model retained participation level ($P = 0.0001$), body mass ($P = 0.0002$), and sex ($P = 0.0086$) as significant predictors for reporting general CP. The overall fit of the model, including both predictors, was significantly better than the

intercept-only (null) model (likelihood ratio $\chi^2(7) = 49.7$, $P < 0.0001$; $AIC_R = 33.71$), with modest model discrimination (c-statistic = 0.58). Forest plots depict ORs and 95% CIs that are presented in **Figure 1** for participation level and **Figure 2** for body mass categories. Professionals were more likely to report general CP than both amateur and recreational riders, whereas there was no significant difference in the likelihood of reporting general CP between recreational and amateur equestrians. Riders weighing <91 kg were less likely to report general CP than those weighing ≥ 91 kg. Females had 1.91 greater odds of reporting general CP than males (95% CI: 1.17–3.12, $P = 0.01$).

Table 2: Frequencies and counts for self-reported demographics, anthropometric characteristics, equestrian engagement details, and chronic pain by participation level in equestrian activities. *P*-values represent results of chi-square tests between the variable and participation level, with significance set at $P < 0.05$.

	Recreational		Amateur		Professional		P-value
	n	%	n	%	n	%	
Sex							
Female	750	97.5	772	96.1	368	92.9	<0.01 [*]
Male	19	2.5	31	3.9	28	7.1	
Age (y)							
18–24	53	6.9	159	19.8	70	17.7	<0.01 [*]
25–29	75	9.8	76	9.5	73	18.4	
30–34	74	9.6	84	10.5	63	15.9	
35–39	76	9.9	86	10.7	52	13.1	
40–44	56	7.3	69	8.6	34	8.6	
45–49	46	6.0	48	6.0	25	6.3	
50–54	65	8.5	54	6.7	26	6.6	
55–59	68	8.8	61	7.6	16	4.0	
60–64	109	14.2	76	9.5	18	4.6	
65–69	79	10.3	55	6.9	10	2.5	
70+	68	8.8	35	4.4	9	2.3	
Height (cm)							
<152	9	1.2	17	2.1	7	1.8	<0.01 [*]
152–165	416	54.1	412	51.3	173	43.7	
168–180	326	42.4	355	44.2	192	48.5	
≥181	18	2.3	19	2.4	24	6.1	
Weight (kg)							
<57	90	11.7	120	14.9	53	13.4	0.06
57–68	229	29.8	252	31.4	134	33.8	
68–79	213	27.7	224	27.9	92	23.2	
79–90	128	16.6	121	15.1	67	16.9	
91–102	55	7.2	58	7.2	31	7.8	
≥103	54	7.0	28	3.5	19	4.8	
Participates in equestrian activities year-round							
No	148	19.3	70	8.7	24	6.1	<0.01 [*]
Yes	621	80.8	733	91.3	372	93.9	
Number of seasons individuals participate in, if not year-round							
1	7	0.9	2	0.3	1	0.3	NA
2	9	1.2	4	0.5	0	0.0	
3	131	17.0	64	8.0	23	5.8	

	Recreational		Amateur		Professional		P-value
	n	%	n	%	n	%	
Engagement frequency on average over the past 6 months							
Monthly	235	30.6	73	9.1	36	9.1	<0.01*
1–2 days/week	194	25.2	138	17.2	38	9.6	
3–4 days/week	253	32.9	336	41.8	116	29.3	
5–6 days/week	78	10.1	226	28.1	126	31.8	
Daily	9	1.2	30	3.7	80	20.2	
Experience chronic pain							
No	450	58.5	453	56.4	181	45.7	<0.01*
Yes	319	41.5	350	43.6	215	54.3	
Experience chronic back pain							
No	590	76.7	583	72.6	261	65.9	<0.01*
Yes	179	23.3	220	27.4	135	34.1	
Experience chronic pelvic pain							
No	702	91.3	730	90.9	337	85.1	<0.01*
Yes	67	8.7	73	9.1	59	14.9	
Experience chronic neck pain							
No	705	91.7	735	91.5	349	88.1	0.10
Yes	64	8.3	68	8.5	47	11.9	
Experience chronic lower leg pain							
No	717	93.2	723	90.0	348	87.9	<0.01*
Yes	52	6.8	80	10.0	48	12.1	
Experience chronic upper leg pain							
No	711	92.5	755	94.0	361	91.2	0.17
Yes	58	7.5	48	6.0	35	8.8	

*Indicates a statistically significant chi-square test ($P < 0.05$).

Participation level ($P = 0.0004$), body mass ($P = 0.001$), engagement frequency ($P = 0.052$), sex ($P = 0.034$), geographical region ($P = 0.194$), and year-round participation ($P = 0.237$) met the cutoff to be entered into the chronic back pain model. The final forward-selection binary logistic regression model retained participation level ($P = 0.0001$), body mass ($P = 0.0001$), and sex ($P = 0.002$) as significant predictors for chronic back pain. The final model, including participation level, body mass, and sex, showed adequate fit compared to the intercept-only (null) model (likelihood ratio $\chi^2(7) = 35.1$, $P < 0.0001$, $AIC_R = 30.5$). Model discrimination was modest (c-statistic = 0.59). Forest plots depicting ORs and 95% CIs are presented in **Figure 1** for participation level and in **Figure 2** for body mass categories. Females were at 2.67 greater odds of reporting chronic back pain than males (95% CI: 1.43–4.97, $P = 0.002$). ORs were significant between all participation levels ($P < 0.05$). Similar to our general CP results, individuals in the lower body mass categories were less likely to report chronic back pain than those in the higher body mass categories.

Participation level ($P = 0.002$), age ($P = 0.008$), sex ($P = 0.136$), body mass ($P = 0.134$), and years of experience ($P = 0.152$) met

the cutoff for the chronic pelvic pain model. Participation level ($P = 0.002$) and age ($P = 0.008$) were retained in the final model to predict experiencing chronic pelvic pain, and showed adequate fit compared to the intercept-only model (likelihood ratio $\chi^2(12) = 36.3$, $P = 0.0003$, $AIC_R = 12.3$). Model discrimination was modest (c-statistic = 0.63). Forest plots depicting ORs and 95% CIs are presented in **Figure 1** for participation level. Professionals were at greater odds of reporting chronic pelvic pain than amateurs and recreational equestrians, while there was no significant difference in odds between amateurs and recreational equestrians. There was no clear-cut age range that demonstrated an increased risk of reporting chronic pelvic pain. Compared to individuals 18–24 years old (y/o), those who were 35–39 y/o had 1.76 (95% CI: 1.01–3.07) greater odds, and those 65–69 y/o had 1.95 (95% CI: 1.04–3.64) greater odds of reporting chronic pelvic pain. Similarly, compared to those who were 25–29 y/o, participants who were 35–39 y/o (OR: 2.28, 95% CI: 1.22–4.26), 50–54 y/o (OR: 2.3, 95% CI: 1.16–4.55), and 65–69 y/o (OR: 2.52, 95% CI: 1.26–5.02) were at greater odds of reporting chronic pelvic pain.

Forest Plot for Odds of Reporting Experiencing Chronic Pain by Participation Level in Equestrian Activities

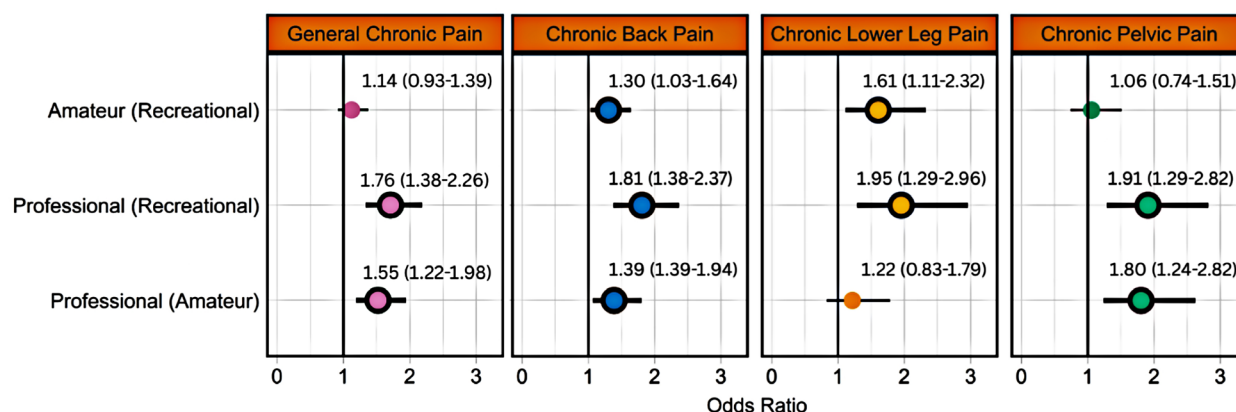


Figure 1: Forest plots depict odds ratios (colored circles) and 95% confidence intervals (horizontal bars) for reporting "yes" to experiencing each chronic pain (CP) outcome (general CP, chronic back, lower leg, and pelvic pain) in relation to participation level in equestrian activities. Significant odds ratios are represented by bolded lines and circles ($P \leq 0.05$). For each row, the group listed first is compared with the reference group in parentheses. For example, data should be interpreted as "Amateurs have 1.3 higher odds of reporting chronic back pain than recreational equestrians."

Forest Plot for Odds of Reporting Experiencing Chronic Pain by Body Mass (kg) in Equestrians

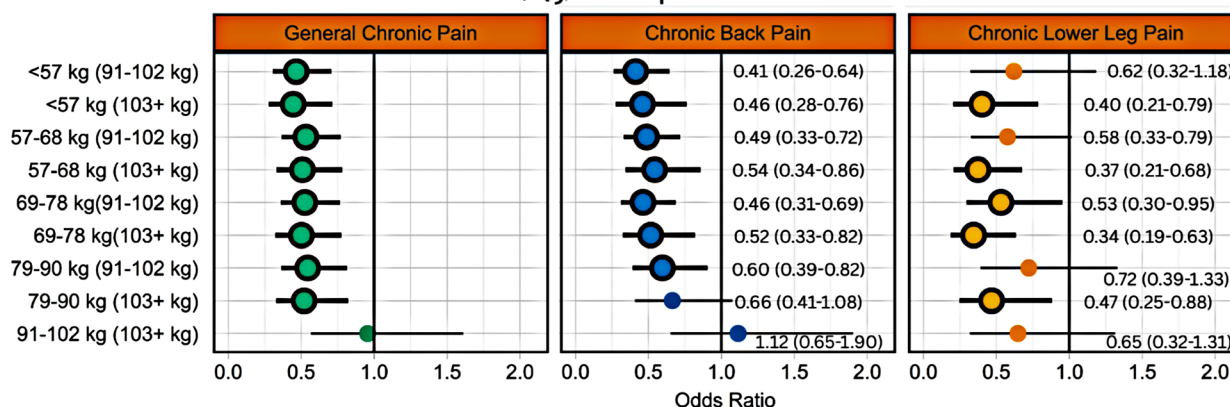


Figure 2: Forest plots depict odds ratios (colored circles) and 95% confidence intervals (horizontal bars) for reporting "yes" to experiencing each chronic pain (CP) outcome (general CP, chronic back, and lower leg pain) in relation to body mass (kg). Significant odds ratios are indicated by bolded lines and circles ($P \leq 0.05$). For each row, the group listed first is compared with the reference group in parentheses. For example, data should be interpreted as "Equestrians reporting they weigh <57 kg were 53% ($1.0 - 0.47 = 0.53$) less likely to report experiencing general CP than those weighing 91-102 kg."

For chronic lower leg pain, participation level ($P = 0.006$), body mass ($P = 0.011$), age ($P = 0.097$), and height ($P = 0.205$) met the cutoff to be included in the model. The final binary logistic regression model retained both participation level ($P = 0.006$) and body mass ($P = 0.005$) with adequate fit compared to the intercept-only model (likelihood ratio $\chi^2(7) = 24.4$, $P = 0.001$, $AIC_R = 10.4$). The model also demonstrated modest model discrimination (c-statistic = 0.61). Forest plots depicting ORs and 95% CIs are presented in **Figure 1** for participation levels, and in **Figure 2** for body mass categories. Professionals and amateurs were at greater odds

of reporting chronic lower leg pain than recreational riders, with no difference between professional and amateur equestrians. Individuals weighing <90 kg were less likely to report lower leg pain than those weighing ≥ 103 kg.

For chronic neck pain, participation level ($P = 0.099$) and sex ($P = 0.10$) met the cutoff to be included in the model. No variables were maintained in the binary logistic regression model for reporting chronic neck pain. Similarly, for chronic upper leg pain, participation level ($P = 0.171$) was the only variable that met the cutoff, and no variables were maintained in the binary logistic regression model.

4. Discussion

This study examined demographic risk factors associated with self-reported CP among adult American equestrians. We hypothesized that participation level would be significantly associated with reporting CP, with professionals at higher odds of reporting general and regional CP than amateur and recreational equestrians. This hypothesis was supported in the current study for general CP and chronic back, lower leg, and pelvic pain. Our second hypothesis was that equestrians with higher body mass, who were female and of older age, would have higher odds of reporting general and regional CP. Body mass was significantly associated with reporting general CP, chronic back pain, and chronic lower leg pain, with heavier individuals being more likely to report CP than lighter individuals. Sex was associated with general CP and chronic back pain, with females at greater odds of reporting chronic back pain than males. However, sex differences were not identified in general or other regional CP. Despite a significant association between age and chronic pelvic pain, greater odds were not confined to a specific age range. As foundational information, these data represent participants across the US, the adult lifespan, and participation levels. While the current study provides foundational information regarding demographic factors associated with reporting CP in American equestrians, these findings should be interpreted with consideration of the study's limitations. These include the use of a pre-existing dataset for secondary analysis, the absence of a standardized definition of CP in the original survey, and modest model discrimination across analyses, indicating a limited ability to distinguish between participants who did and did not report experiencing CP.

The current study aligns with previous literature supporting that professionals have a greater likelihood of reporting CP than recreational and amateur equestrians. This relationship was identified for general CP and chronic back and pelvic pain. Participation level consistently emerges as a key factor associated with CP in equestrians. Financially, professionals rely on training horses, managing boarding facilities, providing lessons and clinics, and working in numerous environments as their primary income. Therefore, their higher odds of reporting CP are associated with greater cumulative exposure to equestrian demands [12,17,23,24,62]. Higher workload increases musculoskeletal stress and the risk of developing overuse injuries and CP in regions such as the low back, pelvis, and shoulder [40,63,64]. As a primary source of income, professionals lack the ability to reduce or modify workload to accommodate pain, which may contribute to the higher reports of CP in this group. Research in other occupational settings reports that the flexibility to modify work tasks is positively associated with reduced levels of disability related to CP and recurrence of CP [65]. Notably, the current study indicates that participation level remains a significant predictor of reporting CP after accounting for demographic and anthropometric characteristics. The elevated reports of CP in professionals across the literature, paired with the current study's findings, highlight the need for future research to focus on the occupational demands and environmental settings (i.e., arena type, stable design, equipment, frequent travel, etc.) [66–69].

Participation level also reflects both the number and the training level of horses ridden regularly [17]. Younger, "greener" horses, defined as horses with limited training and inconsistent responses, are more likely to react unpredictably to environmental stimuli and rider cues [20,21,70,71]. While performing these job demands, professionals are more likely to ride greener horses than amateurs and recreational equestrians, creating a greater risk of acute injury [27,72–76]. A majority of equestrians who have sustained a severe equestrian-related injury report experiencing long-term health impacts, including CP [64]. Consistent with this pattern, experiencing a previous acute injury increased the odds of reporting CP in the same region across most anatomical sites in equestrians [43,52]. Finally, equestrian culture is known for the minimization of human injury, including disregarding injury completely, not seeking medical attention, and not adhering to rehabilitation, all of which could be heightened for professionals who rely on equestrian activities as their primary income [43,77–80]. Financial stress is a key motivator for individuals to continue working despite pain [80–82]. Taken together, the current study extends and reinforces prior work by demonstrating that participation level remains a significant and independent contributor to reports of CP.

Within the equestrian community, the body mass of the rider is commonly discussed in relation to the health, welfare, and movement of the horse [83–85]. Most CP research in equestrians has focused on anthropometric measures in relation to back pain, as this is the most reported region for CP. However, the association between body mass and chronic back pain remains inconsistent across the literature [26,36–40,53,54]. One study reported similar findings to the current study, with body mass being associated with reports of low back pain episodes across the participants' lifetime in Italian equestrians [53]. However, the same study reported no relationship between body mass and experiencing low back pain in the past year [53]. Similar findings are echoed in another study comprised of Portuguese equestrians [54]. While the current study did not collect information regarding BMI, one study reported that increased BMI was associated with higher disability scores [54]. Taken together, the variability between the current and previous studies likely reflects differences in study design, measurement approaches, definitions (or lack thereof) of CP, and how anthropometric variables were captured.

An important divergence between the current study and prior work is the difference in body mass distributions. Previous literature reported an average body mass between 60.1 and 76.5 kg for both females and males [53,54]. When extrapolating the reported body mass ranges based on reported means and standard deviations, these samples only marginally approach the 91 kg threshold identified in the current sample. In contrast, our study collected body mass categorically and included a larger body mass range, with ~15% of the current sample reporting body mass >91 kg. Although the use of categories is a limitation in terms of measurement precision, it offers practical advantages by reducing social desirability bias related to self-reported body mass. Individuals are generally more willing to select an accurate range than to provide an exact number, particularly if they perceive their body mass to fall outside of socially desirable norms [86]. This tendency

may be amplified within equestrian sports, as some equestrian disciplines rely heavily on aesthetic-based scoring and the body mass of the rider is often discussed in terms of horse welfare [5,87–90]. With consideration of the categorical approach and modest model discrimination, the observed associations between body mass and CP should be interpreted with appropriate caution, as these associations likely capture only a portion of the factors contributing to CP in equestrians.

Differences in body mass between the current sample and those in previous studies likely arise from two main factors: national obesity rates and equestrian participation level. Prior work has focused on European equestrians, who come from populations with lower national obesity rates than the United States (e.g., 15.8–23.7% in Italian adults vs. 40.3% in U.S. adults) [91,92]. These differences suggest that a larger proportion of individuals who meet diagnostic criteria for obesity may be engaging in equestrian activities in the United States than in some European countries. Two recent studies evaluating body mass and pain were distributed through national equestrian federations and therefore likely over-represent competitive, registered riders, whereas the current study included equestrians outside these structures [53,54]. As a result, earlier findings may be less generalizable to recreational riders who are not members of a national federation and may experience less pressure related to aesthetic-based scoring. With consideration of these differences, the present study suggests a potential body mass threshold at which CP may increase in a broader, more recreational equestrian population.

Understanding how body mass may influence CP is critical, particularly given its direct implications for equine welfare [93]. Prior work demonstrated that a higher rider-to-horse body mass ratio and rider position in the saddle (which changes with body mass) can impair equine gait and increase the risk of lameness occurring [94]. The study emphasized the importance of future research to quantify rider body weight and anthropometric characteristics (e.g., leg and torso length), as they alter weight distribution, balance, and dynamic loading on the horse's back [93,94]. When a rider is heavier and experiencing CP, it is plausible that the rider uses compensatory movement patterns, which may exacerbate asymmetrical movement and load distribution on the horse. This concern is further supported by research in the general population demonstrating that individuals with low back pain exhibit greater asymmetry in pelvic and trunk motion while sitting and standing compared to individuals without low back pain [95]. Synthesizing findings from previous and current work reveals the vitally important direction of future research in examining how body mass, CP, and asymmetrical movement of the rider influence the horse.

The current study identified a relationship between body mass and reporting chronic lower leg pain. While lower-extremity pain is not commonly reported in equestrian literature, show jumpers reported experiencing pain most frequently in the back (62%), knee (47%), and ankle (36%) [38]. While our survey design precluded joint-specific and discipline-specific comparisons, previous research supports that different disciplines and riding styles (i.e., rising versus sitting trot) impose distinct biomechanical demands on the lower extremities and spine [13,28,38,47,96,97]. Based on the literature, the mechanical demands of different riding styles

may help explain the observed association between body mass and lower-extremity pain and inform targeted prevention strategies. Therefore, future research should examine joint-specific CP across equestrian disciplines.

While the sample collected in this study included a substantially higher proportion of female than male participants, it is broadly representative of the national American equestrian population [55,98,99]. Current literature in the general population reveals that females are disproportionately impacted by CP compared to males [33,100]. Specifically, higher rates of chronic low back pain and chronic neck pain are observed in females [33,100,101]. Within the equestrian population, a recent systematic review reveals inconsistent findings regarding sex differences in relation to back pain [26]. One study evaluating amateur equestrians reported that females are at a higher risk of reporting low back pain compared to males [55]. In contrast, two studies of Italian and Portuguese equestrians found no association between sex and low back pain [26,53]. In the current study, sex was associated with chronic back pain and general CP. However, these findings should be interpreted with caution, given the substantial imbalance in sex distribution, which limits variability, reduces statistical power to detect differences in males, and may result in unstable estimates.

Female equestrians reporting higher rates of experiencing chronic back pain may reflect a combination of anatomical, physiological, and psychological factors, although these interpretations remain speculative. For example, females have a higher prevalence of scoliosis in the general population, which may influence spinal alignment during riding [102]. Non-neutral spinal alignment resulting from scoliosis or anterior pelvic tilt in the saddle could plausibly affect force attenuation and increase susceptibility to persistent pain. Psychological factors, such as depression and anxiety, are associated with chronic low back pain in the general population [103,104]. Rates of anxiety and depression are higher in females, which may contribute to the sex differences observed in the current study [105]. However, these variables were not assessed in the current study, and their role in equestrian populations is unclear. While equestrian activity has been associated with mental health benefits [14,15,18,19], future studies should evaluate how both psychological risk factors and potential protective effects of riding interact to influence CP within this population.

Older age is often associated with increased risk of experiencing CP, due to joint deterioration, muscle weakening, and reduced engagement in physical activity [33]. In the current sample, older age was not consistently associated with a higher likelihood of reporting general or regional CP. Prior work indicates that aging equestrians maintain or exceed age-matched normative grip strength, suggesting that continued engagement in horse-related activities may support musculoskeletal function across the lifespan [16]. Maintaining grip strength in older adults is linked to better quality of life, greater independence in daily activities, and reduced risk of disability [106–108]. Collectively, these findings suggest that continued equestrian participation may support musculoskeletal health. However, aging and its relationship with reporting CP remain unclear based on the current findings, and

future work should focus on longitudinal health implications and benefits of engaging in equestrian activities.

The literature examining age and CP in equestrians remains inconsistent, in part due to variability in how acute and chronic pain are defined and measured [26]. Few studies use a formal definition of CP, defined as pain present for more than half of the days in the past three months, to determine the presence of CP [29]. One study that used this definition also examined the number of episodes of low back pain across multiple time frames (e.g., past 1 month, 3 months, 6 months, 1 year, and lifetime) and reported conflicting findings [53]. Younger age was associated with lifetime and one-year incidence of low back pain, but not with chronic low back pain within the same cohort [53]. Another study reported higher pain intensity ratings among equestrians aged 18–35 years compared with those over the age of 36, although this difference was not statistically significant [37].

Contrary to previous findings, one study identified older age as a risk factor for low back pain–related disability among riders who had experienced low back pain in the past 12 months [54]. However, the effect size was modest, with a 10-year increase in age corresponding to only a 1-point increase on the Roland–Morris Disability Questionnaire. The small magnitude of this effect and the complexity of the analytical model make direct comparison with the current study difficult. Notably, the same study found no significant association between age and the likelihood of reporting low back pain in the past 12 months [54]. Additional studies fail to clarify this relationship, as they report limited or no consistent associations between age and back pain outcomes, including prevalence, pain intensity, and disability [109]. Given the modest model discrimination observed in the current study, age-related findings should be interpreted with caution, as these models do not fully capture the factors influencing the reporting of CP. As current literature remains inconclusive, future research should explore age-related participation factors, including participation level and workload, which may provide clearer insight than aging itself.

4.1. Limitations

The current study relies on self-reported CP status rather than requiring a formal diagnosis from a healthcare provider. Additionally, participants were not provided with a standardized definition of CP or asked to describe their pain (i.e., pain rating intensity, interference with daily activities, etc.). These limitations could result in participants reporting CP without meeting diagnostic criteria, whereas others who met criteria may not have identified themselves as having CP. Furthermore, insight into the pain experience of American equestrians cannot be inferred from the information gathered in the current study. Since anatomical selections provided were based on regions rather than joints, participants may have experienced confusion when choosing which region to select for joint pain. For example, it may have been unclear to participants whether to select either the pelvis or the upper leg region, or both regions, when experiencing chronic hip pain. These factors limit the generalizability of the current study. Regardless, the current study provides valuable data on

the relationship between body mass and CP in equestrians, especially in a group with a large recreational proportion.

While the dataset comes from a convenience sample collected online, the sample's demographics aligned with those reported in the last American Horse Council report [110]. With consideration of the alignment in demographics and the current study having a distribution across the adult lifespan and from all regions of the US, including Hawaii and Alaska, it provides meaningful information and highlights areas for future research. Due to participants being able to self-select multiple disciplines, we were unable to determine discipline-specific relationships, which limits the insights available into reporting differences between disciplines. This limitation may have minimal impact as equestrians often shift between disciplines throughout their lifespan.

4.2. Future Research

The current study highlights areas for future research to further evaluate risk and protective factors for experiencing CP in equestrians, especially within the American equestrian population. Future studies should focus on evaluating the body mass of equestrians regarding CP development and persistence, and how the combination of body mass and CP might impact rider movement asymmetry and thereby negatively impact horse welfare. Considering the current study adds to contradictory findings regarding demographic risk factors and reporting CP, future research should utilize standardized definitions of pain, clearly define recall periods, distinguish between recurring episodes of pain versus the presence of CP, and use multidimensional pain questionnaires. A greater focus on modifiable factors associated with the development and maintenance of CP in future research is likely to facilitate implementable strategies to address the high prevalence of CP within the equestrian population.

5. Conclusion

The findings of the current study provide a new perspective on CP risk factors regarding demographics in equestrians by evaluating a large nationwide sample, including all levels of equestrian participants. American equestrians reported a lower prevalence of chronic back pain than some European samples. The current study reports that higher body mass categories (>91 kg) were associated with greater odds of reporting general and region-specific CP (back and lower leg). These findings suggest a potential threshold effect; however, this should be interpreted as a preliminary association that requires confirmation in studies using continuous measures of body mass, rather than categorical data. Additionally, given the cross-sectional design and modest model discrimination, these associations should not be interpreted as strong or independent predictors. Engagement in equestrian activities across the lifespan may be associated with improved musculoskeletal health in older adults; however, its relationship with CP cannot be determined from the current data. Our study's findings represent preliminary associations of potential risk factors related to reporting CP rather than causal relationships. Additional research is needed to confirm our findings, particularly using longitudinal designs and continuous variables to elicit more detailed relationships. In addition, future research should focus on evaluating the relationships between body mass, CP, and movement patterns in equestrians and how these factors influence horse movement and welfare.

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Authors' Contributions

E.A.O.: Conceptualization, Methodology, Formal analysis, Writing – original draft, Writing – review & editing, Project administration. K.I.T.: Conceptualization, Data curation, Writing – review & editing. M.M.K.: Conceptualization, Methodology, Formal analysis, Writing – original draft, Writing – review & editing, Project administration.

Data Availability

The datasets analyzed during the current study are not publicly available due to institutional review board restrictions, but are available from the corresponding author upon reasonable request.

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Conflicts of Interest

The authors declare that there are no conflicts of interest.

Ethical Approval

This study has been approved by the Institutional Review Board at the University of Kentucky, protocol number 56488. This study has followed the guidelines of the Declaration of Helsinki.

Declaration of Generative AI and AI-Assisted Technologies

During the preparation of this work, the authors used ChatGPT (GPT-4o, OpenAI) sparingly for minor sentence level-editing (e.g., rephrasing). Following the use of this tool, the authors reviewed and edited the content as needed and take full responsibility for the final version of the publication.

References

- [1] Havertz A, Uebis D, Schiffers R, Hildebrand F, Weber CD. Sports injury risk assessment based on a training and functional movement analysis of young elite equestrian athletes—an exploratory cross-sectional study. *BMC Sports Science, Medicine and Rehabilitation* 2025;17:83. <https://doi.org/10.1186/s13102-025-01138-x>.
- [2] de Haan D. A review of the appropriateness of existing micro- and meso-level models of athlete development within equestrian sport. *International Journal of Human Movement and Sports Sciences* 2017;5:1–8. <https://doi.org/10.13189/saj.2017.050101>.
- [3] de Haan D, Dumbell LC. Equestrian sport at the Olympic Games from 1900 to 1948. *The International Journal of the History of Sport* 2016;33:648–65. <https://doi.org/10.1080/09523367.2016.1195373>.
- [4] de Haan D, Henry I, Sotiriadou P. Evaluating the place of equestrian sport in the Long Term Athlete Development (LTAD) and the Sport Policy factors that lead to International Sporting Success (SPLISS) models, Melbourne: 2015.
- [5] Clayton HM, MacKechnie-Guire R, Hobbs SJ. Riders' effects on horses—biomechanical principles with examples from the literature. *Animals* 2023;13:3854. <https://doi.org/10.3390/ani13243854>.
- [6] Hobbs SJ, St George L, Reed J, Stockley R, Thetford C, Sinclair J, *et al.* A scoping review of determinants of performance in dressage. *PeerJ* 2020;8:e9022. <https://doi.org/10.7717/peerj.9022>.
- [7] Roepstorff L, Egenvall A, Rhodin M, Byström A, Johnston C, van Weeren PR, *et al.* Kinetics and kinematics of the horse comparing left and right rising trot. *Equine Veterinary Journal* 2009;41:292–6. <https://doi.org/10.2746/042516409X397127>.
- [8] MacKechnie-Guire R, MacKechnie-Guire E, Fairfax V, Fisher M, Hargreaves S, Pfau T. The effect that induced rider asymmetry has on equine locomotion and the range of motion of the thoracolumbar spine when ridden in rising trot. *Journal of Equine Veterinary Science* 2020;88:102946. <https://doi.org/10.1016/j.jevs.2020.102946>.
- [9] Malchrowicz-Moško E, Wielński D, Adamczewska K. Perceived benefits for mental and physical health and barriers to horseback riding participation. The analysis among professional and amateur athletes. *International Journal of Environmental Research and Public Health* 2020;17:3736. <https://doi.org/10.3390/ijerph17103736>.
- [10] Hogg RC, Hodgins GA. Symbiosis or sporting tool? Competition and the horse-rider relationship in elite equestrian sports. *Animals* 2021;11:1352. <https://doi.org/10.3390/ani11051352>.
- [11] Schwarzmüller-Erber G, Stummer H, Maier M, Kundi M. Nature relatedness of recreational horseback riders and its association with mood and wellbeing. *International Journal of Environmental Research and Public Health* 2020;17:4136. <https://doi.org/10.3390/ijerph17114136>.
- [12] Bye TL, Chadwick G. Physical fitness habits and perceptions of equestrian riders. *Comparative Exercise Physiology* 2018;14:183–8. <https://doi.org/10.3920/cep180012>.
- [13] Douglas J-L, Price M, Peters DM. A systematic review of physical fitness, physiological demands and biomechanical performance in equestrian athletes. *Comparative Exercise Physiology* 2012;8:53–62. <https://doi.org/10.3920/cep12003>.
- [14] Sáez I, León-Guereño P, Malchrowicz-Moško E, Balerdi E, Río X, Lavín B, *et al.* Health benefits and participation barriers of different level horseback riders age-wise. *Frontiers in Psychology* 2022;13:889605. <https://doi.org/10.3389/fpsyg.2022.889605>.
- [15] Schneider IE, Earing J, Martinson K. Revealing motivations for and conflicts associated with recreational horseback trail riding. *Journal of Forestry* 2013;111:282–6. <https://doi.org/10.5849/jof.12-056>.
- [16] Keener MM, Tumlin KI, Heebner NR. Combined driving: task-specific position impacts grip strength of equestrian athletes. *European Review of Aging and Physical Activity* 2022;19:2. <https://doi.org/10.1186/s11556-021-00282-w>.
- [17] Keener MM, Tumlin KI, Dlugonski D. Self-reported physical activity and perception of athleticism in American equestrian athletes. *Journal of Physical Activity and Health* 2023;20:169–79. <https://doi.org/10.1123/jpah.2022-0398>.

- [18] Schwarzmüller-Erber G, Maier M, Stummer H, Kundi M. Recreational horseback riding and its association with physical, mental, and social wellbeing and perceived health. *Anthrozoös* 2021;34:685–706. <https://doi.org/10.1080/08927936.2021.1926709>.
- [19] Anderson K, Karr-Lilienthal. Team members perceptions of benefits of participation on a university equestrian team. *NACTA Journal* 2011;55:8–13.
- [20] Fiedler JM, Ayre ML, Rosanowski S, Slater JD. Horses are worthy of care: horse sector participants' attitudes towards animal sentience, welfare, and well-being. *Animal Welfare* 2025;34:e6. <https://doi.org/10.1017/awf.2024.69>.
- [21] Fiedler JM, Ayre ML, Rosanowski S, Slater JD. Horse sector participants' attitudes towards anthropomorphism and animal welfare and wellbeing. *Animals* 2024;14:2482. <https://doi.org/10.3390/ani14172482>.
- [22] Neville EK, Hicks H, Neville CC. Epidemiology of horse trauma: a literature review. *European Journal of Trauma and Emergency Surgery* 2024;50:741–54. <https://doi.org/10.1007/s00068-023-02436-0>.
- [23] Ekberg J, Timpka T, Ramel H, Valter L. Injury rates and risk-factors associated with eventing: a total cohort study of injury events among adult Swedish eventing athletes. *International Journal of Injury Control and Safety Promotion* 2011;18:261–7. <https://doi.org/10.1080/17457300.2010.545129>.
- [24] Hobbs SJ, Baxter J, Broom L, Rossell L-A, Sinclair J, Clayton HM. Posture, flexibility and grip strength in horse riders. *Journal of Human Kinetics* 2014;42:113–25. <https://doi.org/10.2478/hukin-2014-0066>.
- [25] Kraft CN, Pennekamp PH, Becker U, Young M, Diedrich O, Lüring C, *et al.* Magnetic resonance imaging findings of the lumbar spine in elite horseback riders. *The American Journal of Sports Medicine* 2009;37:2205–13. <https://doi.org/10.1177/0363546509336927>.
- [26] Duarte CR, Raimundo A, Sousa JP, Fernandes O, Santos R. Prevalence of lower back pain and risk factors in equestrians: a systematic review. *Sports* 2024;12:355. <https://doi.org/10.3390/sports12120355>.
- [27] Williams J, Tabor G. Rider impacts on equitation. *Applied Animal Behaviour Science* 2017;190:28–42. <https://doi.org/10.1016/j.applanim.2017.02.019>.
- [28] Keener MM, Critchley ML, Layer JS, Johnson EC, Barrett SF, Dai B. The effect of stirrup length on impact attenuation and its association with muscle strength. *Journal of Strength & Conditioning Research* 2021;35:3056–62. <https://doi.org/10.1519/jsc.0000000000003278>.
- [29] Raja SN, Carr DB, Cohen M, Finnerup NB, Flor H, Gibson S, *et al.* The revised International Association for the study of pain definition of pain: concepts, challenges, and compromises. *Pain* 2020;161:1976–82. <https://doi.org/10.1097/j.pain.0000000000001939>.
- [30] Cohen SP, Vase L, Hooten WM. Chronic pain: an update on burden, best practices, and new advances. *The Lancet* 2021;397:2082–97. [https://doi.org/10.1016/S0140-6736\(21\)00393-7](https://doi.org/10.1016/S0140-6736(21)00393-7).
- [31] Smith E, Hoy DG, Cross M, Vos T, Naghavi M, Buchbinder R, *et al.* The global burden of other musculoskeletal disorders: estimates from the Global Burden of Disease 2010 study. *Annals of the Rheumatic Diseases* 2014;73:1462–9. <https://doi.org/10.1136/annrheumdis-2013-204680>.
- [32] Mills SEE, Nicolson KP, Smith BH. Chronic pain: a review of its epidemiology and associated factors in population-based studies. *British Journal of Anaesthesia* 2019;123:e273–83. <https://doi.org/10.1016/j.bja.2019.03.023>.
- [33] El-Tallawy SN, Nalamasu R, Salem GI, LeQuang JAK, Pergolizzi JV, Christo PJ. Management of musculoskeletal pain: an update with emphasis on chronic musculoskeletal pain. *Pain and Therapy* 2021;10:181–209. <https://doi.org/10.1007/s40122-021-00235-2>.
- [34] Bonanni R, Cariati I, Tancredi V, Iundusi R, Gasbarra E, Tarantino U. Chronic pain in musculoskeletal diseases: do you know your enemy? *Journal of Clinical Medicine* 2022;11:2609. <https://doi.org/10.3390/jcm11092609>.
- [35] Mendonça CR, Noll M, de Carvalho Santos AS e A, Rodrigues AP dos S, Silveira EA. High prevalence of musculoskeletal pain in individuals with severe obesity: sites, intensity, and associated factors. *The Korean Journal of Pain* 2020;33:245–57. <https://doi.org/10.3344/kjp.2020.33.3.245>.
- [36] Lewis V, Kennerley R. A preliminary study to investigate the prevalence of pain in elite dressage riders during competition in the United Kingdom. *Comparative Exercise Physiology* 2017;13:259–64. <https://doi.org/10.3920/cep170016>.
- [37] Lewis V, Baldwin K. A preliminary study to investigate the prevalence of pain in international event riders during competition, in the United Kingdom. *Comparative Exercise Physiology* 2018;14:173–82. <https://doi.org/10.3920/cep180006>.
- [38] Lewis V, Dumbell L, Magnoni F. A preliminary study to investigate the prevalence of pain in competitive showjumping equestrian athletes. *Journal of Physical Fitness, Medicine & Treatment in Sports* 2018;4:555637. <https://doi.org/10.19080/JPFMTS.2018.04.555637>.
- [39] Lewis V, Nicol Z, Dumbell L, Cameron L. A study investigating prevalence of pain in horse riders over thirty-five years old. *International Journal of Equine Science* 2023;2:9–18. <https://doi.org/10.64292/ijes.63>.
- [40] Lewis V, Jones A, Dumbell L, Davies E, Cameron LJ, Williams J. The impact of yard work and stable duties on the perception of pain in United Kingdom recreational and amateur competitive horse riders. *Journal of Physical Fitness, Medicine & Treatment in Sports* 2025;10:555802. <https://doi.org/10.19080/JPFMTS.2025.10.555802>.
- [41] Kraft C, Urban N, Ilg A, Wallny T, Scharfstädt A, Jäger M, *et al.* [Influence of the riding discipline and riding intensity on the incidence of back pain in competitive horseback riders]. *Sportverletzung · Sportschaden* 2007;21:29–33. <https://doi.org/10.1055/s-2007-963038>.
- [42] Ball CG, Ball JE, Kirkpatrick AW, Mulloy RH. Equestrian injuries: incidence, injury patterns, and risk factors for 10 years of major traumatic injuries. *The American Journal of Surgery* 2007;193:636–40. <https://doi.org/10.1016/j.amjsurg.2007.01.016>.
- [43] Keener MM, Tumlin KI. Self-reported acute injury and chronic pain in American equestrian athletes. *Comparative Exercise Physiology* 2023;19:279–92. <https://doi.org/10.1163/17552559-20230021>.
- [44] Eckardt F, Witte K. Horse–rider interaction: A new method based on inertial measurement units. *Journal of Equine Veterinary Science* 2017;55:1–8. <https://doi.org/10.1016/j.jevs.2017.02.016>.

- [45] Hobbs SJ, Serra Braganca FM, Rhodin M, Hernlund E, Peterson M, Clayton HM. Evaluating overall performance in high-level dressage horse–rider combinations by comparing measurements from inertial sensors with general impression scores awarded by judges. *Animals* 2023;13:2496. <https://doi.org/10.3390/ani13152496>.
- [46] Wolframm IA, Bosga J, Meulenbroek RGJ. Coordination dynamics in horse-rider dyads. *Human Movement Science* 2013;32:157–70. <https://doi.org/10.1016/j.humov.2012.11.002>.
- [47] Elmeua González M, Šarabon N. Shock attenuation and electromyographic activity of advanced and novice equestrian riders' trunk. *Applied Sciences* 2021;11:2304. <https://doi.org/10.3390/app11052304>.
- [48] Olivier A, Faugloire E, Lejeune L, Biau S, Isableu B. Head stability and head-trunk coordination in horseback riders: the contribution of visual information according to expertise. *Frontiers in Human Neuroscience* 2017;11:11. <https://doi.org/10.3389/fnhum.2017.00011>.
- [49] Domańska-Kruppa N, Wierzbicka M, Stefanik E. Advances in the clinical diagnostics to equine back pain: a review of imaging and functional modalities. *Animals* 2024;14:698. <https://doi.org/10.3390/ani14050698>.
- [50] Quinn S, Bird S. Influence of saddle type upon the incidence of lower back pain in equestrian riders. *British Journal of Sports Medicine* 1996;30:140–4. <https://doi.org/10.1136/bjism.30.2.140>.
- [51] Ginés-Díaz A, Martínez-Romero MT, Cejudo A, Aparicio-Sarmiento A, Sainz de Baranda P. Sagittal spinal morphotype assessment in dressage and show jumping riders. *Journal of Sport Rehabilitation* 2019;29:533–40. <https://doi.org/10.1123/jsr.2018-0247>.
- [52] Keener MM, Tumlin KI. Corrigendum on: Self-reported acute injury and chronic pain in American equestrian athletes. *Comparative Exercise Physiology* 2024;20:97–9. <https://doi.org/10.1163/17552559-2024x001>.
- [53] Ferrante M, Bonetti F, Quattrini F, Mezzetti M, Demarie S. Low back pain and associated factors among Italian equestrian athletes: a cross-sectional study. *Muscles, Ligaments and Tendons Journal* 2021;11:344–52. <https://doi.org/10.32098/mltj.02.2021.19>.
- [54] Duarte C, Santos R, Fernandes O, Raimundo A. Prevalence of lower back pain in Portuguese equestrian riders. *Sports* 2024;12:207. <https://doi.org/10.3390/sports12080207>.
- [55] Puszczalowska-Lizis E, Szymański D, Pietrzak P, Wilczyński M. Incidence of back pain in people practicing amateur horse riding. *Fizjoterapia Polska* 2022;22:6–15. <https://doi.org/10.56984/8zg1a68my>.
- [56] Cejudo A, Ginés-Díaz A, Sainz de Baranda P. Asymmetry and tightness of lower limb muscles in equestrian athletes: are they predictors for back pain? *Symmetry* 2020;12:1679. <https://doi.org/10.3390/sym12101679>.
- [57] Cejudo A, Ginés-Díaz A, Rodríguez-Ferrán O, Santonja-Medina F, Sainz de Baranda P. Trunk lateral flexor endurance and body fat: predictive risk factors for low back pain in child equestrian athletes. *Children* 2020;7:172. <https://doi.org/10.3390/children7100172>.
- [58] Michaud P-C, van Soest A, Andreyeva T. Cross-Country Variation in Obesity Patterns Among Older Americans and Europeans 2007. <https://doi.org/10.2139/ssrn.1003914>.
- [59] Bassett DR, Pucher J, Buehler R, Thompson DL, Crouter SE. Walking, cycling, and obesity rates in Europe, North America, and Australia. *Journal of Physical Activity and Health* 2008;5:795–814. <https://doi.org/10.1123/jpah.5.6.795>.
- [60] Ohrnberger EA, Tumlin KI, Keener MM. Evaluating the relationship across physical activity domains and chronic pain in adult American equestrians: a secondary analysis. *International Journal of Equine Science* 2026;5:3–20. <https://doi.org/10.64292/ijes.185>.
- [61] Bursac Z, Gauss CH, Williams DK, Hosmer DW. Purposeful selection of variables in logistic regression. *Source Code for Biology and Medicine* 2008;3:17. <https://doi.org/10.1186/1751-0473-3-17>.
- [62] Greve L, Dyson S. Saddle fit and management: An investigation of the association with equine thoracolumbar asymmetries, horse and rider health. *Equine Veterinary Journal* 2015;47:415–21. <https://doi.org/10.1111/evj.12304>.
- [63] Punnett L, Wegman DH. Work-related musculoskeletal disorders: the epidemiologic evidence and the debate. *Journal of Electromyography and Kinesiology* 2004;14:13–23. <https://doi.org/10.1016/j.jelekin.2003.09.015>.
- [64] Ball JE, Ball CG, Mulloy RH, Datta I, Kirkpatrick AW. Ten years of major equestrian injury: are we addressing functional outcomes? *Journal of Trauma Management & Outcomes* 2009;3. <https://doi.org/10.1186/1752-2897-3-2>.
- [65] Teasell RW, Bombardier C. Employment-related factors in chronic pain and chronic pain disability. *The Clinical Journal of Pain* 2001;17:S39–45. <https://doi.org/10.1097/00002508-200112001-00010>.
- [66] Keener MM, Tumlin KI. The Triple-E model: advancing equestrian research with perspectives from one health. *Animals* 2023;13:2642. <https://doi.org/10.3390/ani13162642>.
- [67] Löfqvist L, Chafi MB, Osvalder AL, Bligård LO, Pinzke S. Ergonomic evaluation of long-shafted tools used in horse stables: the effects of shaft length variation and work technique on working posture. *International Journal of Human Factors and Ergonomics* 2012;1:298–312. <https://doi.org/10.1504/ijhfe.2012.050872>.
- [68] Löfqvist L, Osvalder A-L, Bligård L-O, Pinzke S. An analytical ergonomic risk evaluation of body postures during daily cleaning tasks in horse stables. *WORK: A Journal of Prevention, Assessment & Rehabilitation* 2015;51:667–82. <https://doi.org/10.3233/wor-152022>.
- [69] Tumlin K, Liu S, Park J-H. Framing future of work considerations through climate and built environment assessment of volunteer work practices in the United States equine assisted services. *International Journal of Environmental Research and Public Health* 2021;18:10385. <https://doi.org/10.3390/ijerph181910385>.
- [70] Bulens A, Sterken H, Van Beirendonck S, Van Thielen J, Driesen B. The use of different objects during a novel object test in stabled horses. *Journal of Veterinary Behavior* 2015;10:54–8. <https://doi.org/10.1016/j.jveb.2014.09.002>.
- [71] Baragli P, Vitale V, Banti L, Sighieri C. Effect of aging on behavioural and physiological responses to a stressful stimulus in horses (*Equus caballus*). *Behaviour* 2014;151:1513–33. <https://doi.org/10.1163/1568539X-00003197>.
- [72] Meyer H-L, Scheidgen P, Polan C, Beck P, Mester B, Kautner MD, et al. Injuries and overuse injuries in show jumping—a retrospective epidemiological cross-sectional study of show jumpers in Germany. *International Journal of Environmental Research and Public Health* 2022;19:2305. <https://doi.org/10.3390/ijerph19042305>.

- [73] Caparrós T, Alentorn-Geli E, Myer GD, Capdevila L, Samuelsson K, Hamilton B, *et al.* The relationship of practice exposure and injury rate on game performance and season success in professional male basketball. *Journal of Sports Science & Medicine* 2016;15:397–402.
- [74] Borgers J, Breedveld K, Tiessen-Raaphorst A, Thibaut E, Vandermeersch H, Vos S, *et al.* A study on the frequency of participation and time spent on sport in different organisational settings. *European Sport Management Quarterly* 2016;16:635–54. <https://doi.org/10.1080/16184742.2016.1196717>.
- [75] Bruner MW, Munroe-Chandler KJ, Spink KS. Entry into elite sport: a preliminary investigation into the transition experiences of rookie athletes. *Journal of Applied Sport Psychology* 2008;20:236–52. <https://doi.org/10.1080/10413200701867745>.
- [76] Wolfram I. The science of equestrian sports: theory, practice and performance of the equestrian rider. 1st Edition. London, UK: Routledge; 2013.
- [77] Wicklund A, Foster SD, Roy AA. Getting back on the horse: sport-specific return to play in rodeo athletes after concussion injury. *Journal of Athletic Training* 2018;53:657–61. <https://doi.org/10.4085/1062-6050-310-17>.
- [78] Davies E, Liddiard S, McConn-Palfreyman WJ, Parker JK, Cameron LJ, Williams JM. Anxiety and depression in British horseracing stud and stable staff following occupational injury. *Animals* 2023;13:3337. <https://doi.org/10.3390/ani13213337>.
- [79] Davies E, McConn-Palfreyman W, Williams JM, Lovell GP. A narrative review of the risk factors and psychological consequences of injury in horseracing stable staff. *Comparative Exercise Physiology* 2021;17:303–17. <https://doi.org/10.3920/cep200073>.
- [80] Davies E, McConn-Palfreyman W, Parker JK, Williams JM. "If you can walk, if you can breathe, you don't need to go to hospital": Psychological responses of British horseracing staff to occupational injury. *International Journal of Equine Science* 2025;4:52–71. <https://doi.org/10.64292/ijes.152>.
- [81] Davies E, McConn-Palfreyman W, Parker JK, Cameron LJ, Williams JM. Is injury an occupational hazard for horseracing staff? *International Journal of Environmental Research and Public Health* 2022;19:2054. <https://doi.org/10.3390/ijerph19042054>.
- [82] de Vries HJ, Brouwer S, Groothoff JW, Geertzen JH, Reneman MF. Staying at work with chronic nonspecific musculoskeletal pain: a qualitative study of workers' experiences. *BMC Musculoskeletal Disorders* 2011;12:126. <https://doi.org/10.1186/1471-2474-12-126>.
- [83] Azouaghe O. Determining safe rider weights for horses. *Veterinary Record* 2018;182:305. <https://doi.org/doi.org/10.1136/vr.k1222>.
- [84] Challinor CL, Randle H, Williams JM. Understanding rider-horse bodyweight ratio trends, weight management practices and rider weight perceptions within leisure and amateur riders in the UK. *Comparative Exercise Physiology* 2021;17:403–18. <https://doi.org/10.3920/cep200082>.
- [85] Christensen JW, Bathellier S, Rhodin M, Palme R, Uldahl M. Increased rider weight did not induce changes in behavior and physiological parameters in horses. *Animals* 2020;10:95. <https://doi.org/10.3390/ani10010095>.
- [86] Burke MA, Carman KG. You can be too thin (but not too tall): Social desirability bias in self-reports of weight and height. *Economics & Human Biology* 2017;27:198–222. <https://doi.org/10.1016/j.ehb.2017.06.002>.
- [87] Forino S, Cameron L, Stones N, Freeman M. Potential impacts of body image perception in female equestrians. *Journal of Equine Veterinary Science* 2021;107:103776. <https://doi.org/10.1016/j.jevs.2021.103776>.
- [88] Forino S, Cameron L, Stones N, Freeman M. Horse-rider pairing perception by dressage judges and equestrian coaches. *Journal of Equine Veterinary Science* 2023;128:104864. <https://doi.org/10.1016/j.jevs.2023.104864>.
- [89] Torres-McGehee TM, Monsma EV, Gay JL, Minton DM, Mady-Foster AN. Prevalence of eating disorder risk and body image distortion among National Collegiate Athletic Association Division I varsity equestrian athletes. *Journal of Athletic Training* 2011;46:431–7. <https://doi.org/10.4085/1062-6050-46.4.431>.
- [90] Clayton HM, Hobbs S-J. The role of biomechanical analysis of horse and rider in equitation science. *Applied Animal Behaviour Science* 2017;190:123–32. <https://doi.org/10.1016/j.applanim.2017.02.011>.
- [91] Emmerich S, Fryar C, Stierman B, Ogden C. Obesity and severe obesity prevalence in adults: United States, August 2021–August 2023. National Center for Health Statistics (U.S.); 2024. <https://doi.org/10.15620/cdc/159281>.
- [92] d'Errico M, Pavlova M, Spandonaro F. The economic burden of obesity in Italy: a cost-of-illness study. *The European Journal of Health Economics* 2022;23:177–92. <https://doi.org/10.1007/s10198-021-01358-1>.
- [93] Clayton HM, Dyson S, Harris P, Bondi A. Horses, saddles and riders: applying the science. *Equine Veterinary Education* 2015;27:447–52. <https://doi.org/10.1111/eve.12407>.
- [94] Dyson S, Ellis AD, Mackechnie-Guire R, Douglas J, Bondi A, Harris P. The influence of rider-horse bodyweight ratio and rider-horse-saddle fit on equine gait and behaviour: A pilot study. *Equine Veterinary Education* 2020;32:527–39. <https://doi.org/10.1111/eve.13085>.
- [95] Al-Eisa E, Egan D, Deluzio K, Wassersug R. Effects of pelvic asymmetry and low back pain on trunk kinematics during sitting: a comparison with standing. *Spine (Phila Pa 1976)* 2006;31:E135–143. <https://doi.org/10.1097/01.brs.0000201325.89493.5f>.
- [96] Nankervis K, Dumbell L, Herbert L, Winfield J, Guire R, Laund E. A comparison of the position of elite and non-elite riders during competitive show jumping. *Comparative Exercise Physiology* 2015;11:119–26. <https://doi.org/10.3920/cep150004>.
- [97] Legg K, Cochrane D, Gee E, Macdermid P, Rogers C. Physiological demands and muscle activity of jockeys in trial and race riding. *Animals* 2022;12:2351. <https://doi.org/10.3390/ani12182351>.
- [98] American Horse Council Foundation. Economic impact study of the us horse industry 2017. <https://www.cabidigitallibrary.org/doi/pdf/10.5555/20193333566>.
- [99] Stanfill AG, Wynja K, Cao X, Prescott D, Shore S, Baughman B, *et al.* Helmet use in equestrian athletes: opportunities for intervention. *Concussion* 2021;6. <https://doi.org/10.2217/cnc-2020-0019>.
- [100] Overstreet DS, Strath LJ, Jordan M, Jordan IA, Hobson JM, Owens MA, *et al.* A brief overview: Sex differences in prevalent chronic musculoskeletal conditions. *International Journal of Environmental Research and Public Health* 2023;20:4521. <https://doi.org/10.3390/ijerph20054521>.
- [101] Mundal I, Gråwe RW, Bjørngaard JH, Linaker OM, Fors EA. Psychosocial factors and risk of chronic widespread pain: an 11-year follow-up study—the HUNT study. *Pain* 2014;155:1555–61. <https://doi.org/10.1016/j.pain.2014.04.033>.

- [102] Konieczny MR, Senyurt H, Krauspe R. Epidemiology of adolescent idiopathic scoliosis. *Journal of Children's Orthopaedics* 2013;7:3–9. <https://doi.org/10.1007/s11832-012-0457-4>.
- [103] Fernandez M, Colodro-Conde L, Hartvigsen J, Ferreira ML, Refshauge KM, Pinheiro MB, *et al.* Chronic low back pain and the risk of depression or anxiety symptoms: insights from a longitudinal twin study. *The Spine Journal* 2017;17:905–12. <https://doi.org/10.1016/j.spinee.2017.02.009>.
- [104] Shi P, Yang A, Zhao Q, Chen Z, Ren X, Dai Q. A hypothesis of gender differences in self-reporting symptom of depression: implications to solve under-diagnosis and under-treatment of depression in males. *Frontiers in Psychiatry* 2021;12:589687. <https://doi.org/10.3389/fpsy.2021.589687>.
- [105] McLean CP, Asnaani A, Litz BT, Hofmann SG. Gender differences in anxiety disorders: Prevalence, course of illness, comorbidity and burden of illness. *Journal of Psychiatric Research* 2011;45:1027–35. <https://doi.org/10.1016/j.jpsychires.2011.03.006>.
- [106] Musalek C, Kirchengast S. Grip strength as an indicator of health-related quality of life in old age—a pilot study. *International Journal of Environmental Research and Public Health* 2017;14:1447. <https://doi.org/10.3390/ijerph14121447>.
- [107] Hong YS, Kim H. Hand grip strength and health-related quality of life in postmenopausal women: a national population-based study. *Menopause* 2021;28:1330–9. <https://doi.org/10.1097/gme.0000000000001863>.
- [108] Gopinath B, Kifley A, Liew G, Mitchell P. Handgrip strength and its association with functional independence, depressive symptoms and quality of life in older adults. *Maturitas* 2017;106:92–4. <https://doi.org/10.1016/j.maturitas.2017.09.009>.
- [109] Deckers I, De Bruyne C, Roussel NA, Truijien S, Minguet P, Lewis V, *et al.* Assessing the sport-specific and functional characteristics of back pain in horse riders. *Comparative Exercise Physiology* 2021;17:7–16. <https://doi.org/10.3920/cep190075>.
- [110] American Horse Council Foundation. 2023 economic impact study of the US Horse industry. American Horse Council Foundation McLean (VA); 2024. <https://horsecouncil.org/economic-impact-study>.

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