

Evaluating the Relationship Across Physical Activity Domains and Chronic Pain in Adult American Equestrians: A Secondary Analysis

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Abstract

Chronic pain (CP) in equestrians may disrupt rider–horse movement patterns, communication, and welfare. Physical activity (PA) is used to manage CP in other populations. Equestrians engage in high PA across equestrian (EqA), barn work (BW), and non-EqA domains, yet still report high CP rates. This study aims to explore risk and protective PA factors across domains associated with self-reported CP in American equestrians. Secondary analysis of a cross-sectional survey of adult American equestrians ($n = 1,612$). All variables were categorical (EqA, BW, and non-EqA volume; participation level; BW tasks). Chi-square tests informed forward binary logistic regression examining odds (ORs) of reporting CP across PA domains. The sample's participation level was 23.0% professionals, 44.5% amateurs, and 32.5% recreational equestrians, with 45% experiencing CP, most commonly in the back (27.8%). Recreational riders had lower odds of experiencing CP ($OR = 0.6$, $P < 0.001$), chronic lower-leg ($OR = 0.47$, $P = 0.004$), and neck ($OR = 0.57$, $P = 0.01$) pain than professionals. Regardless of participation level, equestrians engaging in categories ≤ 5 hours/week of EqA had lower odds ($OR = 0.46$ – 0.62 , $P = 0.001$ – 0.04) of reporting chronic back pain compared with those spending ≥ 15.5 hours/week. Regular running was protective against reporting CP, particularly in the back ($OR = 0.62$, $P = 0.007$) and pelvic ($OR = 0.50$, $P = 0.02$) regions. Participation level emerged as the primary risk factor for CP, followed by EqA volume for chronic back pain. Higher EqA workloads may exceed adaptive capacity regarding chronic back pain, underscoring the need for context-specific prevention strategies addressing workload management, such as physical training programs scaled to participation level and consideration of equipment fit (i.e., saddle).

Keywords

Horseback riding; risk factors; protective factors; pain prevalence; human–animal interactions

1. Introduction

Chronic pain (CP) is pain (of mild to severe intensity) that persists or recurs for longer than three months after the anticipated healing of the initial injury [1]. CP has been found to affect a wide range of equestrians (25–88%) depending on discipline and participation level [2–8]. It has been reported that 56.1% of American equestrians self-reported experiencing CP, with professionals at 1.5 times greater odds of reporting CP than amateur and recreational equestrians [9]. Management strategies for CP often target modifiable

risk factors related to the development and maintenance of CP, including sedentary lifestyle, poor or limited social interactions, and manual labor [10]. A common strategy to self-manage CP is engaging in physical activity (PA), which helps improve and maintain physical and mental functionality and reduce the severity of comorbidities (e.g., poor sleep, depression) [11,12].

Equestrian activities are a common form of PA and include mounted (i.e., riding or driving a carriage) and unmounted activities (i.e., caring for the horse and completing barn

work). According to the most recent American Horse Council report, although only 1.2% of households in the United States (U.S.) own horses, an additional 19.4% participate in equestrian activities, with nearly half (48%) of those participants reporting an annual household income of <\$75,000 [13].

Equestrian PA presents a complex bi-directional relationship with CP development and recurrence. While equestrian activities are a beneficial form of PA shown to improve balance, muscular strength, physical fitness, flexibility, and mental health, there is also a high risk for acute and overuse injuries [14–20]. Acute injuries frequently result from falls, kicks, and other mechanisms associated with working with a live animal and often progress into persistent pain and other health consequences [8,9,21–25]. One study reported that 62% of riders experienced CP and headaches after sustaining a significant equestrian-related injury [25]. Overuse injuries arise from the repetitive forces and demands of riding and caring for horses [2,26,27]. Chronic back pain rates are as high as 88% in elite dressage riders and are thought to reflect the repetitive, cumulative spinal loading that occurs during riding [2,3,6]. Research further documents frequent CP in the neck, pelvic, and lower extremities across disciplines [5–8,28].

Pain development is multifaceted. In riders, it can arise not only from injury but also from muscle weakness or tightness that produces asymmetrical movement patterns, which in turn can impair balance and coordination [29]. When pain and asymmetry persist, riders may place uneven forces on the saddle and the horse's back, potentially contributing to back discomfort or pain in the horse over time [29–31]. Rider asymmetry can also interfere with clear rider–horse communication and degrade riding performance, increasing opportunities for confusion, frustration, and errors between the duo [5,7,8,29,32]. In addition to these frustrations, CP may negatively impact the equestrian's concentration and confidence, which can lead to errors in practice or competition, causing injury to the horse and rider [33,34]. Therefore, for both human quality of life and horse welfare purposes, understanding areas that may exacerbate CP development and recurrence in equestrians is critical.

Key determinants of overuse injury and CP development align with PA load and task demands, including participation level (i.e., professional, amateur, or recreational), discipline (i.e., dressage), hours spent riding, and saddle type and fit [3–9,35–37]. Time spent engaging in any activity typically scales with participation level, with professionals engaging the most, followed by amateurs and then recreational participants, and this pattern is consistent in equestrians [16,38,39]. In addition to the high volume of engagement, professional equestrians often work with younger, less experienced (green) horses that may be more reactive and increase the chance of injury occurrence [40]. The pattern of PA load and participation level in equestrians increases exposure to cumulative musculoskeletal stress, thus heightening the likelihood of acute and overuse injuries. The high risk of acute injuries, coupled with overuse injuries from accumulated musculoskeletal strain, facilitates the progression to and maintenance of CP. These patterns reveal some of the plausible mechanisms underlying the high CP rates in professional and elite equestrians currently observed [3,9,41]. Despite PA often helping alleviate pain, there is a clear dose-dependent

connection between PA load and CP among equestrians that has only been superficially examined. As equestrian involvement requires significant physical demands, a deepening understanding of the complex, dose-dependent relationship between PA and CP is critically needed.

Equestrians engage in three primary PA domains: equestrian PA (i.e., riding horses or driving a carriage), barn work PA, and non-equestrian PA (i.e., running or lifting weights). Prior work quantifying equestrian PA load suggests that amateur and professional equestrians ride between 8–9 hours/week with large standard deviations (5–7 hours/week), while recreational equestrians spend 6.4 ± 4.5 hours/week riding [16,39]. Notably, the highest prevalence of chronic back pain was reported among equestrians riding 7–8 hours/day, ≥ 5 days/week [2]. Despite participation level, barn work PA typically requires a greater weekly time commitment than riding to maintain the horse's health and welfare, regardless of the horse's training schedule [4,9,38,42,43]. Common tasks (e.g., cleaning stalls, carrying water buckets, stacking hay) are repetitive and often asymmetric, resembling manual labor and imposing substantial physical strain [4,42,44]. British equestrians who completed >2 hours/day of barn work had 1.6 times greater odds of reporting pain compared with those performing <1 hour/day, and nearly 90% of participants reported experiencing pain during barn work activities [5,28]. Despite the clear physical demands of barn work, few studies have examined the relationship between barn work volume and CP, especially within American samples. Finally, non-equestrian PA engagement varies widely (25–91%) across other sporting activities and physical training programs [7,8,16,39,45–47]. Considering the range of PA loads across these domains, a deeper examination of how PA loads relate to CP in equestrians is warranted.

Based on the bi-directional relationship between PA and CP, it is important to examine how the volume and type of PA across different domains are associated with self-reported CP. These relationships are particularly relevant for American equestrians, who have similar CP rates as international equestrians, but for where research evaluating CP is sparse. Therefore, the purpose of this study is to explore the risk and protective factors for self-reporting CP among American equestrians in relation to PA volume across three domains: equestrian activity, barn work, and non-equestrian physical activity.

2. Methods

2.1. Study Design & Data Source

The current study is a secondary analysis of data collected from a cross-sectional, survey-based study conducted in 2020–2021 through REDCap [48,49]. The survey included questions regarding demographics, equestrian participation, PA across the three domains, acute injury, and CP. The original study aimed to (1) evaluate PA participation among American equestrians and perceptions of equestrian activity being a sport by participation level and (2) evaluate the relationship between acute injury and CP among American equestrians of all levels of participation, experience, and age ranges [9,38,50]. The current manuscript is a secondary analysis that investigates a novel aspect of the dataset not addressed in previous manuscripts and is guided by a new set of research aims, inclusion and exclusion criteria,

and analyses that differ from the original objectives of the cross-sectional survey. This data analysis was approved by the University of Kentucky's Institutional Review Board under protocol number 56488.

2.2. Dataset Inclusion and Validation

The original dataset included 2,539 responses. For the secondary analysis, inclusion criteria were (1) survey completion; (2) consistent participation on a weekly basis over the past six months (yes/no) at the time of the original study; (3) age ≥ 18 years; (4) definitive answers to questions regarding CP (e.g., "yes" or "no," not "prefer not to answer"); and (5) definitive answers to sex, age, height, and body mass demographic questions (e.g., not "prefer not to answer"). Participants who did not ride consistently were excluded from the sample, as the authors were interested in equestrians experiencing CP while continuing to participate in equestrian PA regularly. Data validation included analysis for duplicates and responses in which the reported age was less than the years of participation in equestrian activities. Data marked as a duplicate or where the individual's years of participation in equestrian activity were greater than their age were excluded from the subset.

2.3. Questionnaire Details

All questions were categorical (binary and ordinal) and included basic demographics, participation level (recreational, amateur, or professional), and years of participation in equestrian activities. Individuals who reported consistently engaging in equestrian activities over the past six months selected the number of days they rode per week (daily, 5–6 days, 3–4 days, or 1–2 days). To evaluate equestrian PA, participants reported the average number of hours they rode per two-week period over the past six months. There were 14 categorical options ranging from "<3 hours/2 weeks" to ">80 hours/2 weeks." The final equestrian domain question asked how many different horses a participant rode in an average two-week span over the past six months, with options of one, two, 3–4, 5–6, 7–9, or ≥ 10 horses.

For the barn work PA domain, the first question asked whether the participant helped with barn work or prepared their horse for riding (yes/no) over the past six months. Branching logic allowed individuals who answered "yes" to provide binary responses to types of barn work activities completed (i.e., cleaning stalls) and ordinal responses to barn work PA volume and specific tasks (i.e., how many stalls were cleaned consecutively). Barn work PA volume had nine categories, ranging from "1–4 hours/week" to ">40 hours/week."

For the non-equestrian PA domain, individuals selected the types of PA they engaged in regularly (at least once every two weeks over the past six months) from a list of 24 options. The last option was "other," which allowed participants to provide other types of non-equestrian PA they engaged in regularly. Branching logic allowed participants to report their average intensity level for each activity selected (low, low-moderate, moderate, moderate-vigorous, or vigorous) and the average hours per two-week period spent participating in the activity.

The final section allowed participants to report whether they were experiencing CP (referred to as "general CP") using a simple yes/no response. If the participant selected "yes," they could select which anatomical region(s) they were experiencing CP in, with the options: head/face, neck, chest, back, breasts, abdomen, arms, hands, pelvis, genitals, upper leg, lower leg, and foot. Participants were allowed to select more than one anatomical region to reflect if they were experiencing CP in multiple regions. Throughout this manuscript, "regional CP" refers to CP in any of these anatomical regions. **Supplementary Materials** contain the survey questions used for this secondary analysis.

2.4. Data Cleaning

A detailed breakdown of the inclusion criteria and number of participants excluded from the original dataset using the new inclusion criteria is shown in **Figure 1**. Data cleaning and analysis were completed in SAS 9.4.

To allow for easier comparisons across PA domains and other studies, hours spent riding were converted to hours/week. For example, responses of "<3 hours/2 weeks" became "<1.5 hours/week." To address sparse categories while preserving the ordinal structure, categories with fewer than 5% of the sample reporting that category were merged with adjacent categories. Minimal collapsing was implemented to satisfy standard assumptions for contingency analysis (e.g., Pearson χ^2 : $\geq 80\%$ of expected cell counts ≥ 5 and none < 1) and applied consistently across variables. **Table 1** demonstrates how the equestrian and barn PA domain variables were reorganized.

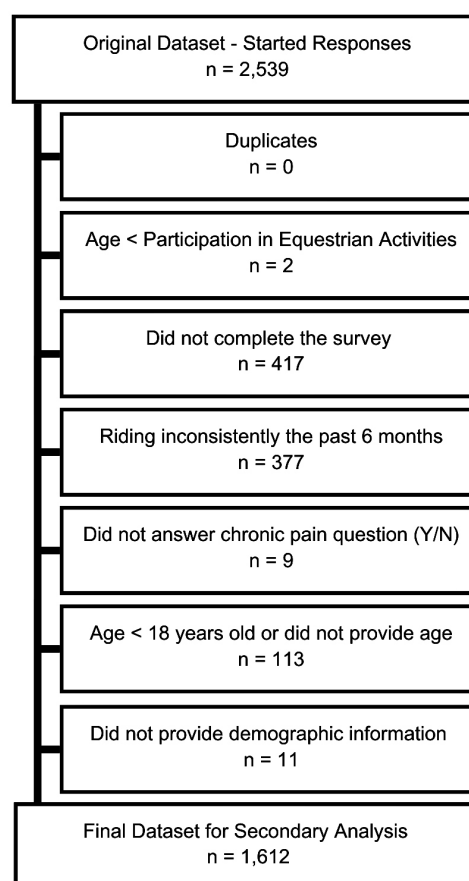


Figure 1: Flowchart of data included in the current study based on the inclusion criteria for the secondary analysis.

Table 1: Original categories and reorganized category frequencies to ensure sufficient sample size ($\geq 5\%$) for analysis.

Equestrian activity time					
Original categories			Reorganized categories		
Category	n	%	Category	n	%
<90 mins/week	88	5.5%	<90 mins/week	88	5.5%
1.5–3 hours/week	349	21.7%	1.5–3 hours/week	349	21.7%
3.5–5 hours/week	428	26.6%	3.5–5 hours/week	428	26.6%
5.5–7.5 hours/week	304	18.9%	5.5–7.5 hours/week	304	18.9%
8–10 hours/week	182	11.3%	8–10 hours/week	182	11.3%
10.5–12.5 hours/week ¹	74	4.6%	10.5–15 hours/week ¹	126	7.8%
13–15 hours/week ¹	52	3.2%	≥15.5 hours/week ²	135	8.4%
15.5–17.5 hours/week ²	18	1.1%			
18–20 hours/week ²	38	2.4%			
20.5–25 hours/week ²	21	1.3%			
25.2–30 hours/week ²	18	1.1%			
30.5–35 hours/week ²	15	0.9%			
35.5–40 hours/week ²	11	0.7%			
≥40 hours/week ²	14	0.9%			
Barn work time					
Original categories			Reorganized categories		
Category	n	%	Category	n	%
Barn work (no) [*]	106	6.6%	No barn work	106	6.6%
1–4 hours/week	439	27.4%	1–4 hours/week	439	27.4%
5–9 hours/week	392	24.5%	5–9 hours/week	392	24.5%
10–14 hours/week	271	16.9%	10–14 hours/week	271	16.9%
15–19 hours/week	114	7.1%	15–19 hours/week	114	7.1%
20–24 hours/week	98	6.1%	20–24 hours/week	98	6.1%
25–29 hours/week ¹	45	2.8%	25–34 hours/week ¹	84	5.2%
30–34 hours/week ¹	39	2.4%	≥35 hours/week ²	97	6.1%
35–39 hours/week ²	20	1.2%			
≥40 hours/week ²	77	4.8%			
11 missing			11 missing		
Number of horses ridden regularly in a two-week period over the last six months					
Original Categories			Reorganized Categories		
Category	n	%	Category	n	%
One horse	541	33.6%	One horse	541	33.6%
Two horses	500	31.1%	Two horses	500	31.1%
3–4 horses	331	20.6%	3–4 horses	331	20.6%
5–6 horses	121	7.5%	5–6 horses	121	7.5%
7–9 horses ¹	50	3.1%	≥7 horses ¹	115	7.2%

10+ horses ¹	65	4.0%			
	4 missing			4 missing	
Number of water buckets carried consecutively					
Original Categories			Reorganized categories		
Category	n	%	Category	n	%
Carry water buckets (No)*	727	48.6%	Does not carry water buckets	727	48.6%
1–2 buckets	371	24.8%	1–2 buckets	371	24.8%
3–4 buckets	146	9.8%	3–4 buckets	146	9.8%
5–6 buckets ¹	83	5.5%	5–10 buckets ¹	142	9.5%
7–10 buckets ¹	59	3.9%	>10 buckets	111	7.4%
>10 buckets	111	7.4%			
	115 missing			115 missing	
The maximum distance water buckets are carried					
Original categories			Reorganized categories		
Category	n	%	Category	n	%
Does not carry buckets	727	48.7	Does not carry water buckets	727	48.7
Up to 25 feet	316	21.1	Up to 25 feet	316	21.1
25–50 feet	261	17.5	25–50 feet	261	17.5
50–100 feet ¹	133	8.9	>50 feet ¹	190	12.7
>100 feet ¹	57	3.8			
	118 missing			115 missing	

^{1,2}Show which categories were combined to create the category with the coinciding number on the reorganized category side.

*Represents an original yes/no question about the task, which was used to create a "Does not complete" category for analysis purposes.

For hours per week of equestrian PA, the original 14 categories were collapsed into seven categories. The first five categories were retained, while the next two adjacent categories were combined to form "10.5–15 hours/week." The last seven categories all had low-frequency levels (0.68–2.4%) and were pooled into a "≥15.5 hours/week." For the number of horses ridden on a regular basis, the two highest categories were combined into ≥7 horses.

For barn work PA, the original nine options were collapsed into seven by keeping the first five categories unchanged, combining two adjacent categories into 25–34 hours/week, and pooling the two highest categories into ≥35 hours/week. Participants who answered "no" to completing barn work PA on a regular basis over the past six months were coded as 0 hours/week, yielding an eighth barn work category. The number of water buckets carried was reorganized so that two adjacent categories were merged to create a 5–10 bucket category. The maximum distance water buckets were carried was reorganized to create a >50 feet category.

For non-equestrian physical activities, low and low-moderate intensity responses, and moderate, moderate-vigorous, and vigorous responses were collapsed into "low intensity" and "moderate to vigorous intensity" for all activities. Similar to equestrian PA, non-equestrian PA domains were converted into hours/week. Hours spent participating in

each activity were then collapsed into ">2 hours/week" and "≥2 hours/week." A third category was created for participants who did not report participating in the activity.

2.5. Statistical Analysis

Statistical analysis was completed in SAS 9.4, with significance set at $P < 0.05$ for all tests. Frequencies and descriptive statistics were calculated for all independent (PA domain variables) and dependent variables (general and regional CP). Spearman correlation tests were used to examine relationships among ordinal independent variables, including equestrian PA, barn work PA, non-equestrian PA, number of horses ridden regularly, number of riding days per week, and participation level. To evaluate the relationships between general and regional CP for each independent variable, chi-square tests were used. Regional pain analyses were conducted when sufficient data were available, defined as expected cell counts ≥5 for at least 80% of cells. Based on expected cell counts, regional analyses were completed for the back, pelvis, lower leg, neck, and upper leg. Relationships that demonstrated significance ($P < 0.05$) with the chi-square tests were further analyzed using binary logistic regressions (1 independent variable) or forward-selection binary logistic regression (≥2 independent variables). If two ordinal variables had significant chi-square results and also demonstrated a moderate or stronger correlation ($|\rho| \geq 0.40$), they were both entered as predictors. If forward

selection retained both predictors of a correlated pair, multicollinearity was evaluated in the final model ($VIF > 5$ or condition index > 30). If multicollinearity was present, the variable with fewer missing responses was retained. When a response was missing for a predictor variable, that observation was not used in the analysis.

For binary logistic regressions, general CP or specific regional CP was always the dependent variable. The reference group for CP was consistently set to "yes." This directional choice enabled interpretation of all odds ratios (ORs) as increased or decreased likelihoods of reporting CP based on the predictor variables. All models were fitted using forward selection with an alpha level of 0.05. Results include ORs with 95% confidence intervals (95% CI) and *P*-values for all retained effects. The *c*-statistic summarizes model discrimination as the area under the curve. To evaluate overall model fit while penalizing model complexity, the Akaike Information Criterion (AIC) was reported, reflecting the trade-off between goodness of fit and the number of variables added to the model. AIC values indicate models that are better supported by the data, with no natural cutoff, and are only interpretable relative to other models within the same dataset. As a baseline of AIC without model comparison does not provide interpretable results, AIC reduction (AIC_R) was reported to provide a relative marker to determine which model represents the best fit for the dataset. AIC_R was defined as $AIC_R = AIC_{null} - AIC_{model}$. For AIC_R , larger positive values indicate greater improvement, 0 indicates no improvement, and negative values indicate worse fit than the null model.

Models were first fit separately for each of the three PA domains of interest: equestrian, barn work, and non-equestrian PA. Only significant variables identified by the chi-square tests for each model were included. Equestrian variables included participation level (reference: professional), equestrian PA (reference: ≥ 15.5 hours/week), and number of horses ridden regularly (reference: one horse). Barn work variables included completing barn work (reference: yes), barn work PA (reference: 1–4 hours/week), binary barn work activities (reference: yes), number of buckets carried (reference: 1–2 buckets), distance buckets were carried (reference: Up to 25 feet), and number of stalls cleaned (reference: > 10 stalls). For non-equestrian activities, only activities reported by $\geq 10\%$ of the sample were included to meet expected cell count for chi-square tests described above. The variables for models included binary physical activities (reference: yes, they participate in this activity) and the intensity time (low intensity and moderate-to-vigorous intensity) for each activity (reference: does not participate).

After individual domain models were fit, all predictors across domains with significant associations ($P < 0.05$) in the chi-square tests were entered into a multivariable model for general CP and each regional CP (when sample size allowed stable estimation). We report the final variables included in the final output for each model (individual domain and across domains). To evaluate different levels of

ORs, we also report ORs for significant models with varying reference groups, with reference groups provided in the Results section.

3. Results

3.1. Demographics

The final dataset included 1,612 responses, with the majority (96.0%) of the sample reporting that they were female. Participants' age was normally distributed across groups, with 14.9% aged 18–24, 22.6% aged 25–34, 19.1% aged 35–44, 13.2% aged 45–54, 17.7% aged 55–64, and 12.5% aged ≥ 65 years. A total of 45.2% reported experiencing general CP, with the most frequently reported region of CP being chronic back pain (27.8%). Other commonly reported sites of CP were the pelvis (10.4%), lower legs (9.1%), the neck (8.9%), and upper legs (7.1%). Less frequently reported regions for CP included the feet (5.0%), arms (4.4%), hands (4.0%), the face (1.7%), the abdomen (1.5%), the chest (1.2%), the breast (0.4%), and the genitals (0.2%). Of those reporting experiencing CP, 115 did not provide information regarding which region they were experiencing CP in. Of the 614 individuals who did report which region(s) they experienced CP in, 39.1% reported experiencing CP in only one region, 33.1% reported CP in two regions, 15.0% reported CP in three regions, 6.0% reported CP in four regions, and the remaining 6.8% reported CP in five or more regions.

Results of the Spearman correlation tests indicated only three pairs of variables with moderate or greater correlations. The number of horses ridden and participation level had a moderate positive correlation of $r^2 = 0.47$, $P < 0.001$. As the participation level increased from recreational to amateur to professional, the number of horses ridden regularly also increased. A similar relationship was found between equestrian PA time and the number of horses ridden, with a moderate positive correlation of $r^2 = 0.41$, $P < 0.001$. As the number of horses increased, so did the time spent engaging in equestrian PA. Finally, commitment per week and equestrian PA had a strong positive correlation of $r^2 = 0.61$, $P < 0.001$. As equestrian PA increased, so did the number of days per week the individual reported riding.

3.2. Equestrian Activity Domain

Table 2 presents the frequencies for the equestrian PA domain variables, as well as the *P*-values from the chi-square tests for those reporting CP general and those not reporting pain.

For general CP, participation level ($P = 0.007$) and the number of horses ridden ($P = 0.006$) had significant associations. The final model identified participation level as the only significant predictor for general CP ($P = 0.006$). The overall fit was acceptable (residual $\chi^2(4) = 6.25$, $P = 0.18$; $AIC_R = 6.21$; *c*-statistic = 0.54). Recreational (OR = 0.66, 95% CI: 0.51–0.87, $P < 0.01$) and amateurs (OR = 0.71, 95% CI: 0.55–0.91, $P < 0.01$) were less likely to report general CP than professionals. There were no significant differences between amateurs and recreational equestrians for reporting general CP (OR = 0.93, 95% CI: 0.74–1.17, $P = 0.55$).

Table 2: Summary of equestrian and barn work volume for the entire sample and stratified by those who reported experiencing chronic pain and those who reported no pain, with *P*-values from the chi-square test results.

	Entire sample		Chronic pain group		No pain group		
	n	%	n	%	n	%	P-value
Participation level							
Professional	371	23.0	194	26.6	177	20.1	0.007*
Amateur	718	44.5	314	43.1	404	45.7	
Recreational	523	32.5	221	30.3	302	34.2	
Equestrian physical activity (hours/week)							
<1.5	88	5.5	36	4.9	52	5.9	0.25
1.5–3.0	349	21.6	139	19.1	210	23.8	
3.5–5.0	428	26.6	194	26.6	234	26.5	
5.5–7.5	304	18.9	142	19.5	162	18.3	
8.0–10.0	182	11.3	90	12.3	92	10.4	
10.5–15.0	126	7.8	62	8.5	64	7.3	
≥15.5	135	8.4	66	9.1	69	7.8	
Days ridden per week							
Daily	116	7.3	59	7.0	66	7.6	0.47
5–6	425	26.7	197	27.4	228	26.1	
3–4	692	43.5	321	44.7	371	42.5	
1–2	359	22.5	150	20.9	209	23.9	
	20 missing		11 missing		9 missing		
Number of horses ridden on a regular basis							
One	541	33.6	216	29.8	325	36.8	0.006*
Two	500	31.1	222	30.6	278	31.5	
Three–Four	331	20.6	163	22.4	168	19.1	
Five–Six	121	7.5	62	8.5	59	6.7	
≥Seven	115	7.1	63	8.7	52	5.9	
	4 missing		3 missing		1 missing		

*Denotes significant *P*-values where $\alpha < 0.05$.

Percentages are calculated by column within each group for each variable; for example, adding the chronic pain percentages by participation level equals 100%.

For chronic back pain, participation level ($P = 0.01$) and equestrian PA ($P = 0.003$) were significant. The final model included only equestrian PA ($P = 0.002$). The overall fit was acceptable (residual $\chi^2(2) = 2.11$, $P = 0.34$; $AIC_R = 8.61$; c-statistic: 0.57). Riding <1.5 hours/week had lower odds of reporting chronic back pain than riding 8–10 hours/week (OR = 0.49, 95% CI: 0.27–0.91, $P = 0.02$) and ≥15.5 hours/week (OR = 0.42, 95% CI: 0.22–0.79, $P < 0.01$). Similarly, riding 1.5–3 hours/week was associated with lower odds of reporting chronic back pain compared with riding 5.5–7.5 hours/week (OR = 0.67, 95% CI: 0.47–0.95, $P = 0.03$).

8–10 hours/week (OR = 0.53, 95% CI: 0.36–0.80, $P < 0.01$), 10.5–15 hours/week (OR = 0.58, 95% CI: 0.37–0.91, $P = 0.02$),

and ≥15.5 hours/week (OR = 0.46, 95% CI: 0.3–0.7, $P < 0.001$). Finally, riding 3.5–5 hours/week was 39% less likely to report chronic back pain than those riding ≥15.5 hours/week (OR = 0.61, 95% CI: 0.41–0.92, $P = 0.02$).

Chi-square tests revealed no significant associations in the equestrian domain for chronic pelvic pain. For chronic lower leg pain, only the participation level had a significant association ($P = 0.0074$). A binary logistic model with no forward selection showed that with participation level, the model fit improved (Wald $\chi^2(2) = 9.55$, $P < 0.01$; $AIC_R = 6.46$). Recreational equestrians were less likely to report chronic lower leg pain than professionals (OR = 0.49, 95% CI: 0.30–0.80, $P < 0.01$) and amateurs (OR = 0.54, 95% CI: 0.34–0.87, $P < 0.01$). There

were no significant differences between amateurs and professionals (OR = 0.90, 95% CI: 0.60–1.34, $P = 0.61$).

Participation level ($P = 0.04$) and the number of horses ridden ($P = 0.04$) were both significantly associated with reporting chronic neck pain. The final model included only participation level ($P = 0.04$). Model fit improved modestly compared with not including participation level (residual $\chi^2(4) = 5.7$, $P = 0.22$; AIC_R = 2.37; c-statistic: 0.56). Recreational equestrians (OR = 0.57, 95% CI: 0.36–0.90, $P = 0.01$) were less likely to report chronic neck pain than professional equestrians. There was no difference between amateurs and recreational equestrians (OR = 1.20, 95% CI: 0.76–1.76, $P = 0.44$), or between amateurs and professional equestrians (OR = 0.65, 95% CI: 0.43–1.01, $P = 0.052$). There were no significant associations in the equestrian domain for upper leg CP, and all other regional CP did not have a large enough sample to run models.

3.3. Barn Work Activity Domain

Across the sample, 93.4% reported completing barn work, and 11 people did not answer the barn work questions and were excluded from the analysis. **Table 3** presents the frequencies for the entire sample and for general CP (no pain versus reports of experiencing CP) for barn work PA and individual barn work tasks. Grooming horses was the most common task reported, while dragging hoses was the least common task reported.

Barn work time ($P = 0.004$), feeding horses ($P < 0.001$), carrying water buckets ($P < 0.001$), number of buckets carried ($P = 0.007$), maximum distance of buckets carried ($P = 0.003$), number of stalls cleaned consecutively ($P = 0.02$), and stacking hay ($P = 0.001$) were all significantly associated with reporting general CP. The final model included carrying water buckets ($P = 0.03$), feeding horses ($P < 0.001$), and the number of stalls cleaned ($P = 0.02$). The overall fit was acceptable (residual $\chi^2(13) = 11.14$, $P = 0.60$; AIC_R = 20.57; c-statistic: 0.58). Not carrying water buckets decreased the likelihood of reporting general CP by 24% compared with carrying them (OR = 0.76, 95% CI: 0.57–0.98, $P = 0.03$). Not feeding horses decreased the likelihood of reporting general CP by 40% compared with feeding horses (OR = 0.60, 95% CI: 0.44–0.82, $P < 0.01$). Cleaning no stalls increased the odds of reporting general CP by 1.5 compared with cleaning 1–2 stalls (95% CI: 1.1–2.1, $P < 0.01$). Cleaning 7–10 stalls (OR = 1.6, 95% CI: 1.02–2.4, $P = 0.04$) and >10 stalls (OR = 1.7, 95% CI: 1.1–2.7, $P = 0.02$) increased the odds of reporting general CP compared with cleaning only 1–2 stalls.

Barn work time ($P = 0.004$), feeding horses ($P = 0.005$), dragging hoses ($P = 0.04$), stacking hay ($P = 0.01$), and the number of stalls cleaned consecutively ($P = 0.02$) all had significant associations with reporting chronic back pain. The final model identified feeding ($P < 0.001$) and the number of stalls cleaned ($P = 0.02$) as significant predictors. Model fit

was acceptable (residual $\chi^2(8) = 10.69$, $P = 0.22$; AIC_R = 15.37; c-statistic: 0.58). Not feeding horses was associated with a 48% decrease in the odds of reporting chronic back pain (OR = 0.52, 95% CI: 0.37–0.74, $P < 0.001$) compared with feeding horses. Compared with cleaning 1–2 stalls, not cleaning stalls increased the odds of reporting chronic back pain by 1.4 (95% CI: 1.02–2.0, $P = 0.04$). Cleaning 7–10 stalls (OR = 1.6, 95% CI: 1.02–2.5, $P = 0.04$) and >10 stalls (OR = 1.9, 95% CI: 1.2–3.1, $P < 0.01$) were associated with greater odds of reporting chronic back pain than cleaning 1–2 stalls. Cleaning 3–4 stalls (OR = 0.52, 95% CI: 0.32–0.86, $P = 0.01$) and cleaning 5–6 stalls (OR = 0.56, 95% CI: 0.32–0.98, $P = 0.04$) decreased the odds of reporting chronic back pain compared with those who reported cleaning >10 stalls.

For chronic pelvic pain, the only variable in the barn work domain with a significant association was the number of stalls cleaned consecutively ($P = 0.01$). A binary logistic model with no forward selection showed that the number of stalls cleaned improved the model fit modestly (Wald $\chi^2(5) = 14.05$, $P = 0.02$; AIC_R = 3.80). Relative to cleaning 1–2 stalls, not cleaning stalls increased the odds of reporting pelvic pain (OR = 1.6, 95% CI: 1.02–2.6, $P = 0.04$), as did cleaning >10 stalls (OR = 3.1, 95% CI: 1.6–5.9, $P < 0.01$).

For chronic lower leg pain, only the number of water buckets carried showed a significant association ($P = 0.02$). The final model fit improved modestly with the addition of the number of water buckets carried (Wald $\chi^2(4) = 11.11$, $P = 0.02$; AIC_R = 2.86). Carrying 5–10 water buckets increased the odds of reporting chronic lower leg pain by 2.1 (95% CI: 1.2–3.6, $P < 0.01$) compared with those who did not carry water buckets. Carrying >10 buckets increased the odds of reporting chronic lower leg pain by 2.5 compared with carrying 3–4 buckets (95% CI: 1.01–6.2, $P = 0.04$). Moreover, carrying no buckets (OR = 0.48, 95% CI: 0.28–0.82, $P < 0.01$) and carrying 3–4 buckets (OR = 0.33, 95% CI: 0.14–0.78, $P = 0.01$), compared with 5–10 buckets, decreased the likelihood of reporting chronic lower leg pain. There were no significant associations between any barn work domain predictors and any other regional CP.

3.4. Non-Equestrian Physical Activity Domain

The most common (65.0%) non-equestrian PA was walking. The non-equestrian activities with sufficient counts for analyses, aside from walking, included stretching (28.3%), hiking (28.0%), resistance training (25.9%), yoga (22.0%), running (15.9%), aerobics (12.5%), and cycling (10.9%). Other forms of non-equestrian PA were less common and were not evaluated in depth: general play (9.4%), Pilates (7.4%), interval training (6.9%), swimming (6.5%), elliptical (training) (6.1%), kayaking/canoeing/paddle boarding (5.7%), circuit training (4.7%), endurance training (3.5%), exercise ball/fit-ball (3.0%), dancing (2.9%), barre (2.8%), group sports (1.9%), boxing/kickboxing (1.7%), water aerobics/calisthenics (1.2%), and martial arts (0.6%).

Table 3: Barn work domain variables, including physical activity per week, individual binary barn tasks, and ordinal detailed barn task information.

	Entire sample		Chronic pain group		No pain group		
	n	%	n	%	n	%	P-value
Barn work physical activity (hours/week)							
No barn work	106	6.6	51	7.1	55	6.3	0.004*
1–4	439	27.4	164	22.7	275	31.3	
5–9	392	24.5	186	25.7	206	23.5	
10–14	271	16.9	126	17.4	145	16.5	
15–19	114	7.1	49	6.8	65	7.4	
20–24	98	6.1	46	6.4	52	5.9	
25–34	84	5.3	45	6.2	39	4.4	
≥35	97	6.1	56	7.7	41	4.7	
	11 missing		6 missing		5 missing		
Feeding							
No	483	30.0	187	25.7	296	33.5	<0.001*
Yes	119	70.0	542	74.3	587	66.5	
Carry water buckets							
No	840	52.1	346	47.5	494	56.0	<0.001*
Yes	772	47.9	383	52.5	389	44.0	
Number of water buckets carried							
None	727	48.6	292	43.4	435	52.8	0.007*
1–2 buckets	371	24.8	178	26.5	193	23.4	
3–4 buckets	146	9.8	72	10.7	74	9.0	
5–10 buckets	142	9.5	73	10.8	69	8.4	
≥11 buckets	111	7.4	58	8.6	53	6.4	
	115 missing		56 missing		59 missing		
Maximum distance water buckets are carried							
Does not carry	727	48.7	292	43.4	435	53.0	0.003*
Up to 25 feet	316	21.2	158	23.5	158	19.2	
25–50 feet	261	17.5	125	18.6	136	16.6	
>50 feet	190	12.7	98	14.6	92	11.2	
	118 missing		56 missing		62 missing		
Dragging hoses							
No	907	56.3	378	51.8	529	59.9	0.001*
Yes	705	43.7	351	48.2	354	40.1	
Cleaning stalls							
No	620	38.5	273	37.5	347	39.3	0.45
Yes	992	61.5	456	62.5	536	60.7	

Number of stalls cleaned consecutively							
No stalls cleaned	507	34.0	219	32.6	288	35.1	0.02*
1–2 Stalls	399	26.7	165	24.6	234	28.5	
3–4 Stalls	248	16.6	113	16.8	135	16.4	
5–6 Stalls	134	9.0	59	8.8	75	9.1	
7–10 Stalls	109	7.3	60	8.9	49	6.0	
>10 Stalls	95	6.4	55	8.2	40	4.9	
	120 missing		58 missing		62 missing		
Equipment used to help clean stalls							
Wheelbarrow/handcart	728	73.6	330	72.5	398	74.5	0.49
Trailer on ATV/tractor	116	11.7	50	11.0	66	12.4	
Tractor buckets	79	9.0	41	9.0	38	7.1	
Other	66	6.7	34	7.5	32	6.0	
	623 missing		274 missing		349 missing		
Clean aisles							
No	756	46.9	325	44.6	431	48.8	0.09
Yes	856	53.1	404	55.4	452	51.2	
Stacking hay							
No	820	50.9	339	46.5	481	54.5	0.001*
Yes	792	49.1	390	53.5	402	45.5	
Grooming horse(s)							
No	266	16.5	124	17.0	142	16.1	0.62
Yes	1,346	83.5	605	83.0	741	83.9	
Tacking up/putting tack on the horse(s)							
No	359	22.3	161	22.1	198	22.4	0.87
Yes	1,253	77.7	568	77.9	684	77.6	
Cleaning tack							
No	577	35.8	255	35.0	322	36.5	0.53
Yes	1,035	64.2	474	65.0	561	63.5	
Leading horses							
No	563	34.9	237	32.5	326	36.9	0.06
Yes	1,049	65.1	492	67.5	557	63.1	

*Denotes significant chi-square results between pain and no pain group with α set to 0.05.

Percentages are calculated by column within each group for each variable, for example, adding the chronic pain group percentages by barn work physical activity equals 100%.

For reporting general CP, running ($P < 0.001$) and resistance training ($P = 0.003$) had significant associations. Moderate-to-vigorous intensity for both non-equestrian physical activities also had significant associations with reporting general CP ($P < 0.01$). The forward-selection binary logistic regression model identified lifting ($P = 0.046$) and moderate-to-vigorous running intensity ($P < 0.001$) as significant

predictors in the final model. Model fit was appropriate (residual $\chi^2(3) = 0.14$, $P = 0.99$; $AIC_R = 19.11$; c-statistic: 0.55).

Engaging in resistance training decreased the odds of reporting general CP compared with those who did not engage in resistance training (OR = 0.79, 95% CI: 0.62–0.99, $P = 0.04$). Running for < 2 hours/week (OR = 0.59, 95% CI: 0.41–0.83, P

< 0.01) and running for ≥ 2 hours/week (OR = 0.39, 95% CI: 0.19–0.78, $P < 0.01$) decreased the odds of reporting general CP compared with those not running. There was no difference between those running <2 hours/week and those running ≥ 2 hours/week (OR = 1.51, 95% CI: 0.71–3.22, $P = 0.28$).

Similar to general CP, chronic back pain showed significant associations with running ($P = 0.003$) and resistance training ($P = 0.03$), as well as with moderate-to-vigorous intensity for both activities ($P < 0.05$). For the forward selection binary logistic regression model, only running ($P = 0.003$) was retained as a predictor in the final model. Model fit improved with the addition of running (residual $\chi^2(5) = 7.16$, $P = 0.21$; $AIC_R = 7.18$; c-statistic: 0.53). Running decreased the odds of reporting chronic back pain by 38% compared with not running (OR = 0.62, 95% CI: 0.44–0.85, $P < 0.01$).

Running was the only significant association with reporting chronic pelvic pain ($P = 0.01$). The binary logistic regression model fit improved modestly with the addition of running to the model (Wald $\chi^2(1) = 5.46$, $P = 0.02$; $AIC_R = 4.31$). Running decreased the odds of reporting chronic pelvic pain by 47% (OR = 0.53, 95% CI: 0.31–0.90, $P = 0.02$) compared with not running. No other regional CP showed significant associations with non-equestrian PA.

3.5. Across Physical Activity Domains

The final predictors included in the across-domain models for general and regional CP are presented in **Table 4**. The final binary logistic regression model for predicting general CP retained participation level ($P = 0.003$), moderate-vigorous running time ($P < 0.001$), and feeding horses ($P = 0.001$). The addition of these three predictors substantially improved model fit (residual $\chi^2(33) = 34.76$, $P = 0.38$; $AIC_R =$

35.51), and model discrimination was modest (c-statistic: 0.59). The final forward-selection binary logistic model for chronic back pain retained equestrian PA time ($P = 0.006$), running ($P < 0.001$), feeding horses ($P < 0.001$), and number of stalls cleaned ($P = 0.04$). Model fit improved with the inclusion of these predictors, and there was no evidence of lack of fit (residual $\chi^2(15) = 14.80$, $P = 0.47$; $AIC_R = 25.50$; c-statistic: 0.62). For chronic pelvic pain, only running and the number of stalls cleaned had significant associations. Model fit was acceptable (residual $\chi^2(2) = 4.40$, $P = 0.22$; $AIC_R = 8.35$; c-statistic: 0.57). For chronic lower leg pain, participation level and number of water buckets carried were entered into the model, and only participation level was retained ($P < 0.01$). Model fit improved with the addition of participation level (residual $\chi^2(4) = 8.78$, $P = 0.07$; $AIC_R = 6.57$; c-statistic: 0.57). Chronic neck pain had only one significant variable (participation level) across domains; model fit is reported above in the equestrian domain.

4. Discussion

This study explores the relationship between PA volume across three domains and its association with self-reported CP in American equestrians. This secondary analysis successfully evaluated the likelihood of reporting general and regional CP in relation to volume and engagement in activities across three domains: equestrian, barn work, and non-equestrian PA. Our findings reinforce a growing body of evidence that CP in equestrians is shaped by participation level and demonstrate a dose-dependent relationship across aspects of all three domains. The final models evaluating the likelihood of reporting general and regional CP across all three domains are the focus of the discussion.

Table 4: Final predictors for reporting general and regional CP across physical activity domains, with odds ratios. All reference variables are indicated in parentheses. For example, the first odds ratio below should be interpreted as: "Recreational equestrians are 40% less likely (1.00–0.60 = 0.4) to report general chronic pain compared with professionals."

Outcome	Predictor (reference)	Adjusted OR (95% CI)	P-value
General chronic pain	Participation level		
	Recreational (Professional)	0.60 (0.45–0.80)	<0.001*
	Amateur (Professional)	0.74 (0.57–0.97)	0.03*
	Recreational (Amateur)	0.81 (0.64–1.04)	0.09
	Feeding horses		
	No (Yes)	0.65 (0.50–0.83)	<0.001*
	Moderate-vigorous running		
	<2 hours/week (0 hours/week)	0.54 (0.38–0.77)	<0.001*
	≥ 2 hours/week (0 hours/week)	0.40 (0.20–0.81)	0.01*
Chronic back pain	<2 hours/week (≥ 2 hours/week)	0.75 (0.35–1.61)	0.46
	Equestrian physical activity		
	<1.5 hours/week (≥ 15.5 hours/week)	0.46 (0.23–0.91)	0.02*
	1.5–3 hours/week (≥ 15.5 hours/week)	0.47 (0.30–0.74)	0.001*
	3.5–5 hours/week (≥ 15.5 hours/week)	0.62 (0.40–0.96)	0.03*
	5.5–7.5 hours/week (≥ 15.5 hours/week)	0.72 (0.46–1.14)	0.16

	8–10 hours/week (≥ 15.5 hours/week)	0.90 (0.55–1.47)	0.66
	10.5–15 hours/week (≥ 15.5 hours/week)	0.74 (0.43–1.27)	0.28
	<1.5 hours/week (8–10 hours/week)	0.53 (0.34–0.81)	0.04*
	1.5–3 hours/week (8–10 hours/week)	0.51 (0.26–0.99)	0.003*
	Feeding horses		
	No (Yes)	0.54 (0.39–0.77)	0.007*
	Stalls cleaned consecutively		
	None (>10)	0.77 (0.47–1.28)	0.31
	1–2 (>10)	0.57 (0.35–0.93)	0.02*
	3–4 (>10)	0.53 (0.32–0.89)	0.01*
	5–6 (>10)	0.55 (0.31–0.97)	0.04*
	7–10 (>10)	0.83 (0.47–1.48)	0.53
	Running		
	Yes (No)	0.62 (0.44–0.88)	0.007*
Chronic pelvis pain	Stalls cleaned consecutively		
	None (>10)	0.48 (0.27–0.87)	0.01*
	1–2 (>10)	0.30 (0.16–0.57)	<0.001*
	3–4 (>10)	0.48 (0.25–0.92)	0.03*
	5–6 (>10)	0.50 (0.24–1.05)	0.07
	7–10 (>10)	0.27 (0.11–0.69)	0.006*
	Running		
	Yes (No)	0.50 (0.28–0.89)	0.02*
Chronic lower leg pain	Participation level		
	Recreational (Professional)	0.47 (0.28–0.79)	0.004*
	Amateur (Professional)	0.89 (0.59–1.35)	0.59
	Recreational (Amateur)	0.53 (0.33–0.84)	0.007*
Chronic neck pain	Participation Level		
	Recreational (Professional)	0.57 (0.36–0.89)	0.01*
	Amateur (Professional)	0.55 (0.43–1.01)	0.05
	Recreational (Amateur)	0.85 (0.56–1.30)	0.44

*Denotes significant odds ratio with significance set at $P < 0.05$.

Equestrian activities, specifically riding, are biomechanically complex and involve high-impact, repetitive movements transferred from the horse to the rider [2,6]. When evaluating the models including variables across all domains, two significant predictors from the equestrian activity domain emerged for reporting general and regional CP: participation level and weekly time spent engaging in equestrian activities.

Participation level emerged as the primary predictor of CP for general CP, chronic lower leg pain, and chronic neck pain. Participation level functions as a higher-order variable within the equestrian domain, as it typically drives equestrian PA volume and the number of horses ridden regularly.

Previous sport-specific research has identified that professionals have a higher rate of CP and acute injury compared with recreational and amateur athletes [51]. Consistent with that pattern, a larger subset of the present dataset reported that professional equestrians engaged in more riding and barn work than amateur and recreational riders [38] and were more likely to report acute injuries across most anatomical regions [9]. This load-dependent interpretation is further supported by work in equestrian populations showing that riders whose main occupation is riding have 1.76 times greater odds of reporting dysfunctional Roland–Morris Disability scores (≥ 4) than hobbyist riders and that professionals reported back pain in the previous month more frequently (56%) than amateurs (13%) [37,52].

Considering the past literature, the current findings point to a consistent, exposure-related pattern in which participation level is repeatedly associated with greater odds of reporting acute and CP across equestrian populations.

The final fitted model shows that recreational and amateur riders are less likely to report general CP than professionals. In this study, general CP refers to chronic pain in at least one body region. Participation level is moderately correlated with the number of horses ridden, suggesting that professional riders take on more mounts and therefore more varied movement patterns. For professional equestrians, their income and livelihood depend on their ability to ride and train horses, manage facilities, and provide lessons or clinics. Training horses requires conditioning, creating exercise tolerance specific to the riding discipline, and developing coordinated and balanced strength bilaterally [53,54]. Similar to humans, horses display natural movement asymmetries, which require creating balance through muscle strength and practice in a specific training program to decrease the likelihood of injury [53–55]. Prior work reports that riders working multiple horses per day are more likely to report back pain than those riding only one horse, which is a pattern consistent with pain linked to rider asymmetries and the repetitive high load of equestrian PA [9,26,27,30]. Riding several horses in a day increases movement variability and demands repeated postural adjustments, which may lead to increased musculoskeletal strain [25]. This relationship is likely bi-directional, as rider asymmetries can also influence the horse's movement, as pain itself can compromise posture and function. Eighty-five percent of riders reported that their pain negatively affected their riding performance by altering their position and range of motion, decreasing their concentration, and increasing fatigue [6]. The loop between pain and posture underscores the complexity of equestrian and equine biomechanics and highlights the need for future research to evaluate the bi-directional relationship between horse and rider asymmetries on each other.

Saddle fit likely contributes to the relationship between participation level and CP, particularly among riders who ride multiple horses. Although saddle type and fit were not assessed in this study, it is reasonable to infer that riders working with several horses use multiple saddles with variable fit. While saddle fit is often evaluated primarily for equine welfare, it also plays a critical role in rider posture and movement patterns [2,5,6]. Poor saddle fit has been associated with rider crookedness and equine thoracolumbar asymmetries, creating a feedback loop of uneven pressure, altered alignment, and asymmetric muscle strain in both horse and rider [30]. Riders using poorly fitted saddles are more likely to report worsening back pain [25]. More than 60% of dressage riders attributed their pain to saddle fit, with 59% reporting that their pain negatively impacted their performance [5]. Common issues identified by coaches, therapists, and saddle fitters include saddles that are too small, that slip to one side, or that shift the rider's weight forward, all of which can disrupt spinal alignment and increase strain on the neck and back [9,28,56]. While the current study lacks the information to evaluate the association between saddle fit and reports of CP, previous findings highlight the need to examine saddle fit in relation to equestrian CP in greater depth.

This evidence aligns with the current study's finding that professionals are at greater risk of chronic neck pain than recreational riders. Biomechanical analyses show that when vertical acceleration is transmitted from the sacrum to the cervical spine (C7) and head, peak acceleration decreases during the rising phase of the posting trot but does not decrease consistently during sitting trot, suggesting that the neck experiences greater forces during sitting phases [56]. Sitting trot requires riders to absorb forces with every step, whereas posting trot allows them to attenuate forces differently during the sitting and posting phases. It can be inferred that spending more time on horses increases the time spent in sitting trot, which would therefore result in greater amount of cervical loading in professional equestrians than in those who engage in lower levels of participation. High rates of chronic neck pain could be detrimental, as correct alignment and coordinated movement of the neck, trunk, and pelvis are essential for maintaining rider balance and control [57–59]. In riders with neck pain (acute or chronic), the ability of cervical muscles to absorb forces and stabilize the head is likely compromised, which can impair rider balance and coordination and increase physical demands on the horse. Considering that participation level is a key factor in this study, future research should examine saddle fit as a modifiable contributor to musculoskeletal strain and pain in equestrians, particularly among professionals who experience higher exposure and biomechanical load. Future studies should also evaluate the specific load and weekly volume riders spend in different gaits by participation level, and how this exposure pattern relates to both acute and chronic pain.

In the chronic back pain model, weekly equestrian PA volume is the primary predictor within the equestrian domain, with riders engaging in more equestrian PA having greater odds of reporting chronic back pain. Mechanical loads generated during riding are transmitted and attenuated through the spine [56]. When sustained over long durations, these forces create lumbar and thoracic loading comparable to occupational manual labor [26,27]. This pattern aligns with [2], which reports the highest prevalence of chronic low back pain among riders training ≥ 5 days per week for 7–8 hours per day. Rider-specific factors, such as reduced hip abductor flexibility and limited pelvic mobility, are also associated with greater odds of chronic back pain and promote asymmetrical movement patterns [29]. When these asymmetries occur in conjunction with prolonged saddle contact, they can amplify uneven loading for both horse and rider and may be further influenced by saddle fit and positioning. Considering these findings in conjunction with the preceding discussion on saddle-related factors, greater time spent in the saddle is consistently associated with higher spinal load, asymmetrical strain, and an increased likelihood of chronic back pain, regardless of participation level. Future research should compare rider biomechanics between riders with and without chronic back pain to clarify these mechanisms. Additionally, longitudinal studies are needed to evaluate pain avoidance across different PA domains, as the current study's cross-sectional design does not enable assessment of these relationships.

In addition to equestrian activity, the volume of barn work and related tasks represents a critical yet underrecognized

source of PA and mechanical loading among equestrians. It has been reported that 35% of professional international event riders feel that barn work contributes to their pain [6]. Another study found that 89.1% of amateur and recreational riders experience pain while performing stable duties, with 53.4% reporting CP [28]. Although the present study does not assess perceived pain sources, the consistency between these findings, despite potential cultural and geographic differences, suggests that barn work PA contributes meaningfully to musculoskeletal strain in equestrians.

In the current study, two barn work predictors (feeding and number of stalls cleaned consecutively) are associated with greater odds of reporting general and regional CP. Feeding tasks, while often routine, encompass numerous physically demanding motions such as lifting hay bales, filling and carrying hay nets, and moving feed bags that were not detailed in the current study's survey. These activities involve repetitive bending, carrying, and twisting motions. Equestrians who assist with feeding experience pain at higher odds align with the results of [28] which reported that approximately 40% of equestrians experience discomfort and 32.6% report severe to excruciating pain during barn work activities involving carrying [28]. While these prior findings [28] and the current study address distinctly different research questions, the findings collectively support the need for further research to evaluate which barn work tasks and sub-domains (i.e., carrying versus lifting) may serve as the most significant contributors to the onset of acute and chronic pain among equestrians. A deeper understanding of these mechanisms will inform the development of future targeted interventions that may include strength and ergonomic training, as well as improvements in equipment and facility design. These findings align with other studies identifying that prolonged, repetitive manual labor is a risk factor for developing musculoskeletal injuries and pain [28,60].

Analyses of the current dataset further indicate significantly greater odds of chronic pelvic and back pain among riders who clean more than ten stalls per week. This finding aligns with previous work, which reports that stall cleaning aggravates low back pain in over half of equestrians [52]. This relationship persists across various cleaning volumes and is not influenced by the method of waste removal, suggesting that cumulative workload, rather than equipment type, is a primary predictor of low back pain. This cumulative workload includes removing manure and urine-soaked bedding, which can weigh approximately 22.8 kg per horse per day [61]. Cleaning stalls is not a barn task that can be ignored, as it is a crucial component of maintaining facility cleanliness and horse welfare. The impact of these findings reveals the need to explore the musculoskeletal strain accumulated from barn work and to identify potential approaches to mitigate the risk of developing CP, such as modifying body mechanics and adjusting equipment used for barn work tasks. Moreover, these findings underscore the importance of evaluating the entire system (equine, equestrian, and environment/equipment) to comprehensively understand and address CP factors within the equestrian population [43].

Engaging in regular PA is well-documented as a method to improve numerous health outcomes, including CP [62–64].

Clinicians often recommend PA as a strategy to self-manage CP symptoms and maintain physical function [63,64]. The current study identifies that running is associated with a lower likelihood of reporting general CP, chronic back pain, and chronic pelvic pain. Specifically, aerobic PA is found to be an effective nonpharmacological and noninvasive therapeutic option for individuals with CP, as participating in aerobic PA can decrease pain sensitization [65,66]. In addition to reducing pain intensity, aerobic PA facilitates significant improvements in aerobic capacity, mental and physical components of quality of life, overall well-being, and depression-related symptoms for individuals with CP [66]. These effects are particularly prominent in individuals with chronic low back pain [66]. Therefore, equestrians who engage in running may be more likely to sustain higher levels of participation in other PA domains, such as equestrian and barn work PA. It is possible that this relationship is present due to selection bias and equestrians experiencing pain are avoiding engagement in other activities. Therefore, additional research is warranted to elucidate the direction of the relationship and potential mechanisms related to running and CP, as it is possible that the relationship exists as a result of equestrians self-selecting not to participate in specific activities due to the pain they are experiencing.

4.1. Limitations

These findings should be interpreted with caution, as the results may not be generalizable to all equestrian populations. The most prominent limitation of this study is the lack of a standardized definition of CP, with participants self-identifying as experiencing CP without requiring a formal diagnosis from a healthcare provider. Therefore, some participants may meet the diagnostic criteria for CP but did not self-report, and conversely, some participants may have self-reported CP inaccurately. As the focus of this study was to examine the relationship between domains of PA and CP, participants who were not consistently engaging in equestrian PA due to an acute injury or CP were excluded. Consequently, we are currently unable to identify the risk and protective factors associated with injuries or pain that may lead to temporary or permanent discontinuation of participation in equestrian PA. Information regarding pain characteristics (i.e., frequency, duration, and interference) was not collected. Thus, the findings cannot provide insight into a typical pain profile for this community. Due to the cross-sectional design of this study, the findings are inherently non-directional; however, they highlight meaningful associations that warrant further investigation.

Another limitation of this study is due to its survey-based design. Since the data was collected through an online survey across the U.S., it is possible that participants misinterpreted questions, resulting in inaccurate responses. We also acknowledge the potential selection bias of online surveys, and that individuals with pre-existing pain may limit their participation in any of these PA domains, as well as not participate in specific barn work tasks. This possibility underscores the need for longitudinal study designs to better disentangle and explore pain-driven behavioral modification. Despite these limitations, the findings provide valuable insights into patterns observed within the equestrian population.

4.2. Future Research

Future research should further investigate both risk and protective factors contributing to CP in equestrian populations, including a more detailed analysis of riding volume (i.e., walking, trotting, sitting trot, etc.) and saddle fit. Identifying how these variables interact with biomechanical strain, horse and rider asymmetries, muscle soreness, and CP may inform targeted, non-pharmacological interventions aimed at preventing the development of CP. Protective factors, such as engaging in moderate barn work volume and aerobic-based activity, should also be explored for their potential to enhance musculoskeletal resilience. Additionally, equestrians often report mental and emotional benefits from horse interaction; examining these psychosocial factors may offer insight into holistic strategies for CP management. Understanding why equestrians with CP maintain high physical activity levels, unlike other populations with CP, could help identify effective coping mechanisms that may be applied to other individuals affected by CP.

5. Conclusion

The current study contributes to a growing body of evidence demonstrating a strong relationship between CP in equestrians and their participation level. Regular engagement in running appears protective, while the findings support a dose-dependent relationship between equestrian PA load and chronic back pain, and between the number of stalls cleaned and chronic back and pelvic pain. Future research should evaluate changes in PA engagement across domains with consideration of acute pain, development of CP, and pain-avoidant behaviors longitudinally. Given that participation level is a significant predictor in models across PA domains, interventions should explore strategies to support professional equestrians by moderating daily riding volume and the number of stalls cleaned consecutively. Importantly, equestrians often experience CP yet continue to engage in PA, presenting a valuable opportunity to study CP in an active population. Ultimately, prevention strategies aimed at supporting long-term musculoskeletal health will be most effective when they are context-specific and account for the interaction among the rider, the horse, equipment/saddle factors, and the working environment.

Supplementary Materials

The **Supplementary Materials** include the questions from the original survey that were used for this secondary analysis.

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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 was approved by the Institutional Review Board at the University of Kentucky (protocol number: 56488) and was conducted in accordance with the guidelines of the Declaration of Helsinki.

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