Title: Prevalence and severity of gastrointestinal symptoms in Equestrian athletes in training and competition: an exploratory analysis

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Abstract

Equestrian sport presents a unique challenge for athletes' gastro-intestinal tract, due to the need to accommodate horses' locomotion, perform discipline specific movements and meet the nutritional requirements of exercise. The gastro-intestinal challenge may be compounded by gut-brain axis involvement, with anxiety well-documented in equestrian athletes. A survey was carried out to assess gastro-intestinal symptom prevalence and severity in recreational and elite equestrian athletes, across a range of disciplines. Participants reported prevalence of 12 symptoms on a 0-10 point scale, and stool consistency using a modified validated questionnaire. Total symptom score, symptom perception and symptom region (Upper GI tract, Lower GI tract and Other) were assessed. A sub-set of elite riders repeated the questionnaire post-competition.

Elite riders had a higher average total GI symptom score but did not differ significantly to the recreational sample (W = 438.50; $p = 0.13$; $r_B = 0.19$; *Small*). There were no regional differences between groups. Prevalence of all abnormal stool consistencies were higher in the elite sample, when compared to the recreational or total sample. Five elite athletes reported blood in stool. Symptoms are not correlated with nor predicted by rider age, or number of competitions performed per year. Symptoms were not significantly different in competition.

The majority of equestrians present with some GI symptoms, with a small proportion of elite and recreational riders showing symptoms that impair exercise performance. The questionnaire provides a useful starting point for athletes, coaches and support personnel to understand symptom prevalence and severity in equestrians.

Keywords

Equestrian; gastro-intestinal symptoms; Show-jumping; Eventing; Dressage; Polo

Introduction

Equestrian sports are under-researched across the sport sciences (Millet et al., 2021), and are uniquely complicated as the only Olympic discipline that requires co-operative partnership between human and non-human (equine) athletes to compete. Equestrian athletes carry additional for the performance and welfare management requirements of equine athlete(s) alongside their own personal and training needs. This can place significant financial costs and psychological stress upon equestrian athletes (Best et al., 2023; Lamperd et al., 2016), with the ability to manage psychological stressors a pre-requisite for elite sport achievement/performance (Hardcastle et al., 2015; Meyers & Sterling, 2000).

Previous sport psychology in equestrian contexts has focussed upon rider anxiety (Schütz et al., 2023; Jane Williams & Tabor, 2017; Wolframm & Micklewright, 2010a, 2011), and how a rider's psychological state may impact rider and horse physiology and performance (Best et al., 2023; Lewinski et al., 2013; J Williams, 2013; Wolframm & Micklewright, 2010b, 2011). Appropriate sports nutrition support may enhance athletes' psychological state and optimise performance (Best et al., 2023). There is a growing understanding of how the gastrointestinal (GI) tract and brain interact in response to physiological stress (i.e. exercise) and modify GI and psychological function(s)(Clark & Mach, 2016; Eisenstein, 2016; Luger et al., 1987). For athletes, this may manifest in potential performance disrupting GI symptoms potentially increasing rider error. This bidirectional communication is referred to as the gut-brain axis, and comprises the autonomic nervous system and enteric nervous system in the GI tract (Clark & Mach, 2016; Eisenstein, 2016). The gut-brain axis is primarily governed by the Vagus nerve, as it runs from the brainstem to the digestive tract, and is responsible for the control of digested materials (Eisenstein, 2016). Secondary mediating factors are gut hormones (e.g. 5-hydroxyptamine, noradrenaline) and gut microbiota (e.g. Turicibacter spp, Ruminococcus gnavus) (Clark & Mach, 2016; Rhee et al., 2009). Inappropriate nutritional choices and a lack of gut training or familiarity may also increase GI distress. Gut-brain axis stressors of particular concern for athletes are anxiety, exercise-induced hyperthermia, exercise duration and intensity and nutrition circa-exercise (Berger et al., 2024; Hughes & Holscher, 2021; Luger et al., 1987; Racinais et al., 2015; Schütz et al., 2023; Wilson, 2020; Wilson, Ferguson, et al., 2023), all of which have been shown to influence prevalence and severity of GI symptoms during exercise, and may respond to training.

GI symptoms during exercise have traditionally been considered within an (ultra-)endurance context (Berger et al., 2024; Hoogervorst et al., 2019; Pugh et al., 2018) and from a broad perspective (Wilson, 2019). However, there is an increased focus on location of symptoms (Gaskell et al., 2019; Wilson, 2019) and breadth of contexts (e.g. (Wilson, Fearn, et al., 2023)). Further, GI symptoms in sport are typically assessed in relatively fixed (cycling) or vertically oscillating (running) torso movement patterns. Equestrian sports are unique as athletes must oscillate their pelvis and lower torso anterior-posteriorly and laterally with some vertical movement to coordinate with and accommodate the horse's gait (Baillet et al., 2017; Cocq et al., 2013; Engell et al., 2016), with further discipline specific postures adopted to attenuate larger forces, account for saddle designs and facilitate movement patterns e.g. show-jumping, and a degree of inter-individual variability (Bye & Lewis, 2019; Deckers et al., 2020; Wilkins et al., 2022, 2023). Potential links to pathology should also be considered, and how we best support athletes in equestrian contexts with nutritional and psychological coaching warrants further investigation (Best et al., 2023; Wolframm & Micklewright, 2011), once baseline GI symptom prevalence and severity are understood.

This research aims to capture the prevalence and severity of GI symptoms in equestrian athletes. It is hypothesised that prevalence of symptoms may exceed that of the general population and potentially other athletic groups due to the previous interest in anxiety and competition practices within equestrian sport. We also hypothesise that severity will vary between individuals, but symptoms will typically be higher in competition than in training.

Methods

Ethical approval for this project was provided by the Waikato Institute of Technology's Human Ethics in Research Group (Approval number: WTLR16010523) and supported by Equestrian Sports New Zealand (ESNZ).

Questionnaire design and distribution

The pre-competition questionnaire design was adapted from previously published work on equestrian participation demographics (Keener et al., 2023) and gastrointestinal symptoms in endurance athletes (Gaskell et al., 2019). Specifically, Gaskell et al's questionnaire (Gaskell et al., 2019) was modified to assess athlete perception of GI symptoms (Overall gut discomfort), total, upper and lower GI symptoms using a 0 – 10 point Likert scale and defecation behaviours as Yes/No responses. A rating of 0 indicated no symptoms for that particular factor. Ratings of 1 – 4 indicated a sensation of GIS but no interference with exercise performance, 5 – 9 indicated GIS potentially impacted or inhibited exercise performance and a rating of 10 indicated either severely impacted exercise performance or cessation (Gaskell et al., 2019).

Distribution took place via introductory articles that contained both a direct link and QR code, published online and in lay publications in New Zealand. This was supported by social media, and direct contact through the national governing body to recruit a known elite sample (ESNZ, Wellington, New Zealand). Given the relative novelty and potential sensitivity of the topic, we anticipated a low uptake relative to potential sample size within each group. To assess competition symptoms, elite participants were requested to provide the date of their next competition and a condensed version of the pre-competition questionnaire focussing upon symptoms experienced by the athlete and the extent to which preparation and nutritional intake were habitual was distributed via email. The modified pre and competition questionnaires are available as supplementary materials.

Statistical analyses

Demographic data and responses to binary questions are reported using a comprehensive range of descriptive statistics and percentages, respectively. One sample t-tests were used to assess the prevalence and severity of symptoms, using participants' perception of overall symptoms, against pre-determined thresholds of a rating of ≥ 1 (awareness of non-zero symptoms) and rating of ≥ 5 (symptoms may inhibit performance) for each group. Differences between groups were assessed via independent samples Mann-Whitney t-tests, due to differences in sample sizes between groups. Differences between training and competition data were assessed via Wilcoxon signed rank tests, with the direction and hypothesis of comparison being training < competition. For defecation symptoms, differences between groups were assessed using contingency tables and chi-square (χ^2) statistics for independence. Relationships between demographic data and symptom severity are assessed via linear regression(s), with years riding and numbers of competitions per year as co-variates; checks for residuals, normality and linearity performed using appropriate plots (Best & Standing, 2019).

All analyses are accompanied by effect sizes. In the case of the independent samples t-tests, rank biserial correlation which are interpreted as per descriptors for Spearman correlation coefficients: <0.1 *trivial*, 0.1 – 0.3 *small,* 0.3 – 0.5 *moderate,* ≥0.5 *large*. For paired and one-sample tests, standardised mean differences (Hedge's *g*) are considered *trivial, small, moderate, large* and *very large* at thresholds of <0.2, 0.2 – 0.6, 0.6 – 1.2, 1.2 – 2.0 and ≥ 2.0 standard deviations (Hopkins et al., 2009). Thresholds for statistical significance across all analyses were $p<0.05$.

Results

Data were collected over three months online. A total of 84 surveys were returned with 57 completed surveys/responses included for analysis and reporting for consistency of interpretation. Data were analysed in two sub-groups – General with recreational riders and Elite with national and international riders, as per ESNZ.

Demographics

Demographic data for General and Elite samples are provided in Table 1, for age, athlete gender, years riding experience, level of competition and number of competitions participated in per year. General included recreational athletes from a wide variety of equestrian events while Elite encompassed those riders who were part of the national high performance system and included international representation (eventing, showjumping and dressage). Event preference for the general sample is presented in Figure 1 panel A, and Figure 1 panel B for the elite sample. Due to specialisation, elite athletes only selected one response whereas the general sample were free to select multiple responses hence response numbers exceed sample size (Figure 1 panel A). Response selection decreased as number of disciplines selected increased i.e. 27 respondents selected a second discipline, 19 respondents selected a third discipline and two respondents selected a fourth discipline (see supplementary materials). Wide age range and participation in year in equestrian are illustrated from under 18 y to over 60+ y and 4 y to 42 y riding experience.

Table 1: Demographics of General and Elite riding populations; significant differences between groups are denoted using*

	Characteristic						
Age range	*Under 18*	*18 - 19*	*20 - 29*	*30 - 39*	*40 - 49*	*50 - 59*	*60 or over*
General	0	2	10	5	11	5	4
Elite	3	4	9	1	1	2	0
Gender	*Female*	*Male*					
General	35	2					
Elite	19	1					
Years of riding^	*Mean ± SD*	*Median ± Range*	*Minimum*	*Maximum*			
General	27 ± 13	28 ± 46	4	50			
Elite	17 ± 9	14 ± 37	5	42			
Competition level	*Recreational*	*Local*	*Regional*	*National*	*International*		
General	4	8	11	13	1		
Elite	0	0	0	11	9		
Competitions per year^	*Mean ± SD*	*Median ± Range*	*Minimum*	*Maximum*			
General	12 ± 7	10 ± 40	0	40			
Elite	17 ± 6	15 ± 24	6	30			

^Values are rounded to the nearest whole year

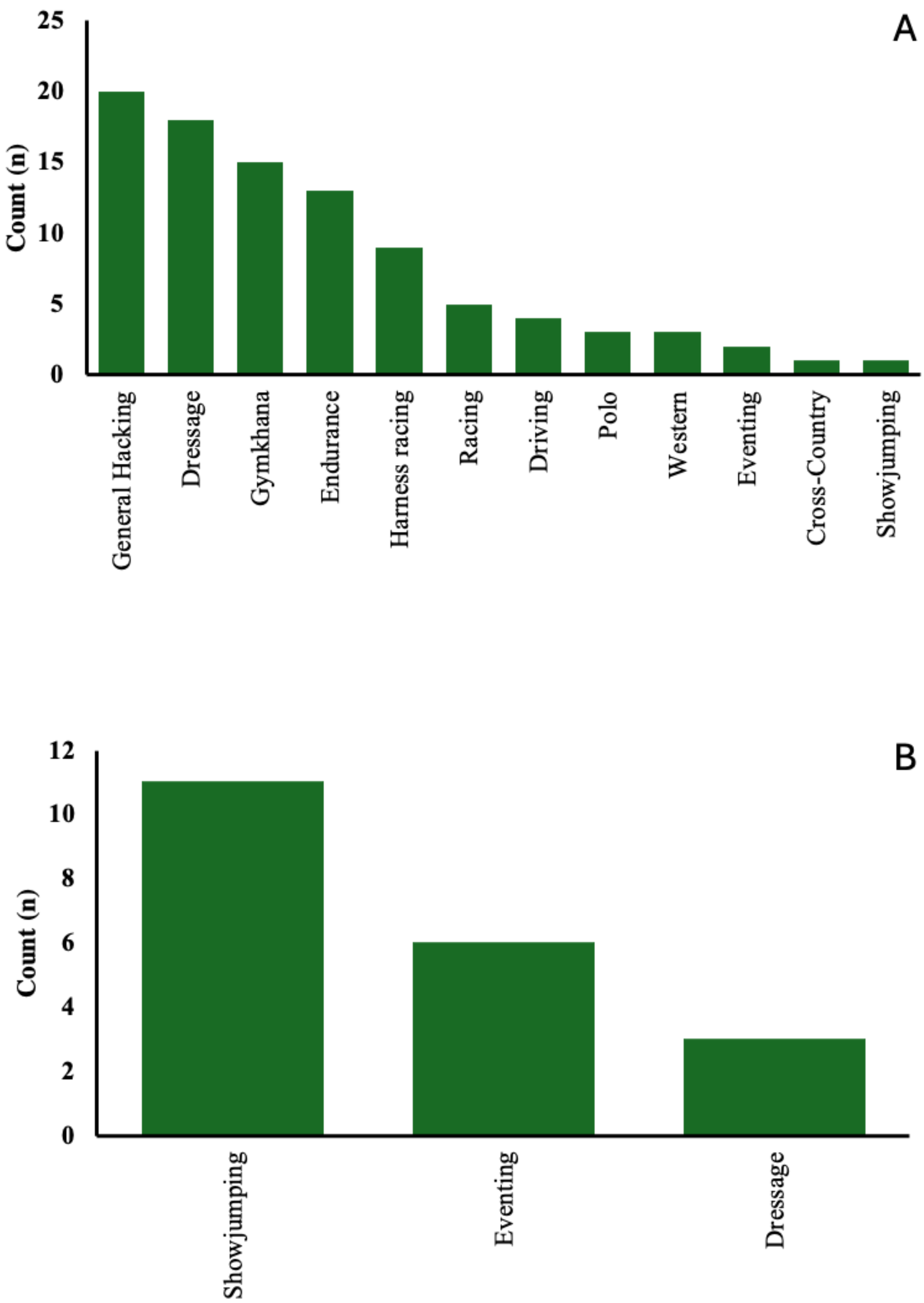

Figure 1 – Preferred discipline for General (Panel A) and Elite (Panel B) samples.

Practitioner engagement

General

The general participation group reported low practitioner (support services including medical, psychological and nutrition) engagement due to GI symptoms within the last year. Thirty two (32) respondents reported not having visited a doctor, 1 stated they were unsure and 4 visited a doctor for GI symptoms. For anxiety related symptoms practitioner engagement within the last year was higher and more evenly distributed. Twenty one (21) respondents reported not having visited a doctor, with the remaining 16 respondents having visited a doctor for anxiety related symptoms. There was no correlation between having visited a doctor for GI symptoms and anxiety (r = -0.02; *Trivial*).

Elite

The Elite group reported low practitioner support engagement due to GI symptoms within the last year. Fifteen (15) respondents reported not visiting a doctor, 1 was unsure and 4 visited a doctor for GI symptoms. Similar values were reported for anxiety, 14 respondents had not visited a doctor, and 6 visited a doctor for anxiety related symptoms. Due to wider availability of specialist support staff, elite athletes were also asked about psychologist and dietitian engagement. Eight (8) reported not having consulted with a psychologist within the last year, 1 was unsure, and 11 had or were actively being supported by a psychologist. No dietitian engagement was indicated by 12 riders, with 1 was unsure and 7 had or were actively being supported by a dietitian. No distinction was made between whether this advice from support personnel was sought for clinical or performance reasons either exclusively or congruently.

Prevalence and severity of symptoms

Prevalence and severity of symptoms are reported pre-competition/general for both groups. Within competition data are only reported for the Elite group, due to being able to validate participation.

Pre-competition/ baseline

Data in the general sample were non-normally distributed as assessed against previously stated criteria (Best & Standing, 2019), Shapiro Wilk values and visual inspection of Q-Q plots. The elite sample appeared to be normally distributed for all variables except lower GI symptoms. However, due to the relatively small sample size of the elite group, and the uneven sample sizes between groups we have opted to perform and report non-parametric equivalents.

Total GI symptom scores and Overall perception of GI symptoms

Total GI symptom scores comprise the total of upper, lower and other GI symptom scores. Median total score for the general sample was 19 and ranged from 0 to 63 (mean ± SD = 20.00 ± 16.60). Median total score for the elite sample was 24 and ranged from 0 to 54.5 (mean ± SD = 24.05 ± 14.95). Whilst the elite sample had a higher average total GI symptom score they did not differ significantly to the general sample (W = 438.50; p = 0.13; r_B = 0.19; *Small*).

Overall perception is an athlete reported measure of GI symptom experience, scored from 0 – 10. The median overall value from the general sample was 2, ranging from 0 to 8 (mean ± SD = 2.27 ± 2.03). Median overall value for the elite sample was 2 and ranged from 0 to 7 (mean ± SD = 2.42 ± 2.02). Differences between samples in overall GI symptom perception were *trivial* (W = 390.50; p = 0.37; r_B = 0.06).

Upper GI symptom scores

Upper GI symptoms comprised belching, heartburn, bloating, urge to regurgitate and vomiting. Symptoms experienced by the general sample ranged from 0 to 29, with a median value of 6, from a possible maximum score of 50 (mean ± SD = 7.70 ± 7.31). In the elite sample, the median value was 8 with a range of 0 to 23 (mean ± SD = 9.68 ± 7.42). Differences in upper GI symptoms between samples were not significant (W = 432.50; $p = 0.15$; $r_B = 0.17$; *Small*).

Lower GI symptom scores

Lower GI symptoms comprised flatulence, lower bloating, left intestinal pain and right intestinal pain. Symptoms experienced by the general sample had a median value of 4 and ranged from 0 to 26, from a possible maximum of 40 (mean ± SD = 7.45 ± 7.27). The elite sample had a median value of 7.5 and ranged from 0 to 20 (mean ± SD = 8.55 ± 6.62). Differences in lower GI symptoms between samples were not significant (W = 425.00; $p = 0.18$; $r_B = 0.15$; *Small*).

Other GI symptom scores and defecation

Other GI symptoms incorporated nausea, dizziness and stitch. The general sample had a median value of 3 and ranged from 0 to 23 (mean ± SD = 4.85 ± 5.61), from a possible maximum of 30. The elite sample had a median of 5.5 and ranged from 0 to 13.5 (mean ± SD = 5.83 ± 3.70). Differences in other GI symptoms between samples were not significant (W = 460.00; $p = 0.07$; $r_B = 0.24$; *Small*).

Defecation responses for general and elite groups are provided below in Table 2. Prevalence of normal stool consistency was significantly lower in the elite sample compared to the general sample (χ^2 (1) = 8.51; $p < 0.001$). Prevalence of all abnormal stool consistencies were higher in the elite sample, when compared to the general sample; however, only values for bloody stool differed significantly (χ^2 (1) = 6.84; $p < 0.001$).

Table 2: Defecation consistency prevalence of each group

			Stool Consistency		
Group/ response	*Normal*	*Abnormally loose*	*Diarrhoea*	*Bloody Stool*	*Constipation*
General					
Yes	18	21	10	0	
No	19	14	25	35	
Blank	0	2	2	2	
Elite					
Yes	2	14	8	5	2
No	18	6	12	15	18
Blank	0	0	0	0	0

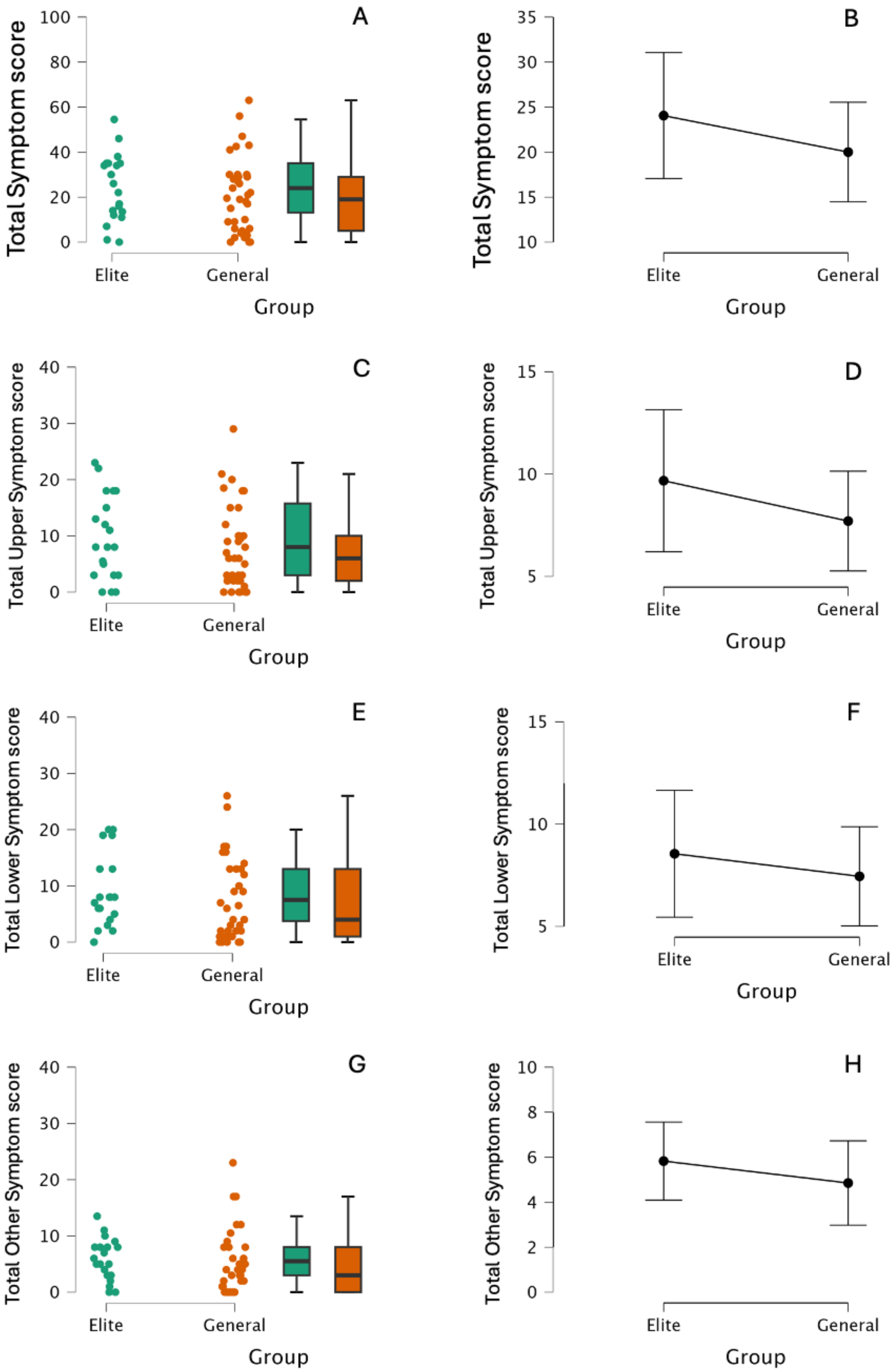

Figure 2 – Symptom location within and between groups for Total (Panels A and B), Upper (Panels C and D), Lower (Panels E and F) and Other (Panels G and H) scores.

Competition

Overall symptom perception did not differ significantly between training and competition (W = 2.50; p = 0.50; r_B = -0.17; *Small*). Similarly, total sample score did not differ between training and competition (W = 12.00; p = 0.91; r_B = 0.60; *Large*). Neither upper (W = 9.00; p = 0.95; r_B = 0.80; *Very Large*), nor lower (W = 9.50; p = 0.75; r_B = 0.27; *Small*), nor other GI symptoms (W = 4.00; p = 0.22; r_B = -0.47; *Moderate*) were significantly worse during competition, however effect sizes indicate a range of responses across participants i.e. if GI symptoms are prevalent in training they are likely to remain in competition to some extent.

Similarly, for defecation symptoms there were no differences in Normal (W = 0.00; p = 0.50; r_B = -1.00; *Very Large*) or Loose stools (W = 4.00; p = 0.81; r_B = 0.33; *Moderate*); or for diarrhoea (W = 1.00; p = 0.98; r_B = 1.00; *Very Large*) or constipation (W = 1.50; p = 0.68; r_B = 0.00; *Null*). No participants for whom competition data were available reported bloody stools in either training or competition.

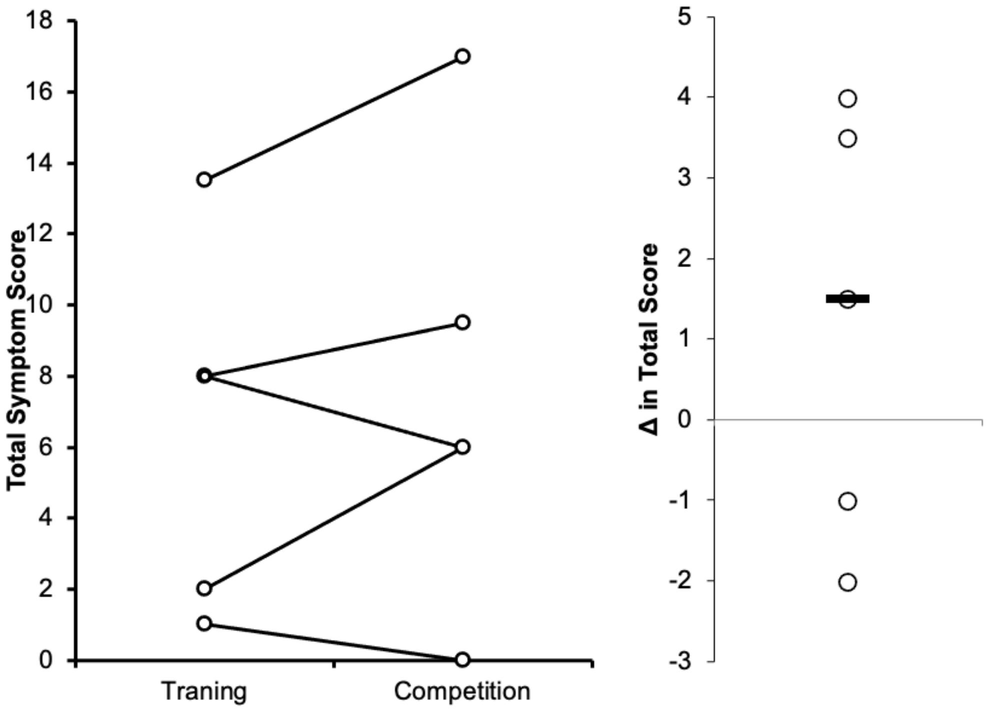

Figure 3 – Individual scores in training and competition for GI symptoms by region in five elite riders. Figures are produced via sheets available from Weissgerber et al., (2015).

Within group comparisons against symptomatic reference values

Figure 4 shows athlete perception of symptoms against symptomatic reference values for prevalence and severity with respect to performance impairment in elite and general samples.

Athlete perceptions of symptoms in the general group showed a significant prevalence of GI symptoms compared to the predefined symptomatic value (W = 442.50; $p = 3.33 \times 10^{-4}$; r_B = 0.68; *Large*), however symptom severity was significantly lower than the value considered to impair performance (W = 25.50; $p = 9.66 \times 10^{-7}$; r_B = 0.76; *Large*).

Athlete perceptions of symptoms in the elite group showed a significant prevalence of GI symptoms compared to the predefined symptomatic value (W = 120.00; $p = 3.55 \times 10^{-3}$; r_B =

0.76; *Large*), however symptom severity was not considered to significantly impair performance (W = 7.50; p = 1.00; r_B = -0.92; *Large*) being lower than the threshold value in the majority of the population.

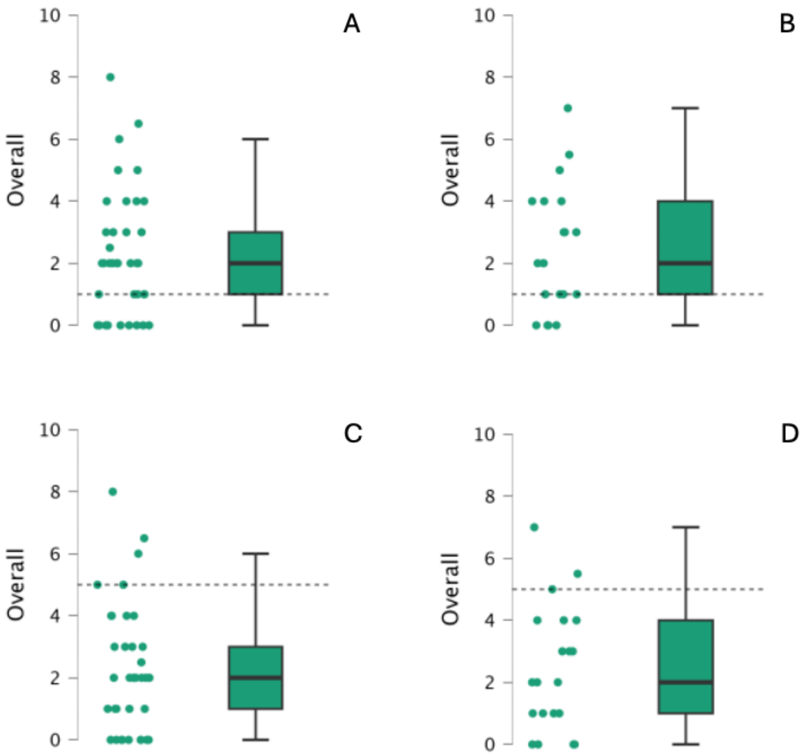

Figure 4 - Athlete perception of symptoms against symptomatic reference values (dashed line) for prevalence (≥1) and severity (≥5) with respect to performance impairment in elite (panels B and D) and general (panels A and C) samples.

Relationships between demographic factors and total symptoms

Three linear regressions were performed with a view to predicting total GI symptoms: participant age group (F(8,43) = 1.46, p = 0.20, R^2 = 0.21), preferred discipline (F(25,26) = 1.51, p = 0.15, R^2 = 0.59) and level of competition (F(5,46) = 1.00, p = 0.43, R^2 = 0.10), none of which were statistically significant predictors of total GI symptoms. Participant gender was not considered, due to the under-representation of males within the sample(s). This suggests that GI symptoms are non-discriminatory, and prevalence cannot be readily predicted when accounting for years of riding experience and number of competitions per year. Neither years of riding experience (-0.09; p = 0.53; *Trivial*), nor number of competitions per year (-0.16; p = 0.26; *Trivial*) were significantly correlated to total GI symptom score. While it appears more riders sought advice for anxiety related to GI symptoms it is unclear the number who sought additional nutrition advice to compliment the bidirectional impact of the brain gut axis and achieved relief or improvement in symptoms.

Discussion

This study aimed to assess the prevalence and severity of GI symptoms in equestrian athletes. We hypothesised that severity would vary between individuals, but symptoms would typically be higher in competition than in training; this was not the case. We also hypothesised that prevalence of symptoms may exceed that of the general population and potentially other athletic groups due to the previous sport psychology research within equestrian sport highlighting a role of anxiety, and its known impact upon GI symptoms (Clark & Mach, 2016; Wilson, Ferguson, et al., 2023). Whilst symptom prevalence exceeded that of the general population (≤60% (Palsson et al., 2024), it was comparable to other sports, with 92% of athletes reporting symptoms of some symptoms/ non-zero values. This is comparable to ultra-endurance runners whom have reported symptom prevalence of up to 96% (Berger et al., 2024).

Gastro-intestinal symptoms are prevalent in recreational and elite equestrians. Despite differences in how symptoms are distributed between groups, upper GI symptoms are more prevalent than lower GI symptoms, irrespective of sample. Differences between groups are statistically *small* (p = 0.13; r_B = 0.19), but the higher mean/median values in the elite sample suggest that factors which contribute to GI symptom severity may differ between elite and recreational equestrians, or be a product of different training and working practices between these groups e.g. prolonged reduction in gastrointestinal blood flow due to increased ridden exercise volume (Berger et al., 2024; Oliveira et al., 2014).

Years of riding experience has no effect on symptom prevalence or severity. It could be assumed equestrian riders are accepting of GI symptoms and these behaviours have become normalised. Values do peak sooner in the elite sample (10/15 years) compared to later in recreational riders (15/20 years), indicating a possible link to ridden volume or variety in horses ridden and GI distress i.e. either riding professionally, producing horses for income, or riding someone else's horses as a form of income increases ridden volume which may increase GI symptom prevalence and severity through alterations in blood flow away from the GI tract, biomechanical factors, reduced eating opportunities and inadequate hydration status (Costa et al., 2019; Oliveira et al., 2014). These findings warrant continued research into differences between elite and recreational equestrian groups, concomitantly capturing symptom prevalence and possible physiological mechanisms. Similar relationships are seen in equestrian injury, where ridden volume and participation in larger volumes of seemingly low risk activities impart a greater rate of injury (Glace et al., 2023; Marlin & Williams, 2024), due to increased baseline exposure to risk factors.

Bloating and flatulence were most commonly reported in both groups, with the elite group also reporting these symptoms as impacting performance in competition. Biomechanical issues, posture, and breathing warrant consideration in both groups alongside gut training and pre-training/pre-event nutritional/food selection. These symptoms may also be a product of eating differently or what is perceived to be more healthily (and often higher in fibre) in the build-up to competition, or due to low quality and possibly a more limited food provision at competition venues. Further information is required to confirm these hypotheses. Regardless, education is required to support general nutrition habits and competition specific nutrition and hydration practices, where total, timing and type of food intake may differ to training/recreational riding (Best et al., 2023) to minimise GI disturbance and maximise performance.

Perceived GI symptom severity is low (Median = 2/10), but frequent in both groups (23/37 recreational sample; 13/20 in elite sample), with ~15% in each group perceiving symptoms to be severe enough to impact their ridden performance (≥5/10 perceived symptom rating reported). This does not appear to change or does so only minorly (e.g. 0.5 to 1.0 units) as a result of competition in the elite sample. These values strongly indicate that athletes are aware of their GI symptoms and their severity, but are unaware of their potential adverse impact(s) on health and performance, and either consider them an accepted part of equestrian participation or are not aware of potential avenues for support either from medical or dietetic practitioners. This is further evidenced by low reporting of doctor's visits due to GI symptoms in both groups, and only 35% of elite riders consulting with a dietitian, despite *moderate* to *large* correlations between symptom perception and total symptom score in both groups (r = 0.73 to 0.81).

Conversely, 16 (43%) recreational riders reporting seeking medical attention for anxiety. Relatively fewer elite riders sought support for anxiety (30%), but more than half (11/20) reported currently or having previously consulted with a psychologist. This is a possible corollary to the lower prevalence of anxiety in elite athletes. Likewise, whilst only 7 elite athletes had previously or were actively being supported by a dietitian, four athletes perceived their symptoms as a 0, and only 1 athlete had a total score of 0, indicating a need for nutritional support in this group, especially for GI symptom management. We recommend adopting a more inter-disciplinary approach to supporting GI issues within all equestrian populations due to the potential role of the gut-brain axis and how it can be impacted by diet and exercise (Clark & Mach, 2016; Hughes & Holscher, 2021). Evidence for the use of psychological and nutrition co-intervention in supporting GI conditions in clinical populations shows beneficial effects (Colomier et al., 2022; Cox et al., 2022), as both elements of the gut-brain axis are addressed congruently. However, it should be acknowledged that much of the work that takes an interdisciplinary approach and shows larger effect sizes is in palliative populations (Lu et al., 2021; Temel et al., 2016). Ideally, an integrated approach would provide a greater breadth and depth of education and strategies for athletes, and builds upon the existing acceptance and knowledge base of psychological support in equestrian sport to date, whilst increasing uptake of nutrition counselling. Further work on clinical aspects of GI function is also required at the gut and microbiome levels, exploring how these may differ in equestrians compared to other groups and sports e.g. animal ownership, lifestyle and hygiene factors compared to other sports may predispose equestrians to certain risk factors or microflora populations, as per other domestic animals (Abdolghanizadeh et al., 2024; Hernandez et al., 2022; Yang et al., 2023).

Loose/diarrhoea in elite group was reported by 14 riders, with 2 reporting constipation in training. More concerning was the 5 riders reporting blood in stool which is a significant concern, the majority of riders reported normal or loose in competition sample. With the higher microbial load of the equestrian environment riders need to take great attention to hygiene practices (eating in the stable environment, hand to face contact, equine to human contact, cleaning stables) and a gut health (consider probiotic use, hand sanitising, and hand washing prior to handling food), especially when in a new environment just as these actions are taken with the equine athlete.

The survey was the first of its kind in equestrian sport, and so carries some limitations and considerations for future research. Given the novelty and potential sensitivity of the topic, we anticipated a low uptake relative to potential sample size. There is a need to break down any perceived barriers and provide quality information for athletes, especially where athlete health may be compromised due to lack of awareness or inaction (e.g. blood in stool). We intend to repeat the survey at a later date, as athlete awareness and access increases. Male athletes are frequently underrepresented in equestrian data, and this was also the case in these participant sets (n = 3/57 pooled; ~5%). Interestingly, male recreational athletes reported total GI scores approximating that of the mean/median for their group, but the elite male exceeded the average values of the elite group. We anticipate that GI symptom and wider research in equestrian sport may progress similarly to relative energy deficiency in sport (REDS (Ackerman et al., 2020;

Mountjoy et al., 2014, 2023)), which links energy availability to wider systemic acute and chronic athlete health effects, well-being and performance. Prior to the development of REDS, research and practice focussed almost exclusively on symptoms related to female athletes (low energy availability, late onset or lack of menstruation and poor bone density outcomes (Souza et al., 2017; Temm et al., 2022)), but as knowledge and understanding grew, the new framework was developed which accounted for the breadth of symptoms and their ability to affect both male and female health and performance (Ackerman et al., 2020; Heikura et al., 2024; Mountjoy et al., 2014, 2023). There is a definite need for future research targeting male equestrian athletes to maximise our understanding of equestrian sport. However, the participation demographic data consistently highlights that equestrian sports are a fantastic opportunity to undertake wider female sport science research and should not be ignored for fear of increased complexity or novelty (Best, 2022).

The questionnaire itself is a useful screening tool for GI symptoms and possible routes of referral need to considered. We caution that although the questionnaire is useful for screening GI symptom prevalence and severity, and their potential for performance impact, there are populations who may ride AND display adverse gut health/GI symptoms. This could be due to co-pathology and or sustained impairment e.g. Paralympic riders (Hobbs et al., 2023; Stockley et al., 2022), or other disability riders who may experience a predisposition to GI conditions e.g. Down Syndrome (Tsou et al., 2020). We welcome open discussion of GI symptoms in equestrian communities, but encourage referral and 'zooming out', to consider potential causes and explanations for GI symptoms. We do not intend this work to empower coaches or support personnel to diagnose or treat GI or associated symptoms in their riders, unless appropriately qualified to do so.

In conclusion, GI symptoms are prevalent and of sufficient severity in equestrian athletes, irrespective of participation level, to be considered a modifiable factor with respect to riding performance. Symptoms do not appear to significantly worsen in competition, nor are they predicated by age, event or level of participation. More simply, athletes may enjoy or improve their riding when GI symptoms are addressed; they do not have to be an accepted part of equestrian sport and may point to greater underlying health risks. Appropriate support from medical and dietetic practitioners should be sought where symptoms persist and certainly if they impact ridden performance.

Declarations

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Conflicts of interest

The authors have no conflicts of interest to declare

Ethical approval

As outlined in **Methods**, the study received appropriate ethical approval and was conducted in accordance with the declaration of Helsinki

Data Availability

Data are available as supplementary materials, and will be made available via the corresponding author's institutional repository and Researchgate profile

Authors' contributions

RB and JP contributed to the manuscript equally, both taking account for participant recruitment, data collection, analyses and manuscript preparation and revisions.

References:

Abdolghanizadeh, S., Salmeh, E., Mirzakhani, F., Soroush, E., Siadat, S. D. & Tarashi, S. (2024). Microbiota insights into pet ownership and human health. *Research in Veterinary Science*, *171*, 105220. https://doi.org/10.1016/j.rvsc.2024.105220

Ackerman, K. E., Stellingwerff, T., Elliott-Sale, K. J., Baltzell, A., Cain, M., Goucher, K., Fleshman, L. & Mountjoy, M. L. (2020). #REDS (Relative Energy Deficiency in Sport): time for a revolution in sports culture and systems to improve athlete health and performance. *British Journal of Sports Medicine*, *54*(7), 369. https://doi.org/10.1136/bjsports-2019-101926

Almario, C. V., Ballal, M. L., Chey, W. D., Nordstrom, C., Khanna, D. & Spiegel, B. M. R. (2018). Burden of Gastrointestinal Symptoms in the United States: Results of a Nationally Representative Survey of Over 71,000 Americans. *The American Journal of Gastroenterology*, *113*(11), 1701–1710. https://doi.org/10.1038/s41395-018-0256-8

Baillet, H., Thouvarecq, R., Vérin, E., Tourny, C., Benguigui, N., Komar, J. & Leroy, D. (2017). Human Energy Expenditure and Postural Coordination on the Mechanical Horse. *Journal of Motor Behavior*, *49*(4), 441–457. https://doi.org/10.1080/00222895.2016.1241743

Berger, N. J. A., Best, R., Best, A. W., Lane, A. M., Millet, G. Y., Barwood, M., Marcora, S., Wilson, P. & Bearden, S. (2024). Limits of Ultra: Towards an Interdisciplinary Understanding of Ultra-Endurance Running Performance. *Sports Medicine*, *54*(1), 73–93. https://doi.org/10.1007/s40279-023-01936-8

Best, R. (2022). The player–pony dyad in Polo: lessons from other sports and future directions. *Animal Frontiers*, *12*(3), 54–58. https://doi.org/10.1093/af/vfac003

Best, R. & Standing, R. (2019). All things being equal: spatiotemporal differences between Open and Women's 16-goal Polo. *International Journal of Performance Analysis in Sport*, *19*(6), 919–929. https://doi.org/10.1080/24748668.2019.1681790

Best, R., Williams, J. M. & Pearce, J. (2023). The Physiological Requirements of and Nutritional Recommendations for Equestrian Riders. *Nutrients*, *15*(23), 4977. https://doi.org/10.3390/nu15234977

Bye, T. L. & Lewis, V. (2019). Saddle and stirrup forces of equestrian riders in sitting trot, rising trot, and trot without stirrups on a riding simulator. *Comparative Exercise Physiology*, *16*(1), 75–85. https://doi.org/10.3920/cep190031

Clark, A. & Mach, N. (2016). Exercise-induced stress behavior, gut- microbiota-brain axis and diet: a systematic review for athletes. *Journal of the International Society of Sports Nutrition*, 1–21. https://doi.org/10.1186/s12970-016-0155-6

Cocq, P. de, Muller, M., Clayton, H. M. & Leeuwen, J. L. van. (2013). Modelling biomechanical requirements of a rider for different horse-riding techniques at trot. *Journal of Experimental Biology*, *216*(10), 1850–1861. https://doi.org/10.1242/jeb.070938

Colomier, E., Oudenhove, L. V., Tack, J., Böhn, L., Bennet, S., Nybacka, S., Störsrud, S., Öhman, L., Törnblom, H. & Simrén, M. (2022). Predictors of Symptom-Specific Treatment Response to Dietary Interventions in Irritable Bowel Syndrome. *Nutrients*, *14*(2), 397. https://doi.org/10.3390/nu14020397

Costa, R. J. S., Hoffman, M. D. & Stellingwerff, T. (2019). Considerations for ultra-endurance activities: part 1- nutrition. *Research in Sports Medicine (Print)*, *27*(2), 166–181. https://doi.org/10.1080/15438627.2018.1502188

Cox, S. R., Czuber-Dochan, W., Wall, C. L., Clarke, H., Drysdale, C., Lomer, M. C., Lindsay, J. O. & Whelan, K. (2022). Improving Food-Related Quality of Life in Inflammatory Bowel Disease through a Novel Web Resource: A Feasibility Randomised Controlled Trial. *Nutrients*, *14*(20), 4292. https://doi.org/10.3390/nu14204292

Deckers, I., Bruyne, C. D., Roussel, N. A., Truijen, S., Minguet, P., Lewis, V., Wilkins, C. & Breda, E. V. (2020). Assessing the sport-specific and functional characteristics of back pain in horse riders. *Comparative Exercise Physiology*, *17*(1), 7–15. https://doi.org/10.3920/cep190075

Eisenstein, M. (2016). Microbiome: Bacterial broadband. *Nature*, *533*(7603), S104–S106. https://doi.org/10.1038/533s104a

Engell, M. T., Clayton, H. M., Egenvall, A., Weishaupt, M. A. & Roepstorff, L. (2016). Postural changes and their effects in elite riders when actively influencing the horse versus sitting passively at trot. *Comparative Exercise Physiology*, *12*(1), 27–33. https://doi.org/10.3920/cep150035

Gaskell, S. K., Snipe, R. M. J. & Costa, R. J. S. (2019). Test Re-Test Reliability of a Modified Visual Analogue Scale Assessment Tool for Determining Incidence and Severity of Gastrointestinal Symptoms in Response to Exercise Stress. *International Journal of Sport Nutrition and Exercise Metabolism*, 1–26. https://doi.org/10.1123/ijsnem.2018-0215

Glace, B. W., Kremenic, I. J., Hogan, D. E. & Kwiecien, S. Y. (2023). Incidence of concussions and helmet use in equestrians. *Journal of Science and Medicine in Sport*, *26*(2), 93–97. https://doi.org/10.1016/j.jsams.2022.12.004

Hardcastle, S. J., Tye, M., Glassey, R. & Hagger, M. S. (2015). Exploring the perceived effectiveness of a life skills development program for high-performance athletes. *Psychology of Sport and Exercise*, *16*, 139–149. https://doi.org/10.1016/j.psychsport.2014.10.005

Heikura, I. A., McCluskey, W. T. P., Tsai, M.-C., Johnson, L., Murray, H., Mountjoy, M., Ackerman, K. E., Fliss, M. & Stellingwerff, T. (2024). Application of the IOC Relative Energy Deficiency in Sport (REDs) Clinical Assessment Tool version 2 (CAT2) across 200+ elite athletes. *British Journal of Sports Medicine*, bjsports-2024-108121. https://doi.org/10.1136/bjsports-2024-108121

Hernandez, J., Rhimi, S., Kriaa, A., Mariaule, V., Boudaya, H., Drut, A., Jablaoui, A., Mkaouar, H., Saidi, A., Biourge, V., Borgi, M. A., Rhimi, M. & Maguin, E. (2022). Domestic Environment and Gut Microbiota: Lessons from Pet Dogs. *Microorganisms*, *10*(5), 949. https://doi.org/10.3390/microorganisms10050949

Hobbs, S. J., Alexander, J., Wilkins, C., George, L. St., Nankervis, K., Sinclair, J., Penhorwood, G., Williams, J. & Clayton, H. M. (2023). Towards an Evidence-Based Classification System for Para Dressage: Associations between Impairment and Performance Measures. *Animals*, *13*(17), 2785. https://doi.org/10.3390/ani13172785

Hoogervorst, D., Burg, N. van der, Versteegen, J. J., Lambrechtse, K. J., Redegeld, M. I., Cornelissen, L. A. J. & Wardenaar, F. C. (2019). Gastrointestinal Complaints and Correlations with Self-Reported Macronutrient Intake in Independent Groups of (Ultra)Marathon Runners Competing at Different Distances. *Sports*, *7*(6), 140. https://doi.org/10.3390/sports7060140

Hopkins, W. G., Marshall, S. W., Batterham, A. M. & Hanin, J. (2009). Progressive Statistics for Studies in Sports Medicine and Exercise Science. *Medicine & Science in Sports & Exercise*, *41*(1), 3–13. https://doi.org/10.1249/mss.0b013e31818cb278

Hughes, R. L. & Holscher, H. D. (2021). Fueling Gut Microbes: A Review of the Interaction between Diet, Exercise, and the Gut Microbiota in Athletes. *Advances in Nutrition*, *12*(6), 2190–2215. https://doi.org/10.1093/advances/nmab077

Keener, M. M., Tumlin, K. I. & Dlugonski, D. (2023). Self-Reported Physical Activity and Perception of Athleticism in American Equestrian Athletes. *Journal of Physical Activity and Health*, *20*(3), 169–179. https://doi.org/10.1123/jpah.2022-0398

Lamperd, W., Clarke, D., Wolframm, I. & Williams, J. (2016). What makes an elite equestrian rider? *Comparative Exercise Physiology*, *12*(3), 105–118. https://doi.org/10.3920/cep160011

Lewinski, M. von, Biau, S., Erber, R., Ille, N., Aurich, J., Faure, J.-M., Möstl, E. & Aurich, C. (2013). Cortisol release, heart rate and heart rate variability in the horse and its rider: Different responses to training and performance. *The Veterinary Journal*, *197*(2), 229–232. https://doi.org/10.1016/j.tvjl.2012.12.025

Lu, Z., Fang, Y., Liu, C., Zhang, X., Xin, X., He, Y., Cao, Y., Jiao, X., Sun, T., Pang, Y., Wang, Y., Zhou, J., Qi, C., Gong, J., Wang, X., Li, J., Tang, L. & Shen, L. (2021). Early Interdisciplinary Supportive Care in Patients With Previously Untreated Metastatic Esophagogastric Cancer: A Phase III Randomized Controlled Trial. *Journal of Clinical Oncology*, *39*(7), 748–756. https://doi.org/10.1200/jco.20.01254

Luger, A., Deuster, P. A., Kyle, S. B., Gallucci, W. T., Montgomery, L. C., Gold, P. W., Loriaux, D. L. & Chrousos, G. P. (1987). Acute Hypothalamic–Pituitary–Adrenal Responses to the Stress of Treadmill Exercise. *The New England Journal of Medicine*, *316*(21), 1309–1315. https://doi.org/10.1056/nejm198705213162105

Marlin, D. J. & Williams, J. M. (2024). UK rider reported falls in a 12-month period: circumstances and consequences. *Comparative Exercise Physiology*, *20*(3), 209–218. https://doi.org/10.1163/17552559-00001029

Meyers, M. C. & Sterling, J. C. (2000). Physical, hematological, and exercise response of collegiate female equestrian athletes. *The Journal of Sports Medicine and Physical Fitness*, *40*(2), 131–138.

Millet, G. P., Brocherie, F. & Burtscher, J. (2021). Olympic Sports Science—Bibliometric Analysis of All Summer and Winter Olympic Sports Research. *Frontiers in Sports and Active Living*, *3*, 772140. https://doi.org/10.3389/fspor.2021.772140

Mountjoy, M., Ackerman, K. E., Bailey, D. M., Burke, L. M., Constantini, N., Hackney, A. C., Heikura, I. A., Melin, A., Pensgaard, A. M., Stellingwerff, T., Sundgot-Borgen, J. K., Torstveit, M. K., Jacobsen, A. U., Verhagen, E., Budgett, R., Engebretsen, L. & Erdener, U. (2023). 2023 International Olympic Committee's (IOC) consensus statement on Relative Energy Deficiency in Sport (REDs). *British Journal of Sports Medicine*, *57*(17), 1073–1097. https://doi.org/10.1136/bjsports-2023-106994

Mountjoy, M., Sundgot-Borgen, J., Burke, L., Carter, S., Constantini, N., Lebrun, C., Meyer, N., Sherman, R., Steffen, K., Budgett, R. & Ljungqvist, A. (2014). *The IOC consensus statement: beyond the Female Athlete Triad--Relative Energy Deficiency in Sport (RED-S)*. *48*, 491–497. https://doi.org/10.1136/bjsports-2014-093502

Oliveira, E. P. de, Burini, R. C. & Jeukendrup, A. (2014). Gastrointestinal Complaints During Exercise: Prevalence, Etiology, and Nutritional Recommendations. *Sports Medicine (Auckland, N.Z.)*, *44*(S1), 79–85. https://doi.org/10.1007/s40279-014-0153-2

Palsson, O. S., Tack, J., Drossman, D. A., Nevé, B. L., Quinquis, L., Hassouna, R., Ruddy, J., Morris, C. B., Sperber, A. D., Bangdiwala, S. I. & Simrén, M. (2024). Worldwide population prevalence and impact of sub-diagnostic gastrointestinal symptoms. *Alimentary Pharmacology & Therapeutics*, *59*(7), 852–864. https://doi.org/10.1111/apt.17894

Pugh, J. N., Kirk, B., Fearn, R., Morton, J. P. & Close, G. L. (2018). Prevalence, Severity and Potential Nutritional Causes of Gastrointestinal Symptoms during a Marathon in Recreational Runners. *Nutrients*, *10*(7), 811–817. https://doi.org/10.3390/nu10070811

Racinais, S., Alonso, J. M., Coutts, A. J., Flouris, A. D., Girard, O., González-Alonso, J., Hausswirth, C., Jay, O., Lee, J. K. W., Mitchell, N., Nassis, G. P., Nybo, L., Pluim, B. M., Roelands, B., Sawka, M. N., Wingo, J. & Périard, J. D. (2015). Consensus recommendations on training and competing in the heat. *British Journal of Sports Medicine*, *49*(18), 1164. https://doi.org/10.1136/bjsports-2015-094915

Rhee, S. H., Pothoulakis, C. & Mayer, E. A. (2009). Principles and clinical implications of the brain–gut–enteric microbiota axis. *Nature Reviews Gastroenterology & Hepatology*, *6*(5), 306–314. https://doi.org/10.1038/nrgastro.2009.35

Schütz, K., Rott, J. & Koester, D. (2023). Competition Anxiety in Equestrians Across Different Disciplines and Performance Levels. *International Journal of Equine Science*, *2*(1), 24–33.

Souza, M. J. D., Nattiv, A., Joy, E., Misra, M., Williams, N. I., Mallinson, R. J., Gibbs, J. C., Olmsted, M., Goolsby, M., Matheson, G. & Panel, E. (2017). 2014 Female Athlete Triad Coalition Consensus Statement on Treatment and Return to Play of the Female Athlete Triad: 1st International Conference held in San Francisco, California, May 2012 and 2nd International Conference held in Indianapolis, Indiana, May 2013. *British Journal of Sports Medicine*, *48*(4), 289. https://doi.org/10.1136/bjsports-2013-093218

Stockley, R. C., George, L. S., Spencer, J. & Hobbs, S. J. (2022). A synthesis of potential impairment assessment tools for Para dressage classification. *EUJAPA*, *15*(1), 11–11. https://doi.org/10.5507/euj.2022.011

Temel, J. S., Greer, J. A., El-Jawahri, A., Pirl, W. F., Park, E. R., Jackson, V. A., Back, A. L., Kamdar, M., Jacobsen, J., Chittenden, E. H., Rinaldi, S. P., Gallagher, E. R., Eusebio, J. R., Li, Z., Muzikansky, A. & Ryan, D. P. (2016). Effects of Early Integrated Palliative Care in Patients With Lung and GI Cancer: A Randomized Clinical Trial. *Journal of Clinical Oncology*, *35*(8), JCO.2016.70.504. https://doi.org/10.1200/jco.2016.70.5046

Temm, D. A., Standing, R. J. & Best, R. (2022). Training, Wellbeing and Recovery Load Monitoring in Female Youth Athletes. *International Journal of Environmental Research and Public Health*, *19*(18), 11463. https://doi.org/10.3390/ijerph191811463

Tsou, A. Y., Bulova, P., Capone, G., Chicoine, B., Gelaro, B., Harville, T. O., Martin, B. A., McGuire, D. E., McKelvey, K. D., Peterson, M., Tyler, C., Wells, M., Whitten, M. S. & Workgroup, G. D. S. F. M. C. G. for A. with D. S. (2020). Medical Care of Adults With Down Syndrome. *JAMA*, *324*(15), 1543–1556. https://doi.org/10.1001/jama.2020.17024

Weissgerber, T. L., Milic, N. M., Winham, S. J. & Garovic, V. D. (2015). Beyond Bar and Line Graphs: Time for a New Data Presentation Paradigm. *PLOS Biology*, *13*(4), e1002128. https://doi.org/10.1371/journal.pbio.1002128

Wilkins, C. A., Nankervis, K., Protheroe, L. & Draper, S. B. (2023). Static pelvic posture is not related to dynamic pelvic tilt or competition level in dressage riders. *Sports Biomechanics*, *22*(10), 1290–1302. https://doi.org/10.1080/14763141.2020.1797150

Wilkins, C. A., Wheat, J. S., Protheroe, L., Nankervis, K. & Draper, S. B. (2022). Coordination variability reveals the features of the 'independent seat' in competitive dressage riders. *Sports Biomechanics*, 1–16. https://doi.org/10.1080/14763141.2022.2113118

Williams, J. (2013). Performance analysis in equestrian sport. *Comparative Exercise Physiology*, *9*(2), 67–77. https://doi.org/10.3920/cep13003

Williams, Jane & Tabor, G. (2017). Rider impacts on equitation. *Applied Animal Behaviour Science*, *190*, 28–42. https://doi.org/10.1016/j.applanim.2017.02.019

Wilson, P. B. (2019). "I think I'm gonna hurl": A Narrative Review of the Causes of Nausea and Vomiting in Sport. *Sports (Basel, Switzerland)*, *7*(7), 162. https://doi.org/10.3390/sports7070162

Wilson, P. B. (2020). The Psychobiological Etiology of Gastrointestinal Distress in Sport. *Journal of Clinical Gastroenterology*, *54*(4), 297–304. https://doi.org/10.1097/mcg.0000000000001308

Wilson, P. B., Fearn, R. & Pugh, J. (2023). Occurrence and Impacts of Gastrointestinal Symptoms in Team-Sport Athletes: A Preliminary Survey. *Clinical Journal of Sport Medicine*, *33*(3), 239–245. https://doi.org/10.1097/jsm.0000000000001113

Wilson, P. B., Ferguson, B. K., Mavins, M. & Ehlert, A. M. (2023). Anxiety and visceral sensitivity relate to gastrointestinal symptoms in runners but not pre- or during-event nutrition intake. *The Journal of Sports Medicine and Physical Fitness*, *63*(7), 846–851. https://doi.org/10.23736/s0022-4707.23.14804-3

Wolframm, I. A. & Micklewright, D. (2010a). Effects of trait anxiety and direction of pre-competitive arousal on performance in the equestrian disciplines of dressage, showjumping and eventing. *Comparative Exercise Physiology*, *7*(04), 185–191. https://doi.org/10.1017/s1755254011000080

Wolframm, I. A. & Micklewright, D. (2010b). Pre-competitive arousal, perception of equine temperament and riding performance: do they interact? *Comparative Exercise Physiology*, *7*(1), 27–36. https://doi.org/10.1017/s1755254010000152

Wolframm, I. A. & Micklewright, D. (2011). The effect of a mental training program on state anxiety and competitive dressage performance. *Journal of Veterinary Behavior: Clinical Applications and Research*, *6*(5), 267–275. https://doi.org/10.1016/j.jveb.2011.03.003

Yang, Y., Hu, X., Cai, S., Hu, N., Yuan, Y., Wu, Y., Wang, Y., Mi, J. & Liao, X. (2023). Pet cats may shape the antibiotic resistome of their owner's gut and living environment. *Microbiome*, *11*(1), 235. https://doi.org/10.1186/s40168-023-01679-8