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The prevalence and perceptions of non-steroidal anti-inflammatory drug use among ultra-endurance runners

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ABSTRACT

Ultra-endurance running imposes extreme physical demands often resulting in exercise-induced muscle damage (EIMD), pain, and inflammation. Many athletes use non-steroidal anti-inflammatory drugs (NSAIDs) despite safety concerns, questionable efficacy, and recent bans in some events. However, the prevalence, patterns, and cultural drivers of NSAID use across performance levels remain underexplored. This mixed-methods, cross-sectional survey included 167 ultra-endurance runners across five self-reported performance tiers. The survey, developed iteratively with expert input, captured NSAID usage during training and competition, motivations, perceived risks/benefits, information sources, and openness to alternatives. Quantitative data were analysed descriptively; qualitative responses underwent inductive thematic analysis. Over half (53%) reported NSAID use, with ibuprofen most common. Usage patterns varied by calibre; Tier 5 (World-class) athletes described strategic use, while lower tiers reported more reactive use. Despite 77% being aware of potential harms, most often renal and gastrointestinal (GI), usage remained high due to perceived benefits. Female participants reported use often linked to menstrual or menopause-related discomfort. Information sources were largely informal, reflecting entrenched norms around pain management. Findings highlight the need for targeted behaviour change strategies, sex-informed approaches, and development of safer, evidence-based pain management alternatives in ultra-endurance sport.

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Muscle damage; performance; recovery; pain; ultramarathon

Introduction

Ultra-endurance running events, commonly referred to as ultramarathons, encompass any race exceeding the traditional marathon distance of 42.195 km (26.2 miles), ranging from 50 km races to multi-day events covering hundreds of kilometres (Scheer et al., 2020). These races are conducted on diverse terrains, including trails, mountains, deserts, and roads. Popular worldwide ultra-endurance events include the Ultra-Trail du Mont-Blanc (UTMB), Comrades Marathon, Marathon des Sables, and Western States Endurance

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Run. Over the past decade, participation in ultramarathons has exponentially risen (Berger et al., 2024), accompanied by growing research interest in understanding the psychophysiological and biomechanical factors that dictate performance in these events.

Performance in ultramarathons is influenced by a complex interplay of psychophysiological and environmental factors, which may partly differ from those governing shorter endurance events. For example, aerobic capacity (VO_{2max}) explains a fair component of endurance performance over distances up to marathon (Billat et al., 2001; Hagan et al., 1981; Maughan & Leiper, 1983) and fractional utilization of VO_{2max} is an even stronger predicter performance in races up to marathon distance (Sjödin & Svedenhag, 1985). However, this predictive power declines as race length increases (Coates et al., 2021). In ultramarathons under 100 km, VO_{2max} retains moderate relevance but for races exceeding this distance, factors such as peripheral muscle fatigue, body composition, and running economy become increasingly important (Pastor et al., 2022). Moreover, the influence of aerobic capacity appears to vary by athlete calibre, with greater predictive value in faster competitors (Martinez-Navarro et al., 2022). These findings suggest that ultramarathon performance is constrained by the relative contribution of aerobic metabolism but also by musculoskeletal resilience and race-specific strategies and psychology.

Exercise-induced muscle damage (EIMD) is widely recognized as another primary factor mitigating performance in ultramarathons, particularly in events exceeding 100 km. Unlike gastrointestinal distress, which affects up to 80% of competitors (Tiller et al., 2019) but can often be managed mid-race, some markers of EIMD (e.g. ultra-structural disruption, inflammation, oedema) accumulate progressively and cannot be reversed over the course of a race. In ultra-endurance events with a significant downhill running component, grade-specific biomechanical and structural alterations occur (reviewed in Bontemps et al., 2020), which leads to acute and delayed neuromuscular alterations (reviewed in Owens et al., 2019) and EIMD characterized by (i) structural alterations, such as Z-line disruption and sarcomere length non-uniformity; (ii) functional declines, including reduced strength and impaired running economy; (iii) symptomatic responses like delayed-onset muscle soreness; and (iv) systemic markers, such as elevated creatine kinase levels in the bloodstream (Giandolini et al., 2016; Malm et al., 2004). Surveys of ultramarathon runners highlight that EIMD (including neuromuscular fatigue) are the most frequently cited physiological barriers to performance (Tiller & Millet, 2024), surpassing both gastrointestinal issues and respiratory limitations. Given the prolonged recovery time required following extensive EIMD, understanding strategies to mitigate this process is crucial for improving both performance and post-race recovery.

To manage muscle soreness and nociceptive discomfort due to EIMD, many marathon and ultramarathon runners turn to pharmacological interventions, including nonsteroidal anti-inflammatory drugs (NSAIDs). Despite reports of use, the efficacy and safety of NSAIDs in this context remain contentious, particularly given recent bans in high-profile events such as UTMB, which has banned the use of ibuprofen in all events due to purported "negative" health risks. Some authors suggest that acute kidney injury (AKI) associated with ultra-endurance performance correlates with NSAID use and therefore NSAIDs act as a significant risk factor for AKI (Hodgson et al., 2017). Indeed, NSAIDs may affect renal function in athletes by increasing water retention by arginine vasopressin in kidneys and reducing glomerular filtration rate (Baker et al., 2005). However, the subsequent effect on core temperature regulation and sweat loss in athletes is less clear

(Emerson et al., 2021). Moreover, ibuprofen aggravates exercise-induced small intestinal injury and induces gut barrier dysfunction in healthy individuals (Van Wijck et al., 2012). The reliance on NSAIDs over alternative analgesics suggests a gap in both knowledge and available strategies for pain management in endurance athletes.

Athlete calibre may be an important factor influencing NSAID use in ultra-endurance running. Performance level can shape not only physiological demands but also competition strategies, recovery practices, and the perceived trade-offs between potential benefits and health risks of pharmacological aids. Higher-calibre athletes may face greater performance pressures, competitive anxiety, and a "win at all costs" mentality, which have been linked to increased use of ergogenic substances despite known risks (Melzer et al., 2022). In this context, elite athletes may be more inclined to incorporate NSAIDs in a planned and strategic way to maintain performance, whereas recreational athletes may use them more reactively in response to discomfort. While NSAID prevalence has been reported in general endurance-running populations, no study to date has examined how usage patterns and motivations vary systematically by athlete calibre. Addressing this gap is important for developing targeted education and intervention strategies that reflect the differing pressures, beliefs, and practices across the performance spectrum.

Therefore, the primary aim of this study was to investigate the prevalence of NSAID use among ultra-endurance runners across five performance calibres from Recreationally Active to World-class, while also exploring perceptions of effectiveness, reasons for use, and openness to potentially safer alternatives through a combination of closed- and open-ended questions. Additionally, the study aimed to gain insight into the underlying beliefs and influences shaping NSAID use within the ultra-endurance running community.

Methods

Ethical approval

This study was granted ethical approval by Liverpool John Moores University Research Ethics Committee (UREC reference: 24/SPS/063). Informed consent was provided by survey participants prior to beginning the survey. Potential participants could withdraw at any time without reason, and their data was removed and deleted.

Survey design

A cross-sectional, mixed-methods survey, combining closed and open-ended questions was employed. The survey (Supplemental material 1) was designed through an iterative process by experts, to capture the performance calibre and training history of participants, prevalence and details of NSAID use, reasons for use, perceptions and practical insights surrounding NSAID use during training and competition, sources of education used for NSAID use and openness to alternatives to NSAIDs. Defining who is "an expert" is subject to debate and there are several methods for doing so (Mauksch et al., 2020). We acknowledge suggestions by Kuchinke (1997), which state that part of being an expert is high commitment to the domain of expertise, which is in line with the general emphasis on deliberate practice in expert learning (Ericsson et al., 1993). To define how close the experts are to the topic, we propose objective closeness i.e. familiarity with the topic as

a result of exploration by research (as proposed by (Needham et al., 1990). The authors have demonstrable published research experience in endurance and ultra-endurance performance and as practitioners providing nutrition and physiological support to amateur and elite ultra-endurance athletes. The survey also underwent iterative piloting with a small group of ultra-endurance athletes to ensure face validity, clarity, and comprehension. Feedback was used to refine wording, improve logical flow, and minimize ambiguity. Internal consistency was not assessed statistically, as the survey did not employ multi-item scales intended to measure a single latent construct.

Participants

Participant recruitment took place between November 2024 to February 2025. Participants were eligible if they were aged 18 or older, had trained for or completed at least one ultra-running event (> 42.195 km) in the past 12 months, and could describe their training and performance calibre using a provided framework. To define training and performance calibre of the athlete(s) supported by the survey respondents, a modified version of the participant classification framework proposed by Mckay et al. (2022) was employed. In brief, this system uses training volume and performance metrics to classify a participant to one of the following:

- Tier 5: World Class • World medallists. • World record holders and athletes achieving within 2% of world-record performance and/or world-leading performance. • Top 3-20 in world rankings.
- Tier 4: International/Elite • Competing at the international level. • Top 4-300 in world rankings, with this number dependent on size and depth of competition in the event. • Achievement of within ~ 7% of world-record performance and/or world-leading performance. • Maximal, or nearly maximal training, within the given sports norms, with intention to compete at top-level competition.
- Tier 3: Highly trained/National Level • Competing at the national level. • Competing in national and/or state leagues/tournaments. • Achievement of within ~ 20% of world-record performance and/or world-leading performance. • Completing structured and periodized training and developing towards (within ~20%) of maximal or nearly maximal norms within the given sport. • Developing proficiency in skills required to perform sport.
- Tier 2: Trained/Developmental • Local-level representation. • Regularly training ~ 3 times per week. • Identify with a specific sport. • Training with a purpose to compete. • Limited skill development.
- Tier 1: Recreationally Active • Meet World Health Organisation minimum activity guidelines: Adults aged 18-64 years old completing at least 150 to 300 min moderate-intensity activity or 75-150 min of vigorous intensity activity a week, plus muscle-strengthening activities 2 or more days a week. • May participate in multiple sports/forms of activity.

The sample size was determined based on the principle of information power, which suggests that the adequacy of a sample is dependent on the richness of the data and its relevance to the study aims rather than a predetermined number (Braun & Clarke, 2016).

Data collection ceased when the research team determined that sufficient responses had been gathered to meaningfully address the research questions. This decision was informed by ongoing assessment of data saturation, ensuring that additional responses were not yielding new insights relevant to the study's objectives.

For the quantitative component of our investigation, no *a priori* sample size calculation was conducted due to the exploratory nature of the study, the absence of prior data on NSAID use by performance tier, and the very small global population of athletes in the highest tier. Instead, recruitment aimed to maximize response rates across all tiers to permit meaningful descriptive comparisons.

Data collection and handling

Prospective respondents were invited to participate in the current survey via social media platforms (X, Instagram and LinkedIn) and contacted by email, where this information was publicly available. Invitations also encouraged prospective respondents to share the invitation to participate within their network or institution to maximize recruitment coverage. Information about the study was also shared through podcasts that targeted the ultra-endurance community, particularly those with guest speakers with a wide-reaching network of listeners. Survey responses were collected via Jisc Online Surveys tool (Jisc v.3, Bristol, UK) and data exported to Microsoft Excel (v.16.7) for analysis. The survey was conducted and distributed in English, with data obtained from participants across multiple countries. Figures were produced in GraphPad prism (v.9 GraphPad Software, Boston, Massachusetts USA). Due to the sensitive nature of the survey, respondents were not required to complete all questions of the survey. As such, the number of respondents per questions is explicitly stated in the results section.

Thematic analysis

We conducted an inductive thematic analysis of open-ended survey responses following the six-step approach outlined by Braun and Clarke (2006). First, we familiarized ourselves with the data through repeated reading and initial note-taking. Next, we generated codes across the dataset, capturing key features of the data relevant to the research question. These codes were then collated into potential themes, which were refined and reviewed to ensure they accurately reflected the dataset. Themes were defined and named to best represent the patterns identified, and a final analysis was conducted to produce a coherent narrative supported by illustrative data extracts.

Results

Participant characteristics

A total of 167 participants completed the survey, with nationality distribution as follows: UK (39%), USA (27%), Canada (6%), Ireland (5%), Hungary (4%), Australia (3%), Germany (2%), Italy (2%), France (2%), and the Netherlands (2%). Additionally, 0.6% of participants were from Argentina, Croatia, Finland, Bulgaria, Latvia, Malta, Norway, Poland, Portugal, South Africa, Switzerland, and Ecuador. Table 1 displays the general characteristics of

Table 1. General characteristics of participants.

	Participants (n = 167)
Sex: Male *(n, %)*	102 (61%)
Female *(n, %)*	65 (39%)
Age (Years)	41.1 ± 9.3
Weight (kg)	71.5 ± 13.4
Height (cm)	175.1 ± 9.3
Years in Ultra-Endurance Racing	6.5 ± 4.9
Races per Year (50km+)	3.1 ± 1.6
Training Volume (h/week) *	12.8 ± 6.4

Note: The values are the mean ± S.D. * Training volume in the 3 months leading up to 'A' race.

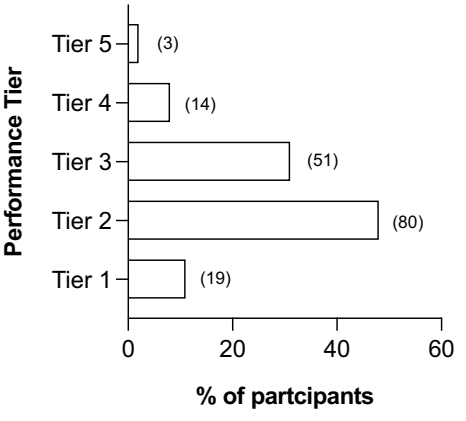

Figure 1. Distribution of survey respondents across performance tiers. The bar chart illustrates the percentage and number (n) of athletes categorised by their self-assessed performance level, following the framework from Mckay et al. (2022).

participants, as well as self-reported years competing in ultra-endurance racing, races per year and training volume in the 3 months leading up to "A" race (priority race in the athlete's annual race calendar).

Previous research highlights the widespread use of analgesics and NSAIDs in professional and elite sports, as well as among high-performance amateur athletes (Leyk et al., 2023). However, NSAID consumption across different performance levels has yet to be specifically categorized in ultra-endurance running. Therefore, to characterize NSAID use in the context of performance calibre, participants were asked to self-select which tier best describes their performance calibre. The participant classification framework outlined by Mckay et al. (2022) and as described in Methods was adopted (data presented in Figure 1).

NSAID consumption

Participants were first informed that questions regarding NSAID use specifically referred to oral forms (e.g., pills, capsules, soft gel capsules) and events where the use of NSAIDs is permitted. A non-exhaustive reference list and guidance for identifying NSAIDs were

provided to participants to assist in identifying NSAID use during training and/or competition. Of the 167 participants in the study, 53% ($n = 89$) reported taking NSAIDs in training, competition or both. Among participants who reported NSAID use 85 chose to provide further context for their use; 78% ($n = 66$) reported using them to "mask an existing injury", while 56% ($n = 48$) reported using them to "prevent performance deterioration" during training or competition. Participants were allowed to select either or both responses. Among NSAID users whose primary reason for use was alleviating discomfort rather than masking injury, 45% ($n = 38$) reported using NSAIDs during training, 61% ($n = 52$) during recovery and 59% ($n = 50$) during competition. Participants were allowed to select multiple responses. Subsequently, participants were offered to describe the regularity of their NSAID use in training, recovery or competition to alleviate discomfort. Responses ($n = 88$) are summarized in Table 2.

Participants were asked to name NSAIDs consumed during training, recovery and competition to alleviate discomfort, reduce performance deterioration, or enhance performance, excluding use for masking existing injuries. Ibuprofen was the most popular NSAID consumed, with 84% ($n = 71$) participants reporting use, followed by 11% ($n = 9$) for naproxen, 8% ($n = 7$) for diclofenac, 4% ($n = 3$) for aspirin, 1% ($n = 1$) for celecoxib and 8% ($n = 7$) for other. When asked whether their NSAID intake during training and/or competition was planned (similar to event nutrition), or unplanned (taken only when deemed necessary), 14% ($n = 9$) of participants reported planned use, whereas 71% ($n = 48$) of participants reported unplanned use and 15% ($n = 10$) reported both. When examining NSAID usage across performance tiers, Tiers 1 through to 4 reported the highest percentage of unplanned use. In contrast, all participants in Tier 5 reported both planned and unplanned NSAID intake, with planned consumption at specific time points and additional consumption as the need arose. Figure 2 shows the distribution of NSAID intake across performance tiers. Participants who reported planned NSAID use were asked about its distribution during an event.

Twenty-five participants who used NSAIDs during competition were able to articulate whether they had a strategy towards their NSAID use. Twenty-four percent (n = 6) of participants who used NSAIDs during ultra-endurance running events reported intake both before or at the start of the event. In addition, another twenty-four percent (n = 6) reported intake at specific time points during the race. An additional 16% (n = 4) indicated NSAID use towards the latter half/end of the event. A further twelve percent (n = 3) reported using them as needed due to acute injury, 8% (n = 2) of participants used

Table 2. Frequency of NSAID use for training, competition, or recovery in ultra endurance runners.

	Training	Recovery	Competition
Always *% (n)*	0% (0)	0% (0)	5% (4)
Very often *% (n)*	1% (1)	6% (5)	7% (6)
Often *% (n)*	5% (4)	8% (7)	6% (5)
Sometimes *% (n)*	27% (24)	33% (29)	28% (25)
Rarely *% (n)*	67% (59)	53% (47)	54% (48)

Note: This refers to NSAID use intended to alleviate discomfort associated with the session or event, reduce perceived performance deterioration, or improve performance, and specifically excludes use for masking existing injuries.

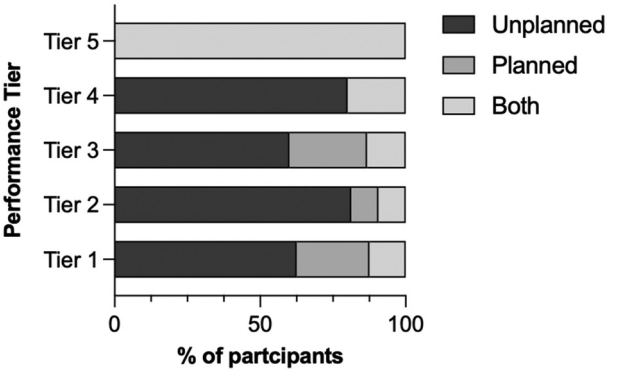

Figure 2. Distribution of NSAID intake across performance tiers.

Table 3. Themes in responses regarding NSAID intake during ultra-endurance running events. The sample size ($n = 25$) reflects the number of respondents to this specific question.

	Participants (n=25)
Only before/at the start of event *% (n)*	24% (6)
Only at specific time points *% (n)*	24% (6)
Only halfway through the event *% (n)*	8% (2)
Only towards the end/finish of event *% (n)*	16% (4)
Only if the need arises (acute injury) during event *% (n)*	12% (3)
Other *% (n)*	16% (4)

them halfway through the event, and 16% (n = 4) of participants reported other varying reasons. Responses are reported in Table 3.

NSAID information and awareness of adverse drug reactions

When asked about sources of information regarding NSAIDs 41% ($n = 64$ of 155 respondents) cited websites as their primary source. This was followed by a similar proportion of participants citing podcasts (33%, $n = 51$) and doctors (31%, $n = 48$) as their source of information. Interestingly, only 5% ($n = 8$) of participants reported obtaining NSAID information from a nutritionist/dietician. The remaining responses are reported in Figure 3. Tier 1 participants identified doctors as their primary source of information regarding NSAIDs (19%), while Tier 4 participants reported both doctors and coaches (27%) as their main sources. In Tier 2, websites were cited as their primary source of information, whereas in Tier 3, participants (18%) favoured podcasts. Finally, Tier 5 participants evenly distributed their sources of information across doctors, academic literature, academic consultations, and websites, with each source accounting for 25%.

Participants were asked if they were aware of the potential adverse effects associated with the use of NSAIDs. A total of 77% ($n = 127$) of participants stated they were aware, while 6% ($n = 10$) of participants were not aware, and 17% ($n = 29$) were unsure. Awareness of the potential adverse effects of NSAIDs exceeded 50% across all performance tiers, indicating a generally high level of awareness regardless of performance calibre. Notably, Tier 1 had the highest proportion of participants who were either

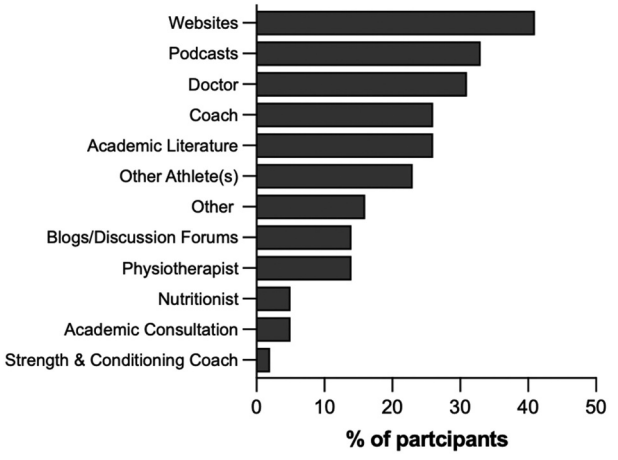

Figure 3. Sources of NSAID information reported by participants.

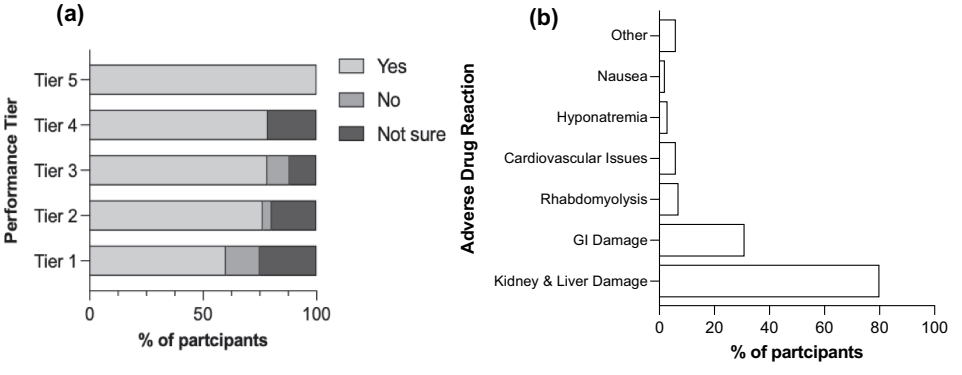

Figure 4. (a) Awareness of adverse effects associated with NSAID use across performance calibre. (b) Themes related to awareness of adverse drug reactions to NSAIDs.

unaware (15%) or unsure (25%), while participants in Tier 5 were the only group to report 100% awareness (see Figure 4(a)). However, the small sample size in Tier 5 should be considered when interpreting these results. Among participants aware of the potential side effects, the most reported side effect was renal (kidney) issues, with 80% ($n = 101$) of participants reporting awareness of it. Gastrointestinal issues were reported by 31% ($n = 39$) of participants and 7% ($n = 9$) mentioned rhabdomyolysis as a possible adverse effect. Responses are reported in Figure 4(b).

Considerations and attitudes towards NSAID use

The closed-ended questions in this survey provided valuable data on performance level, NSAID consumption, and awareness of adverse effects. However, to gain richer insights into participants' considerations, perceptions, and attitudes towards NSAID use, we also included open-ended questions in this section. Participants were asked about their reasons for considering NSAID use ($n = 164$ responses). The most common reasons

reported were to reduce "muscle pain" or "damage" (37%, $n = 60$) and to reduce "inflammation" (32%, $n = 52$). Other reasons cited were to reduce "soft tissue pain" (20%, $n = 33$), to reduce "perception of effort" (8%, $n = 13$) and to reduce "performance deterioration" (10%, $n = 17$). Additionally, 45% ($n = 73$) of participants reported they would not consider using NSAIDs, similar to when asked about NSAID use during training or competition. Participants who selected "Other" (10%, $n = 17$) and those who indicated they would not consider using NSAIDs were asked to provide reasons for their responses. Similarly, some participants that would not consider using NSAIDs also provided open ended text responses regarding their considerations for avoiding NSAID use. Illustrative extracts and emergent themes are presented in Table 4.

To gain a deeper understanding of athlete's attitudes towards NSAID use, participants were provided with several statements and asked to choose the response that most accurately reflected their views ($n = 165$ responses). A substantial proportion (39%, $n = 65$) of participants strongly disagreed that the benefits of NSAID use outweigh any negative effects, while 14% ($n = 23$) agreed. Regarding perceived competitive disadvantage, the majority of participants (35%, $n = 59$) disagreed that not using NSAIDs would put them at a disadvantage compared to competitors, while 32% ($n = 52$) were neutral, and only 10% ($n = 17$) agreed. Conversely, 32% ($n = 52$) of participants agreed that they could perform just as well without NSAIDs as with them, while 16% ($n = 26$) disagreed. When asked whether NSAIDs improve competitive performance, 39% ($n = 65$) of participants were neutral, while 25% ($n = 41$) of participants agreed, and 20% ($n = 33$) disagreed. All statements and corresponding responses are reported in Table 5. A similar proportion of participants across performance tiers responded consistently to each statement. Notably, the highest percentage of participants in Tier 5 believed that the benefits of using NSAIDs outweigh the negative effects and that NSAIDs enhance competitive performance. Across Tiers 1 to 4, more than 50% of participants disagreed with the statements that they would be at a competitive disadvantage if they did not use NSAIDs and that NSAIDs enhance competitive performance. Thirty percent or more of

Table 4. Considerations for avoiding NSAID use as determined by open-ended question responses. Raw data included illustrative extracts from open-ended question responses relevant to the theme.

Illustrative Extracts	Emergent Theme
"Too dangerous for my heart and kidneys." *"I would not want to delay my recovery, or have GI distress, or kidney issues."*	Health Risks and Side Effects
"I prefer to do things naturally if at all possible. Sleep, hydration, nutrition." *"I don't eat any chemicals unless it's unavoidable."*	Preference for Natural or Alternative Approaches
"Using them creates an expectation of less discomfort/reduces my tolerance for discomfort". *"I also don't want to develop a tolerance to reduce my body's ability to adapt to exercise."*	Concerns About Pain Tolerance and Adaptation
"Studies show no positive performance impact on endurance due to NSAIDs during runs with high risk of negative effects" *"I'm not aware of any benefits of using NSAIDs so I wouldn't use them"*	Lack of Perceived Benefit
"I prefer to avoid medications in general and feel that the risks do not outweigh the benefits." *"If I were to use medication to mask pain, I would choose a med that acts only on pain signalling/perception rather than inflammatory pathways."*	General Avoidance of Medications
"Because the point of running ultra-endurance events is to "endure". That means any sort of drug taken to reduce the amount of pain is against the idea of why you test yourself in an endurance race. I run to test my limits. I don't race to win" *"View their use as dangerous, and their systemic use as cheating"*	Violation of Sporting Culture and Values

Table 5. Attitudes towards NSAID use and impact on performance.

	Strongly Disagree % (n)	Disagree % (n)	Neutral % (n)	Agree % (n)	Strongly Agree % (n)
'The benefit of using NSIADs for my performance outweighs any negative effects'	39% (65)	20% (33)	23% (38)	14% (23)	4% (6)
'I believe that I would be at a disadvantage to other competitors If I didn't use NSAIDs'	20% (33)	36% (59)	32% (52)	10% (17)	2% (4)
'I believe I could perform just as well without using NSAIDs as I could with using them'	2% (3)	16% (26)	29% (48)	32% (52)	22% (36)
'I believe that NSAIDs improve competitive performance'	12% (19)	20% (33)	39% (65)	25% (41)	4% (7)

participants across performance Tiers 1 to 4 remained neutral on the statement that the benefits of using NSAIDs for performance outweigh any negative effects, suggesting uncertainty regarding the overall impact of NSAIDs on performance. This may reflect mixed perceptions of their effectiveness or concerns about potential side effects. Lastly, participants were asked if they would consider using scientifically proven alternative methods to manage discomfort and pain during training and racing, regardless of their current or past NSAID use, provided these methods had minimal side effects. In response, 82% ($n = 136$) of participants stated they would be open to alternative methods, 5% ($n = 8$) reported they would not, and 13% ($n = 21$) were uncertain.

Consideration of NSAID use amongst female athletes

Whilst sex-specific differences in NSAID use was not a primary aim of this survey, our results revealed themes that are noteworthy. Among male participants, 52% ($n = 53$) reported using NSAIDs, with 56% ($n = 36$) of females reporting NSAID use. Participants were invited to share any additional information regarding their own NSAID use that might be relevant for future research. A large proportion of female participants reported using NSAIDs exclusively for menstrual pain:

> My NSAID use is purely related to severe period pain. I will only take NSAIDs if I have severe period pain which would otherwise impair my performance

Another female-specific reason for NSAID use reported by participants was to alleviate discomfort related to menopause:

> Through peri-menopause NSAIDs have helped me with joint and hip discomfort, not injury related but it does help my performance.

These findings suggest that NSAID use among female participants may be influenced not only by exercise-related factors but also by menstrual and menopause-related discomfort, highlighting the need for further research into sex-specific reasons for NSAID use and targeted interventions for women.

Discussion

The primary aim of this study was to investigate the prevalence of NSAID use among ultra-endurance runners across five performance calibres from recreational to World-class, while also exploring perceptions of effectiveness, reasons for use, and openness to

potentially safer alternatives through a combination of closed- and open-ended questions. Additionally, the study aimed to gain insight into the underlying beliefs and influences shaping NSAID use within the ultra-endurance running community.

To our knowledge, this is the first study to comprehensively examine NSAID use in ultra-endurance runners across defined performance levels, offering new insights into usage patterns, motivations, and beliefs that have been largely overlooked in previous research (Gorski et al., 2011; Joslin et al., 2013; Pannone & Abbott, 2024). The high prevalence of NSAID use reported here (53%) aligns with previous studies reporting rates between 48–61% in endurance runners and ultramarathon participants (Hoffman & Fogard, 2011; Martínez et al., 2017). Ibuprofen was the most frequently consumed NSAID (84%), followed by naproxen (11%), possibly reflecting their over-the-counter availability in countries such as the UK and USA, which accounted for most participants in this survey. A novel aspect of our findings is that while all participants in Tier 5 (World-class) report both planned and unplanned NSAID use, consuming them at specific time points and as needed for acute injuries, NSAID consumption in the lower tiers was predominantly unplanned. Whilst the sample of Tier 5 athletes was small due to the very small number of athletes in this category worldwide, the results may suggest that higher tier competitive athletes incorporate NSAIDs into their competition strategies in a more structured manner, akin to nutrition planning, whereas lower-calibre athletes tend to use NSAIDs more reactively in response to emerging discomfort. Within the constraints of small subgroup sizes and our descriptive design, a greater proportion of Tier 5 respondents endorsed statements that the benefits of NSAID use outweigh potential adverse effects and that NSAIDs enhance competitive performance relative to lower tiers. However, these comparisons are descriptive only and should be interpreted with caution. This finding may reflect a "win at all costs" mentality and the performance-driven beliefs often observed in elite sport (Watson & White, 2007). NSAID use was similar between male and female participants (52% and 56%, respectively), with many females reporting menstrual and menopause-related pain as primary reasons for use in open-ended survey responses. These novel insights highlight the importance of considering sex-specific factors when evaluating NSAID consumption in ultra-endurance sports and opens new avenues for research in female ultra-endurance athletes.

It could be speculated that a lack of knowledge of possible side effects of NSAIDs during exercise could account for the high frequency of use by athletes. However, our data suggest this not to be the case since 77% of participants acknowledged associated risks, which represents a substantial increase in awareness compared with other reports (Gorski et al., 2011; Thorpe et al., 2022; Warner et al., 2002). The high prevalence of NSAID use in the face of knowing the associated risks suggests that perceived benefits, particularly in reducing muscle pain or damage (37%) and inflammation (32%), may outweigh concerns for many ultra-endurance runners. These findings are supported by previous research, in which 62% of professional triathletes who took NSAIDs immediately before or during a race, expected the drug to prevent pain during the race (Gorski et al., 2011). Holgado and colleagues' suggestion that NSAID use may be driven by the perceived ergogenic benefits, despite an awareness of the risks involved, also supports our perspective (Holgado et al., 2018). The most frequently reported reason for NSAID use in the present study was to mask an existing injury (78%), followed by preventing performance deterioration (56%). The tendency of athletes with minor injuries to continue training and

competing rather than allowing for full recovery has been identified as a key factor contributing to the high prevalence of NSAID use in other reports and may lend further support to our data (Corrigan & Kazlauskas, 2003; Warden, 2009).

A possible explanation for more than half of the athletes in our survey reporting NSAID use could be the absence of well-documented alternatives to manage nociceptive discomfort (such as muscle soreness), or the potential concerns associated with alternative options. As an example, cannabidiol (CBD) is permitted for use by WADA and has demonstrated anti-inflammatory and analgesic properties, suggesting its potential as an alternative to NSAIDs (Machado Bergamaschi et al., 2011; Mechoulam & HANUŠ, 2002). Within elite sport, CBD use has increased since its removal from the World Anti-Doping Agency (WADA) prohibited list (Kasper et al., 2020) but concerns remain given that CBD is the only cannabinoid permitted for use and all other cannabinoids (of which there are ≥ 140) are prohibited. Most commercially available CBD products are broad spectrum and therefore often contain other cannabinoids than CBD with some studies suggesting that commercially available products often contain significantly higher amounts of THC than stated on the label, often exceeding the legal threshold and including other prohibited cannabinoids (Gurley et al., 2020). Therefore, the present study highlights an innovation gap in the management of discomfort and pain in sport, underscoring the need for validated alternative methods with no adverse effects, an area of high interest, as 82% of participants in our study expressed a willingness to try such approaches.

A further theme which arose from our data as a factor influencing NSAID use is the reliance on fellow athletes for information, with 23% of participants reporting this as their primary source of information, consistent with previous research (Overbye, 2021). This may reflect broader cultural norms within sport, where performance, self-management, and peer advice shape attitudes towards analgesic and NSAID use (Read et al., 2023). Risk-sharing cultures often reinforce such behaviours, where self-administration and knowledge exchange among peers foster a sense of autonomy and expertise (Malcolm, 2009). In this context, athletes often act as "mini experts", relying on personal experience and anecdotal advice to make independent decisions about NSAID use (Roderick, 2006). The self-administration of these substances poses risks and may be influenced by the subcultural norms and traditions within the specific sporting environment (Overbye, 2021).

Building on this, understanding and addressing the cultural, behavioural and psychological factors that influence athlete's decision-making is essential if safer alternatives to pain management are to be implemented. Although NSAID use does not constitute a violation of anti-doping regulations in many competitions (with exceptions such as UTMB regulations), athletes frequently report using these substances for performance reasons, as demonstrated in the present study. Melzer et al. (2022) have shown that athlete's attitudes towards ergogenic substances are often influenced by their desire to minimize pain and maintain performance, particularly in high pressure or competitive environments. Athletes experiencing elevated levels of competitive anxiety or adhering to a "win at all costs" mentality may be more inclined to use NSAIDs, viewing them as a means to maintain or enhance performance despite the known associated risks (Melzer et al., 2022). The tendency for athletes to use NSAIDs when the perceived benefits are high and the risk of detection is low (Melzer et al., 2022) is reflected in our findings, where over 60% of participants across all performance levels agreed or remained neutral about the benefits of NSAIDs outweighing

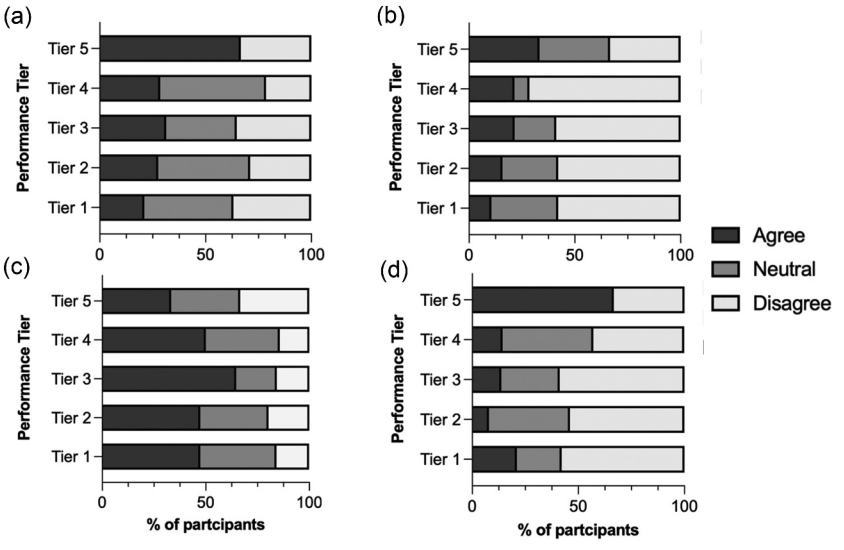

Figure 5. Percentage of participants within performance tiers responding to the above statements: (a) "the benefit of using NSAIDs for my performance outweighs any negative effects", (b) "I believe I would be at a disadvantage to other competitors if I didn't use NSAIDs", (c) "I believe I could perform just as well without NSAIDs as I could with using them", and (d) "I believe that NSAIDs improve competitive performance.".

any negative effects (Figure 5(a)). Our observations may be explained by the Low-Cost Hypothesis and Rational Choice Theory (Clarke & Cornish, 2017; Diekmann & Preisendörfer, 2003). According to the Low-Cost Hypothesis, individuals are more likely to engage in a given behaviour when the perceived cost or risk is minimal. The Rational Choice Theory further posits that an athlete's decision-making involves weighing potential benefits against associated costs. In this context, the perceived benefits of pain relief and performance enhancement likely outweigh the perceived risks. Consequently, interventions aimed at reducing NSAID use should extend beyond knowledge-based approaches and incorporate targeted behaviour change strategies that address risk perception, decision-making processes, and the cultural acceptance of NSAID use in sports.

Limitations

This study provides novel and important insights into NSAID use among ultra-endurance runners, however several limitations should be acknowledged. First, the cross-sectional survey design limits causal inference. While associations between NSAID use and factors such as performance tier, sex, and perceived benefits were observed, we cannot determine directionality or causality from this data.

Second, the survey relied on self-reported data, which may be subject to recall bias or social desirability bias. For instance, underreporting or overreporting of NSAID use, particularly in relation to competition rules or health concerns, cannot be excluded.

Whilst the anonymous nature of the survey may reduce this bias, it must be acknowledged.

Third, the distribution of participants across performance tiers was uneven, with fewer in Tier 5 (World-class) and 4 (International/Elite). Whilst it could be argued that this limits generalizability to all elite and world class athletes it should be acknowledged that such athletes represent a considerably smaller population to sample. For example, Tier 5 athletes are World medallists, World record holders and athletes achieving within 2% of world-record performance and/or world-leading performance and those in Top 3–20 in world rankings. As we report data for 3 athletes in this category, it represents approximately 17% of the athletes who meet these criteria. Likewise, while the sample was international, there was higher representation from English-speaking countries, which may reflect regional attitudes, regulations, and access to NSAIDs that are not globally representative.

Fourth, although we explored reasons for NSAID use, the survey did not capture data on specific dosages, chronicity of use, or co-ingestion with other substances (e.g., caffeine, supplements), which may influence outcomes and health risks. Additionally, menstrual and menopause-related NSAID use emerged as a significant theme, but the survey was not designed to comprehensively explore sex-specific motivations or hormonal influences on pain management. Future studies should also consider incorporating pharmacokinetic assessments and wearable monitoring technologies to better understand the physiological impact of NSAID use in ultra-endurance settings.

Fifth, while thematic analysis enriched the findings, qualitative responses were brief and context-limited, and further qualitative studies involving semi-structured interviews and focus groups may better capture the nuanced beliefs, behaviours, and cultural drivers surrounding NSAID use in ultra-endurance sport. Due to the sensitive nature of the survey and guidance from the authors local ethics committee, respondents were not obliged to answer all questions. Taken together, interpretations of these cultural and contextual factors in the present study should be viewed as speculative and theoretically informed, drawing on existing literature rather than derived from in-depth ethnographic or cultural analysis.

Finally, as the recruitment materials referenced NSAID use in the study title, there is a possibility of self-selection bias, whereby individuals with experience or strong views on NSAID use may have been more likely to participate. This may have influenced the prevalence estimates reported, although the inclusion criteria explicitly invited participants irrespective of prior NSAID use.

Conclusion

Taken together, this study highlights the high prevalence of NSAID use among ultra-endurance runners across performance levels, driven by pain management, injury masking, and perceived performance benefits, despite widespread awareness of associated risks. Patterns of use varied by calibre, with elite athletes describing more strategic use and lower-tier athletes using NSAIDs reactively. The influence of peer advice, sex-specific factors, and cultural norms underscores the complexity of decision-making around NSAID use. Critically, our findings reveal an innovation gap in safe, evidence-based alternatives with 82% of participants expressing openness to such options. Addressing this gap will

require more than education alone and should incorporate targeted behaviour change strategies that consider risk perception, cultural influences, and athlete motivations are essential to support healthier and more sustainable approaches to pain management in sport.

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