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Published in:
Journal of Science and Medicine in Sport

DOI (link to publication from Publisher):
10.1016/j.jsams.2022.08.018

Publication date:
2022

Document Version
Publisher's PDF, also known as Version of record

Journal of Science and Medicine in Sport 25 (2022) 810–819

Contents lists available at ScienceDirect

Journal of Science and Medicine in Sport

journal homepage: www.elsevier.com/locate/jsams

Review

Prevalence, frequency, adverse events, and reasons for analgesic use in youth athletes: A systematic review and meta-analysis of 44,381 athletes

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ARTICLE INFO

Article history:
Received 2 May 2022
Received in revised form 29 August 2022
Accepted 31 August 2022
Available online 5 September 2022

Keywords:
Athletes
Sport
Analgesics
Pain

ABSTRACT

Objectives: To identify the prevalence, frequency, adverse effects, and reasons for analgesic use in youth athletes.
Design: Systematic review and meta-analysis.
Methods: Systematic searches in Embase, Medline, and SPORT-Discus from inception to September 2021, screening of reference lists, and citation tracking were performed to identify observational studies including athletes aged 15–24 years and reporting data on prevalence and/or frequency of analgesic use. Study quality was assessed using the Newcastle-Ottawa Scale. Random-effect proportion meta-analyses, stratified by type of analgesic medication and prevalence measure, estimated the prevalence of analgesic use. Data on usage frequency, adverse events, and reasons for analgesic use was synthesized narratively.
Results: Forty-nine studies were included (44,381 athletes), of which 19 were good/high quality. Seven categories of analgesics were identified across 10 prevalence time-points. Meta-analyses suggested common use of NSAIDs (point prevalence 48 % [95 % CI 23 % to 73 %], in-season prevalence 92 % [95 % CI 88 % to 95 %]). The lowest prevalence was found for use of local anesthetic injections within the previous 12 months (2 % [95 % CI 1 % to 3 %]). Seven to 50 % of athletes reported weekly analgesics use. The proportion of adverse events ranged from 3.3 % to 19.2 %. Reasons for using analgesics included treatment of sports-related pain or injury, to treat illness, and to enhance performance.
Conclusions: Analgesics are commonly used in youth athletes, but estimates vary depending on type of analgesic and prevalence measure. As the majority of studies were of poor methodological quality, future high-quality research should include prospective data collection of analgesic use to understand consumption trajectories.

Practical implications

- Based on the evidence of common use of NSAIDs in youth athletes, clinicians may carefully assess their recommendation of NSAIDs use and adhere to consensus-based strategies for pain management in athletes
- Due to the common use of over-the-counter analgesics, poor awareness of benefits and harms, and perceived pressure to use analgesics, youth athletes may be educated about safe analgesic use and proper pain management strategies.
- Sports medicine clinicians must trade off the benefits, risks, burden and costs associated with analgesic management strategies, and in doing so, consider the athletes preferences and the tension between masking pain and understanding the protective role of pain in the presence of injury

1. Introduction

Analgesics, such as non-steroidal anti-inflammatory drugs (NSAIDs) and paracetamol, are among the most frequently used drugs in sports medicine,[1,2] and their use in athletes has received increasing attention in recent years. International guidelines have been developed for analgesic pain management in athletes at the elite, and mainly senior, level,[3] and the importance of athlete health protection through proper

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https://doi.org/10.1016/j.jsams.2022.08.018

use of analgesics has become increasingly recognized. Unfortunately, this is not yet the case for youth athletes, where the use of analgesics has received less attention, particularly at the non-elite level.

Individual studies indicate that youth athletes regularly use analgesics.[4–8] While analgesics may be used safely and effectively as part of a multimodal treatment plan to manage sports-related pain and injury,[3] high or long-term use is associated with an increased risk of adverse events. Use of NSAIDs in athletes has been associated with a five times higher incidence of adverse events including gastrointestinal bleeding, hematuria, and cardiovascular events.[9] Long-term use of paracetamol may cause renal functioning disorder and hepatoxicity,[10,11] and even short-term use of opioids is associated with risk of addiction and cognitive disturbances.[12] Finally, previous reports indicate that youth athletes use analgesics to prevent pain and mask injury,[7,8,13] thus raising concerns of a potential increase in injury risk and progression of existing injuries.[14,15]

Despite indications of widespread use of analgesics in youth athletes and the potential health-related concerns associated with the use, no systematic review has yet been conducted to summarize the evidence on the use of analgesics in youth athletes. Accordingly, the primary aim of this systematic review and meta-analysis was to identify the prevalence of analgesics use in youth athletes. The secondary aims were to identify usage frequency, adverse events, and reasons for analgesic use in youth athletes.

2. Methods

This systematic review was guided by the recommendations for performing systematic reviews in the Cochrane Handbook[16] and reported in accordance with The Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA 2020) statement[17] and the PERSiST (implementing Prisma in Exercise, Rehabilitation, Sport medicine and SporTs science) guidance.[18] The study protocol was pre-registered and made publicly available at Open Science Framework prior to initiating the literature searches (https://osf.io/4ktsr/).

2.1. Eligibility criteria

Cross-sectional studies, retrospective or prospective cohort studies, case-control studies, and case series published in full-text in peer-reviewed journals in English, Spanish, Italian, Dutch, or any Scandinavian language were eligible for inclusion. The population of interest was athletes aged 15–24 years old participating in any sports discipline at any performance level. As the definition of *youth* varies between countries and sports disciplines, we defined *youth* according to the United Nations as persons between 15 and 24 years of age.[19] Studies were excluded if they included mixed populations (i.e., athletes and non-athletes) and did not report separate data for athletes only, assessed use of analgesics in athletic population with underlying conditions or diseases not related to sport (e.g., cancer pain, dysmenorrhea), if studies only reported on non-medical use of analgesics, and if full text was not available.

2.2. Outcomes

The primary outcome was prevalence of analgesic use. Analgesics were defined as any pharmacological agent producing diminished sensation to pain without loss of consciousness,[20] and were categorized as paracetamol, non-steroid anti-inflammatory drugs (NSAIDs), acetylsalicylic acid, opioids, local anesthetic injections, mixed analgesics (if reported as more than one type of analgesic e.g., paracetamol and/or NSAIDs without the possibility to sub-classify), and unspecified analgesics (if reported simply as 'analgesics' without further specifying the type) without restrictions on route of administration. Both point prevalence (i.e., proportion of athletes reporting analgesic use at a specific point in time) and period prevalence measures (i.e., the proportion of athletes reporting analgesic use at any point during a given time period of interest)[21] were included with no restrictions on methods of reporting (e.g., athlete self-report, pharmacy record, coach reports and doping control forms) nor indications or reasons for analgesic use (i.e., both sports-related and non-sports-related reasons). Secondary outcomes were frequency of analgesic use, adverse events, and reasons for use. All approaches of estimating and reporting frequency of analgesic use, adverse events, and reasons for use were included.

2.3. Search strategy

Systematic literature searches were performed in Embase (Ovid), Medline (PubMed), and SPORT-Discus from database inception to September 17th 2021 with no language restrictions. The search strategy was developed by two authors (JRP and AB) in collaboration with a research librarian and included Medical Subject Headings (MeSH) terms and individual text words in title and abstract. The search strategy was suitably adapted to the specifications of the individual databases. The complete search strategy is presented in Supplementary Table 1. Hand-searches were performed by screening the cited references in a previous systematic review investigating analgesic use in elite athletes.[22] Finally, reference lists of included studies were screened to identify additional studies, and forward citation tracking of the included studies was performed in Web of Science.

2.4. Selection of studies

Screening was independently carried out by two authors (JRP and AA) following duplicate removal in EndNote X9 (Clarivate Analytics, Philadelphia, USA). Articles were initially screened by title and abstract for eligibility using Covidence systematic review software (Veritas Health Innovation, Melbourne, Australia). Full-text articles were then retrieved and screened for inclusion. Disagreements were solved by consensus.

2.5. Data extraction

Data were independently extracted by two authors (JRP and AA) using a standardized Excel data extraction sheet (Supplementary Table 2). Inconsistencies were solved by consensus. If unable to reach consensus, a third author (AB) was consulted. In case of several types of analgesics or multiple prevalence measures were reported in the same study, all were extracted. If relevant data was not reported in the text, the data was extracted from figures and graphs. If the data could not be extracted from the published studies, an e-mail including a list with the data of interest were sent to the corresponding author of the study. The corresponding author was contacted twice within a two-week period. If no response was obtained two weeks after the second request, the first or last listed author was contacted. Data was considered missing if no replies had been received from the authors two weeks after the second email.

2.6. Quality assessment

Two reviewers (JRP and AA) independently assessed study quality using the Newcastle-Ottawa scale (NOS) for cohort studies and the modified NOS for cross-sectional studies as described in the Cochrane Handbook for Systematic Reviews of Interventions.[16,23] These tools comprise three overall domains relating to selection of study groups, comparability of the groups, and ascertainment of the exposure/outcome of interest. For cohort studies, eight items were scored with one or two stars, for a maximum total of nine stars, leading to an overall judgement of study quality as high, moderate or low. For cross-sectional studies, seven items were scored with one or two stars, for a maximum total of 10 stars, leading to an overall judgement of study quality as very good, good, satisfactory, or unsatisfactory. Disagreements between the reviewers were solved by consensus. If unable to reach consensus, a third author (AB) was consulted. Overall quality of evidence was

evaluated for point prevalence outcomes using the Grading of Recommendations Assessment, Development, and Evaluation (GRADE) tool for systematic reviews of prognostic studies.[24,25]

2.7. Data synthesis

Pooled prevalences with 95 % confidence intervals (95 % CI) were calculated using random-effects meta-analyses with continuity corrections using the 'metaprop' command in Stata version 17 (StataCorp 2021, College Station, TX, USA). The metaprop command computes 95 % CIs by using the score statistic and the exact binomial methods and incorporates Freeman-Tukey double arcsine transformation of proportions.[26] Pooled prevalences were quantified for NSAIDs, unspecified analgesics, mixed analgesics, paracetamol, acetylsalicylic acid, opioids, and local anesthetic injections. The results were reported stratified by type prevalence measure (point prevalence, 3-days period prevalence, 7-days period prevalence, 1-month period prevalence, 3-months period prevalence, 6-months period prevalence, 12-months period prevalence, in-season, previous season, and lifetime use). In case a study reported more than one subtype of the same analgesic (e.g., prescription and non-prescription NSAIDs) at the same time point, the analgesic with the highest prevalence was included in the main analysis to avoid underestimation of pooled proportion estimates. Univariate meta-regression analyses were performed to investigate the effect of participant and study characteristics on the proportion estimates. The covariates tested in meta-regression analyses included age, percentage of female, and year of publication. In accordance with the Cochrane Handbook, meta-regression analyses were only performed when ≥10 studies were available.[16] The impact of level of sports performance level (elite (i.e., elite or professional as defined in individual studies) vs. non-elite (i.e., all other performance levels)) was investigated by subgroup analysis. Statistical heterogeneity was estimated as I-squared (I^2) and tau square (τ^2) and presented in analyses containing ≥4 studies, as the I^2 estimate is biased in meta-analyses of very few studies.[27–29] Small-study bias was assessed by visual inspection of funnel plots. Due to the low number of studies available per outcome, small study bias was only assessed for point prevalence of use of NSAIDs and unspecified analgesics, in accordance with the Cochrane Handbook.[16] Due to heterogeneity in terms of measures used, data on frequency of analgesic use, adverse events, and reasons for use was summarized narratively.

2.7.1. Sensitivity analyses

Numerous sensitivity analyses were performed to examine whether overall findings were robust to the potentially influential decisions made. Firstly, in studies reporting more than one subtype of the same analgesic at the same time point (e.g., prescription and non-prescription NSAIDs), the primary meta-analyses using the analgesic with the highest prevalence were re-run using the alternate type of analgesic (i.e., the analgesic with the lower prevalence). Secondly, due to inconsistency and unclear reporting of the definition of point prevalence, two sensitivity analyses were performed by excluding, firstly, the studies explicitly stating that they assessed current use, and secondly, the studies with unclear definitions of point prevalence. Finally, due to unclear reporting of route of administration in most studies, a sensitivity analysis was performed by categorizing local anesthetic injections by active pharmacological agent (i.e., NSAID, paracetamol, acetylsalicylic acid, mixed analgesics, opioids, or unspecified analgesics). These sensitivity analyses were not pre-registered.

3. Results

3.1. Study selection process

Following the initial literature search and duplicate removal, 10,595 records were screened by title/abstract and 287 full-text articles were considered for inclusion. After review, 39 studies were included. With the addition of three studies identified from citation tracking, and seven studies identified from reference list screening, the final number of included studies was 49 (Fig. 1). All included studies are referenced in supplementary Tables 3 and 4.

3.2. Study characteristics

Of the 49 included studies, 43 were cross-sectional studies and six were cohort studies, reporting data on a total of 44,381 athletes (range 21–11,577) (37 % were female). Data on analgesic use from all six cohort studies was cross-sectional baseline data. Studies were conducted across 19 countries, with three studies including athletes from multiple countries during international tournaments. Twenty-three studies involved multiple sports. Nine of 26 single-sport studies involved football (soccer). Other sports found in single-sport studies included swimming, softball, wrestling, handball, cycling, basketball, ice hockey, and ballet. Four studies did not specify the type of sport studied. In terms of performance level, 15 studies included elite athletes, 14 studies included collegiate athletes, four studies included competitive athletes, five studies included athletes from multiple levels, three studies included professional athletes, and two studies included recreational athletes. Subelite and amateur athletes were included in one study each, and four studies did not specify level of performance. Study characteristics are reported in Supplementary Table 3. Athlete-reported questionnaires were the most common data collection tool (40 studies), with the remaining studies obtaining data from athlete interviews, doping control forms, medical records, and urine sample testing. NSAIDs were the most commonly studied group of analgesic, followed by unspecified analgesics, mixed analgesics, local anesthetic injections, paracetamol, opioids, and acetylsalicylic acid (Supplementary Table 4). A total of 10 prevalence time points were identified, including point prevalence, 3 days-, 1 week-, 1 month, 3 months, 6 months, 12 months, in-season-, previous season-, and lifetime period prevalence. The number of available outcomes for each analgesic group stratified by type of prevalence measure is presented in Supplementary Table 5.

3.3. Study quality and overall quality of the evidence

The methodological quality of the included studies is summarized in Table 1 (cohort studies) and Table 2 (cross-sectional studies). For cohort studies, three studies were judged as high quality, two studies moderate quality, and one study low quality. For cross-sectional studies, two were judged as very good quality, 14 as good quality, 19 as satisfactory quality, and eight as unsatisfactory. The selection domain was generally scored low as studies commonly did not report information on the characteristics of non-respondents (86 %), did not provide a sample size calculation (79 %), and applied convenience sampling strategies (44 %). Conversely, the outcome domain was generally well-described as all included studies assessed the outcome either by objective measures (i.e., urine sampling) or self-report and 88 % clearly described and applied appropriate statistical analyses. Risk of small study-bias was indicated by the visual asymmetry in the funnel plot for NSAIDs (Supplementary Fig. 1). Overall quality of evidence ranged from very low to low (Supplementary Table 6). The main reasons for downgrading were inconsistency and indirectness.

3.4. Prevalence of analgesic use

3.4.1. NSAIDs

The pooled point prevalence of NSAIDs use in youth athletes was 48 % (95 % CI 23 % to 73 %: 13 studies; $tau^2 = 0.11$; $I^2 = 99.7$; very low quality of evidence). The pooled period prevalence estimates of NSAIDs use ranged from 7 % within the previous seven days (95 % CI 6 % to 8 %: two studies) to 95 % lifetime prevalence (95 % CI 92 % to 97 %: two studies) (Fig. 2).

The meta-regression analyses on point prevalence of NSAIDs use showed no impact of age (slope 0.02 [95 % CI −0.05 to 0.09];

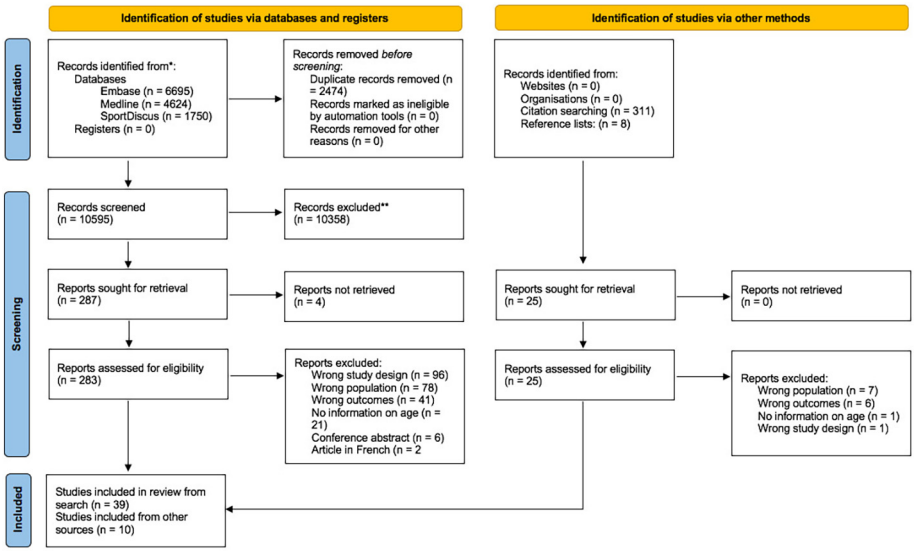

Fig. 1. Flow chart.

tau^2 = 0.13; 11 studies), % female (slope 0.00 [95 % CI −0.01 to 0.01]; tau^2 = 0.13; 12 studies), or year of publication (slope 0.00 [95 % CI −0.02 to 0.02]; tau^2 = 0.12; 13 studies). The subgroup analysis showed lower point prevalence of NSAIDs use in non-elite athletes (31 % [95 % CI 6 % to 64 %]: 7 studies) than in elite athletes (64 % [95 % CI 20 % to 97 %]: 5 studies) but did not reduce heterogeneity in the pooled estimates (I^2 = 99.7 % and 99.5 %, respectively). The sensitivity analysis on analgesic subtypes did not change the results of the main analyses (Supplementary Fig. 2). Excluding the four studies assessing current NSAIDs use on the point prevalence meta-analysis resulted in an increased, but not statistically significantly higher, point prevalence (66 % [95 % CI 0.36 to 0.89]; nine studies) and did not reduce heterogeneity (I^2 = 99.3 %) (Supplementary Fig. 3). However, excluding the nine studies with unclear definitions of point prevalence resulted in a statistically significantly lower point prevalence (12 % [95 % CI 0.01 to 0.33]; four studies) but did not reduce heterogeneity (I^2 = 99.3 %).

3.4.2. Unspecified analgesics

The pooled point prevalence of use of unspecified analgesics was 50 % (95 % CI 0.36 to 0.64: nine studies; I^2 = 97.6; low quality of evidence). The pooled period prevalence estimates ranged from 7 % within the previous three days (95 % CI 0.06 to 0.8: two studies) to 73 % in the previous season (95 % CI 0.66 to 0.80: one study) (Fig. 2). The subgroup analysis showed higher point prevalence of use of unspecified analgesics in non-elite athletes (61 % [57 % to 65 %] five studies) than in elite athletes (40 % [95 % CI 15 % to 67 %]: three studies), and also reduced heterogeneity in the pooled estimate for non-elite athletes (I^2 = 56.3, I^2 not calculated for elite athlete subgroup due to too few studies) Conversely, the 12-months period prevalence was higher in elite athletes (71 % [95 % CI 61 % to 80 %] three studies) than in non-elite athletes (36 % [95 % CI 33 % to 39 %]: two studies) (I^2 valued not calculated due to too few studies in each subgroup). The sensitivity analyses did not change the results of the main analyses nor reduce heterogeneity (Supplementary Figs. 4 and 5). As only one study assessed current use of unspecified analgesics, the impact of pooling different point prevalence measures was only investigated by excluding this one study.

3.4.3. Mixed analgesics

The pooled point prevalence of use of mixed analgesics was 54 % (95 % CI 0.29 to 0.79: five studies; low quality of evidence). The pooled period prevalence estimates ranged from 11 % within the previous seven days (95 % CI 0.08 to 0.14: two studies) to 29 % within the previous 12 months (95 % CI 0.28 to 0.30: two studies) (Fig. 2). Descriptions of the included medications is outlined in Supplementary Table 3.

3.4.4. Local anesthetic injections

The pooled 3-days period prevalence estimate for use of local anesthetic injections was 2 % (95 % CI 0.01 to 0.03: two studies). Additionally, one study reported a 12-months period prevalence of 2 % (95 % CI 0.02 to 0.02) (Fig. 2). The sensitivity analysis categorizing local anesthetic injections according to the active pharmacological agent resulted in a decreased, but not statistically significantly lower, point prevalence of unspecified analgesic use (43 % [95 % CI 0.20 to 0.67]; 11 studies). Similarly, a non-significant decrease in point prevalence of use of mixed analgesics was observed (0.43 [95 % CI 0.10 to 0.80]; six studies).

3.4.5. Paracetamol, acetylsalicylic acid, and opioids

The pooled point prevalence of paracetamol use was 21 % (95 % CI 0.17 to 0.25: two studies; very low quality of evidence). One study each reported data on paracetamol use within the previous month (34 % [95 % CI 0.30 to 0.38]), three months (3 % [95 % CI 0.00 to 0.06]) and 12 months (19 % [95 % CI 0.18 to 0.20]). In regard to acetylsalicylic acid use, one study

Table 1
Study quality for cohort studies.

Study (year)	Selection (1)	Selection (2)	Selection (3)	Selection (4)	Comparability (1)	Outcome (1)	Outcome (2)	Outcome (3)	Overall judgement
Anderson (1991)	*	*			*		*		Low
Gouttebarge (2018)	*	*	*	*	*	*	*	*	High
Mohamad Shariff (2013)	*	*	*	*	*	*	*	*	High
Schmidt (2014)	*	*		*	*		*		Moderate
Spiera (2021)	*	*		*	*	*	*		Moderate
Tso (2020)	*	*	*	*	*		*	*	High

One asterisk indicates that the domain was scored with one star.

Table 2
Study quality for cross-sectional studies.

Study (year)	Selection (1)	Selection (2)	Selection (3)	Selection (4)	Comparability (1)	Outcome (1)	Outcome (2)	Overall judgement
Aavikko (2013)	*	*	*	**	**	*	*	Very good
Alaranta (2006)	*	*		**	**	*	*	Good
Alexander (2021)	*		*	*	**	*	*	Good
Babwah (2014)	*			**	**	*	*	Good
Braun (2017)				**	**	*	*	Satisfactory
Brewer (2014)	*				**	*	*	Satisfactory
Buckman (2013)	*				**	*	*	Satisfactory
Christopher (2020)				**	**	*	*	Satisfactory
De Souza (2012)				**	**	*	*	Satisfactory
Garcin (2005)				**	**	**	*	Good
Goulet (2010)	*				**	*	*	Satisfactory
Hibberd (2013)				**	**	*	*	Satisfactory
Hill (2004)				**	**	*	*	Satisfactory
Holmes (2013)				**	**	*	*	Satisfactory
Kahlenberg (2016)	*	*			**	*	*	Satisfactory
Kordi (2012)	*	*	*		**	*	*	Good
Lazic (2011)	*			**	**	*	*	Good
Loosli (1992)	*			**	**	*	*	Good
Loraschi (2014)				**	**	*	*	Satisfactory
Malek (2014)	*		*		**	*	*	Satisfactory
Mkumbuzi (2015)				**	**	*	*	Satisfactory
O'Connor (2019)					**	*	*	Unsatisfactory
Omeragic (2021)		*		**	**	*	*	Good
Ozkan (2020)	*				**	*	*	Satisfactory
Peric (2016)					**	*	*	Unsatisfactory
Perry (2020)				**	**	*	*	Satisfactory
Qasrawi (2021)	*	*	*		**	*	*	Good
Rossi (2016)	*			**	**	*	*	Good
Rossi (2021)	*			**	**	*	*	Good
Rovere (1985)				**	**	*		Satisfactory
Sari (2021)	*	*	*	**	*	*	*	Very good
Schneider (2019)	*			**	**	*	*	Good
Sekulic (2008)					**	*	*	Unsatisfactory
Selanne (2014)					**	*	*	Unsatisfactory
Spence (1996)	*	*			**	*	*	Satisfactory
Stache (2014)					**	*		Unsatisfactory
Tricker (1996)	*				**	*	*	Satisfactory
Tricker (2000)	*				**	*		Unsatisfactory
Tscholl (2009)	*	*		**	**	*	*	Good
Warner (2002)	*			**	**	*	*	Good
Wolf (2011)	*				**	*	*	Satisfactory
Yargic (2021)					**	*	*	Unsatisfactory
Zenic (2010)					**	*	*	Unsatisfactory

One asterisk indicates that the domain was scored with one star. Two asterisks indicate that the domain was scored with two stars.

each reported data on point prevalence (25 % [95 % CI 0.19 to 0.31]; low quality of evidence), 1-month period prevalence (3 % [95 % CI 0.02 to 0.04]), 3-months period prevalence (12 % [95 % CI 0.02 to 0.22]), and 12-months period prevalence (16 % [95 % CI 0.15 to 0.17]). The pooled 12-months period prevalence of opioid use was 13 % (95 % CI 0.13 to 0.14: two studies). One study each reported data on point prevalence (3 % [95 % CI 0.01 to 0.05]: low quality of evidence) and 3-months period prevalence (3 % [95 % CI 0.00 to 0.06]) of opioid use (Fig. 2).

3.4.6. Sex specific differences in prevalence of analgesic use

Five studies reported higher prevalence of analgesic use in female athletes compared to male athletes, and two studies, reported higher prevalence in male athletes. In female athletes, the point prevalence ranged from 28 to 43 %, 1-month period prevalence from 53 to 75 %, and 12-months period prevalence from 17 to 34 %. In male athletes, these were 20–30 %, 30–60 %, and 19–39 %, respectively.

3.5. Frequency of analgesic use

Frequency of analgesic use was reported by 14 studies (Table 3). Across studies, 7 % and 50 % of athletes reporting weekly use of analgesics, and 6–35 % reported monthly use.

3.6. Adverse events

Four studies reported on adverse events associated with analgesic use. In relation to NSAIDs use, the proportion of users reporting adverse events ranged from 3.3 % to 19.2 %, and included gastro-intestinal symptoms, tiredness, light-headedness, decrease in perceived muscle power, increased sweating, increased appetite, dry mouth, exacerbation of asthma symptoms, nausea, vomiting, headache, fatigue, allergy, non-immunomodulated adverse reactions, bronchospasms, and anaphylaxis. One study reported on adverse events associated with non-NSAID analgesics (unspecified) and included non-immunomodulated adverse reactions and oral allergy syndrome reported by 6.3 % of users.

3.7. Reasons for analgesic use

Twenty studies reported on reasons for analgesics use. Athletes reported using analgesics to treat sports-related pain or injury in 16 studies, to prevent or block pain to enable participation in sport in seven studies, to manage general muscle soreness or cramps in two studies, to treat illness including fever, headaches, and colds, and to improve performance in one study each, respectively. One study presented estimates for analgesic use stratified by sports-related reasons and non-sports related reasons, with 35 % of users reporting sports-related reasons.

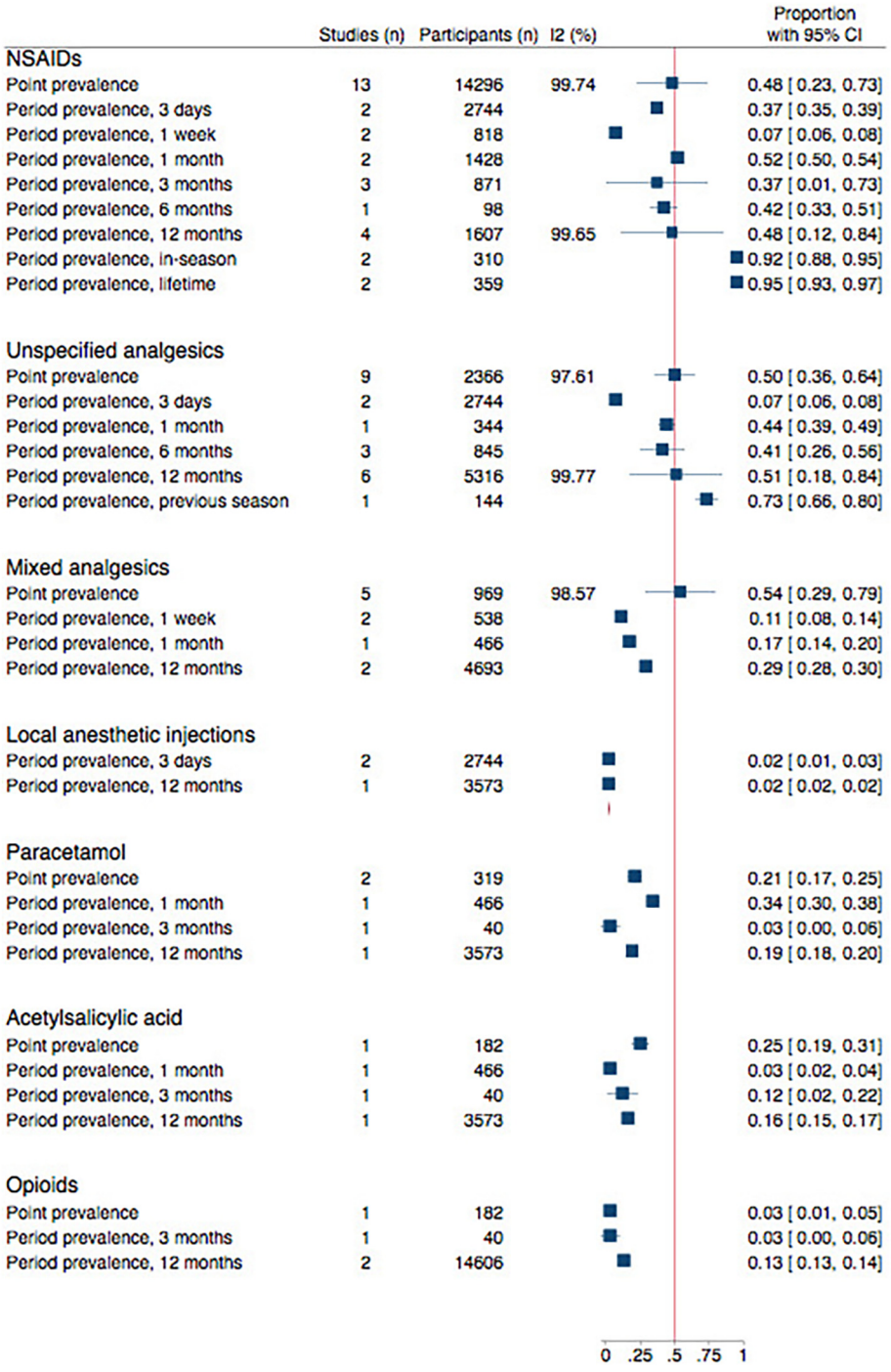

Fig. 2. Stratified prevalence meta-analysis. Rows indicate pooled estimates. Red lines represent a 50 % prevalence. The boxes indicate study weight and whiskers indicate 95 % CI.

4. Discussion

This systematic review and meta-analysis examined the prevalence, frequency, adverse effects, and reasons for analgesic use in youth athletes. NSAIDs were commonly used with the pooled proportions of athletes reporting use in the previous 3 days to 12 months ranging from 7 to 92 %. In general, other analgesics were used less commonly, with local anesthetic injections and opioids being the least commonly used groups of analgesics. Overall quality of evidence was very low to low, and the statistical heterogeneity was deemed high in the pooled estimates. Frequency of analgesic use varied widely with 7–50 % of athletes reporting weekly use and 6–35 % reporting monthly use. The proportion of athletes reporting adverse events ranged from 3.3 % to 19.2 %.

4.1. Prevalence of analgesic use

NSAIDs were the most frequently studied and reported to be the most commonly used type of analgesic, with approximately one in two youth athletes reporting NSAIDs use. These findings are in line

Table 3
Frequency outcomes.

Author (year)	Country	Sport (performance level)	Sample size	% female	Type of analgesic	Frequency (%)[a]
Brewer et al. (2014)	USA	Aerobics, jogging, resistance training, racquetball (Recreational)	263	51.7	Ibuprofen, acetaminophen, or naproxen	Once/week: 21.3 Twice/week: 9.5
Christopher et al. (2020)	USA	Mixed[b] (Collegiate, NCAA-division 1–3)	313	73.4	NSAIDs	3–7 times/week: 9.9 1–2 times/week: 20.6 1–3 times/month: 34.9
Goulet et al. (2010)	Canada	Mixed[c] (N/I)	3573	44	Aspirin Local anesthetics Tylenol Atasol Other analgesics	Aspirin Rarely: 8.5 Occasionally: 4.7 Regularly: 1.0 Local anesthetics Rarely: 0.7 Occasionally: 0.2 Regularly: 0.4 Tylenol Rarely: 9.7 Occasionally: 5.9 Regularly: 1.4 Atasol Rarely: 2.0 Occasionally: 1.0 Regularly: 0.5 Other analgesics Rarely: 1.7 Occasionally: 1.1 Regularly: 0.4
Hibberd et al. (2013)	USA	Swimming (high school elite)	102	61.7	Analgesics (unspecified)	<1 time/month: 14.7 1–3 times/month: 23.7 ≥1 times/week: 33.3
Holmes et al. (2013)	USA	Football (Collegiate, NCAA-division 1 and 3)	210	0	NSAIDs	Daily/weekly (in season): 50 Daily/weekly (out of season): 14 Usually/always (prior to match): 10.9 Usually/always (during match): 0.5 Usually/always (after match): 32.7 Usually/always (prior to practice): 5.2 Usually/always (during practice): 0.5 Usually/always (after practice): 20.4
Mkumbuzi et al. (2015)	Zimbabwe	Football (professional)	86	0	NSAIDs	Daily: 12 Weekly: 11 Twice/wk.: 0 Monthly: 6 Rarely: 43
Omeragic et al. (2021)	Bosnia and Herzegovina	Athletics, weightlifting, karate, handball, basketball, volleyball, football (competitive)	112	34.8	Analgesics (unspecified)	Daily: 19.6 Weekly: 10.7 As needed: 3.6
Peric et al. (2016)	Croatia	Ballet (elite)	21	100	Analgesics (unspecified)	Occasionally:53 Frequently: 37
Qasrawi et al. (2021)	Palestine	Mixed[d] (N/I)	227	41.4	NSAIDs	3–7 times/week: 3.5 Once/week: 7 1–2 times/month: 14.1 Few times/year: 33
Schneider et al. (2019)	Germany	Basketball (elite)	182	29.1	Mixed analgesics[e]	Frequent use: 40.1

Table 3 (*continued*)

Author (year)	Country	Sport (performance level)	Sample size	% female	Type of analgesic	Frequency (%)[a]
					Ibuprofen	15.9
					Diclofenac	21.4
					Paracetamol	6.6
					Acetylsalicylic acid	6.6
					Tramadol	0
Sekulic et al. (2008)	Serbia	Dance (N/I)	21	100	Analgesics (unspecified)	Rarely: 19.1 Often: 4.8
Tso et al. (2020)	USA	American football, endurance sports (Collegiate, NCAA division 1 and 3 and competitive high school)	286	0	NSAIDs	Daily: 11.5 Weekly: 15 Rarely: 66.7
Yargic et al. (2021)	Turkey	Wrestling (elite)	166	27.7	NSAIDs or paracetamol	1–3 days/week: 46.9 4–6 days/week: 12.6 7 days/week: 2.4
Zenic et al. (2010)	Croatia	Ballet, dance, synchronized swimming (Amateur, semi-professional, professional)	69	100	Analgesics (unspecified)	Rarely: 24.6 Occasionally: 17.4 Regularly: 10.1

[a] Expressed as a proportion of the total sample size.
[b] American football, lacrosse, rugby, basketball, football, tennis, volleyball, baseball, softball, cross country, dance, golf, swimming, track and field, triathlon.
[c] Baseball, gymnastics, swimming, basketball, hockey, skiing, athletics, soccer, speed skating.
[d] Football, basketball, volleyball, table tennis, marathon, tennis, handball, badminton, swimming, taekwondo, gymnastics, weightlifting, boxing.
[e] Defined as use of either ibuprofen, diclofenac, paracetamol, acetylsalicylic acid, or tramadol.

with the results of a previous systematic review of analgesic use in elite-level, and mainly senior, athletes.[22] The analgesic efficacy of NSAIDs has consistently been reported to be small and no better than other oral analgesics for musculoskeletal pain and acute soft tissue injuries.[30–32] This is especially of importance as high or long-term use of NSAIDs are associated with multiple severe health risks.[33] Due to these health risks, guidelines on analgesic pain management in athletes recommend paracetamol alone or in combination with NSAIDs for acute pain and highlight that in most cases there is no rationale for long-term use of NSAIDs.[3,34] Despite these recommendations, the reported rates of paracetamol use tended to be lower than estimates for NSAIDs use in studies reporting paracetamol and NSAIDs data separately.

The pooled proportions of youth athletes reporting use of opioids ranged from 3 % to 13 % across prevalence measures. Our finding of varying estimates and few studies reporting prevalence of opioid use in athletes is in line with a previous systematic review of opioid use in sport.[35] While opioids may be considered in athletes for management of severe acute pain when non-opioid medications and non-pharmacological treatment strategies are insufficient, as proposed in the International Olympic Committees consensus statement,[3,34] they are associated with serious adverse effects warranting a thorough diagnostic evaluation and considerations for regulations of substance use in sport.[34] However, as none of the included studies measuring opioid use reported the reasons for, frequency, or duration of usage, our understanding of opioid use in youth athletes remains limited. Furthermore, a recent study reported that opioid use during active athletic career predicted use and misuse in later life and retirement in former athletes,[36] further highlighting the importance of closely monitoring and cautiously prescribing opioids to youth athletes.

Similarly to our findings, a recent systematic review reported varying rates of analgesic use for musculoskeletal pain in non-athlete adolescents (≤19 years of age), with the proportion reporting analgesic use ranging from 8 to 75 % across 20 individual studies.[37] Another systematic review including 163 individual studies showed that the proportion of adolescents reporting to have self-medicated analgesics ranged from 5.4 % to 93 % across 14 different prevalence measures.[38] While previous systematic reviews synthesizing the use of analgesics in sports have been published,[22,39,40] none have assessed the use in adult athletes only, thus hindering a direct comparison between youth and adult athletes. However, our meta-regression analysis showed no impact of age, suggesting that the prevalence of analgesic use was not significantly associated with age.

4.2. Frequency of analgesic use

Weekly use of analgesics was reported by 7–50 % of youth athletes, while 6–35 % reported monthly use. These findings are of particular concern due to the increasing risk of adverse effects associated with high or long-term analgesic consumption.[11,41] Self-medication and lack of knowledge regarding adverse effects and consequences of prolonged use[5,13,42] may be important contributors to this finding. The extent of self-medication practices is supported by Sari and Pedersen et al.[4] reporting that almost 90 % of youth elite handball players obtained analgesics from home or bought it over-the-counter, while Tricker et al.[13] reported that only 14 % of college athletes obtained analgesics after consulting a physician.

4.3. Reasons for analgesic use

Reasons for using analgesics included treatment of sports-related pain and injury and associated symptoms, to treat illness, to enhance performance, and to prevent or block pain to enable participation in sport. The latter is in contrast to guidelines and recommendations for analgesic pain management in athletes stating that analgesics should not be used for pain prevention.[3,34] In this context, a main concern is that delayed reporting of pain and injury and removal from athletic activity due to analgesic use may negatively impact injury risk and the severity of existing injuries, thereby possibly leading to lifelong disability, persistent pain, and continued use of analgesics.[14,15,36] As athletes from an early age may be introduced and socialized into the sport ethic culture of playing through pain,[43,44] this finding may partly be explained by mediated cultural influences in sports communities including pain normalization, risk glorification, and external pressures, leading athletes to engage in risky behaviour by ignoring and covering signs of fatigue, pain, and injury.[8,43–47]

4.4. Implications for clinical practice

The findings from this review indicate the common use of over-the-counter analgesics, poor awareness of their benefits and harms, and perceived pressure to use analgesics.[7,13,48] Therefore, youth athletes may be educated about safe analgesic use and non-pharmacological pain management strategies. It has previously been highlighted that the existing evidence on efficacy and safety of analgesics in athletes does not provide a sufficient body of evidence to guide athletes and healthcare professionals in making analgesic treatment decisions.[22] Consequently, sports medicine clinicians must trade off the benefits, risks, and costs associated with management strategies, and in doing so, consider the athletes preferences and the tension between masking pain and understanding the protective role of pain in the presence of injury.[3,49]

4.5. Limitations

This study has limitations. Although a number of covariates were analyzed in the meta-regression analyses, we were not able to explain the heterogeneity in proportion estimates between studies. The fact that heterogeneity remained high after stratifying by type of analgesic and prevalence measure, and adjusting for relevant covariates, likely reflects differences in constructs not captured by the included covariates and may lower the confidence in the pooled estimates. However, evidence suggest that prevalence systematic reviews generally yield high measures of heterogeneity, partly due to large variations in sample sizes and diverse point estimates, but that these estimates can be biased and are not synonymous with important variability between studies.[27]

The low number of studies available per type of analgesic medication and prevalence measure prevented meta-regression analyses on other outcomes than point prevalence of NSAIDs use and subgroup analyses stratifying by level of performance was only possible a limited number of outcomes. Similarly, further subgroup or meta-regression analysis investigating the impact of type of sport, country, and risk of bias on the estimates would have provided valuable information. However, due to the limited number of studies available per stratum, this was not possible. When more than one subtype of the same analgesic was available at the same time point (e.g., point prevalence of prescription and non-prescription NSAIDs), the primary meta-analyses included the type with the highest prevalence to avoid underestimation. While the sensitivity analyses did not significantly change the pooled estimates, this approach may still have underestimated the prevalence of analgesic use as it was not possible to extract data on the proportion of athletes using only one subtype and the proportion using both. Study-specific terminology was used to guide the categorization in the subgroup analyses of performance level, which may have led to misclassification and potential residual confounding in the subgroup analyses. However, as highlighted by a recent study, defining and classifying performance levels in sport is challenged by the lack of consistent terminology in the existing literature. Reporting of population characteristics varied widely. Consequently, five studies were included despite not reporting information on age. However, as these studies were conducted in college athletes, compliance with inclusion criteria was assumed. Finally, pooled point prevalence estimates tended to be either similar to or larger than most period prevalence measures. This may partly be explained by the inconsistent and poorly described definitions of point prevalence, which may have led to misclassification. This is supported by the sensitivity analysis showing a statistically significantly lower point prevalence for NSAIDs use when excluding the studies with unclear definitions of point prevalence. Secondly, this observation may partly be explained by recall bias, as current or recent use may be more accurately recalled than longer time periods, possibly leading to an underestimation of period prevalence measures. Finally, 61 % of the studies reporting point prevalence assessed analgesic use specifically in relation to management of sports related injury or pain, whereas for studies reporting period prevalence, this was 16 %, suggesting that these studies may not measure the exact same construct.

4.6. Future research

Few high-quality studies assessing the epidemiology of analgesic use in youth athletes suggests that further high-quality research is needed before robust conclusions can be drawn. Research should focus on a wider range of analgesics and standardized survey instruments should be developed and validated in athlete populations to allow for better comparisons between studies. Prospective data collection with long-term tracking and short recall periods should be used to understand consumption patterns across different types of sports. Given the low number of studies reporting adverse events associated with analgesic use, the prevalence and incidence of adverse events should be further explored to guide athletes and health professionals in making analgesic treatment decisions. There is a lack of understanding regarding how the use of analgesics is influenced by the sociocultural context. As such, mixed-methods approaches may be adopted to elaborate on reasons for analgesic use and external factors impacting the use. As just above one third of the included athletes were female, future studies should aim to include more balanced samples of athletes and explore sex-specific differences in analgesic consumption patterns. Finally, differences in consumption patterns between athlete and non-athlete populations should be explored to determine the effect of sport as an exposure for analgesic use.

5. Conclusion

Analgesics are commonly used by youth athletes, but estimates vary across types of analgesics and prevalence measure and heterogeneity was high in the pooled estimates. Of the identified analgesics, NSAIDs appeared to be the most used type of analgesic. Across studies, 7–50 % of athletes reported weekly use. Adverse effects were reported by 3 % to 19 % of athletes. Reasons for using analgesics included treatment of sports-related pain or injury and associated symptoms, to treat illness, and to enhance performance. As the majority of the included studies were of poor methodological quality, future high-quality studies are needed to better understand prevalence, incidence, consumption trajectories, and adverse events associated with analgesic use in youth athletes.

Funding information

This systematic review and meta-analysis was performed as part of a PhD project funded by the Danish Ministry of Culture, The Danish Society for Sports Physical Therapy, The Beckett Foundation, Østifterne f.m.b.a, and the Faculty of Health Sciences, University of Southern Denmark.

Role of funding bodies

The funding sources had no role in the collection, analysis or interpretation of the data, and had no rights in approving or disapproving publication of the finished manuscript.

Confirmation of ethical compliance

Not applicable to the study design.

Availability of data, code, and other materials

Template data collection form, data extracted from included studies, data used for analyses, and analytic codes are available upon reasonable request from the corresponding author.

Declaration of interest statement

JRP has received funding for the submitted work from Danish Ministry of Culture, The Danish Society for Sports Physical Therapy, The Beckett Foundation, Østifterne f.m.b.a, and the Faculty of Health, University of Southern Denmark. JBT holds a grant from Pfizer unrelated to the submitted work. The remaining authors declare no conflicts of interest.

Acknowledgements

We would like to acknowledge the funding bodies supporting the submitted work, including the Danish Ministry of Culture, The Danish Society for Sports Physical Therapy, The Beckett Foundation, Østifterne f.m.b.a, and the Faculty of Health Sciences, University of Southern Denmark.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jsams.2022.08.018.

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