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# Oral non-steroidal anti-inflammatory drug use in recreational runners participating in Parkrun UK: Prevalence of use and awareness of risk

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## Keywords

Adverse Drug Reactions < Patient Safety; Drug Utilisation; Pharmacovigilance < Pharmaceutical Public Health; Non-prescription Medicines < Community Pharmacy; Patient Behaviour; Consumer Attitudes; Patient Attitudes < Lay Perspectives

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## Abstract

**Objective** Non-steroidal anti-inflammatory drugs (NSAIDs) are widely used in endurance running and by elite athletes. We examined the pattern of use of NSAIDs, the purpose of use and knowledge of the adverse effects of NSAID use in a population of recreational runners at Parkrun UK.

**Methods** An online observational non-interventional cross-sectional survey of Parkrun UK participants being over the age of 18, on Parkrun UK's mailing list, and residing in the UK.

**Key Findings** Runners ( $n = 806$ ) had a high use of NSAIDs in the past 12 months (87.8%). The average age of respondents was 48.39 years. There was a significant association between those taking an oral NSAID in the last twelve months and those with a sporting injury ( $\chi^2 = 10.89$ ,  $df = 1$ ,  $n = 797$ ,  $P = 0.001$ ). Ibuprofen was the most commonly used NSAID (81.1%). A third of runners had experienced an adverse drug reaction associated with NSAIDs, usually gastrointestinal. Half of runners used NSAIDs with no advice, and patient information leaflets were the most common source for those that had advice. Ninety-four per cent of runners would like more information on the harms and benefits of NSAIDs.

**Conclusions** Some recreational runners have a high use of NSAIDs, which is chronic in nature and a potential health risk. Recreational runners want more information on the harms and benefits of NSAIDs. Race event organizers should provide evidence-based advice on the use of NSAIDs.

## Introduction

Non-steroidal anti-inflammatory drugs (NSAIDs) are readily available over the counter, without prescription. They have a wide range of action including analgesic, anti-inflammatory and antipyretic properties,<sup>[1]</sup> most causing non-selective inhibition of cyclooxygenase isoenzymes 1 and 2. Their analgesic and anti-inflammatory properties are made use of by both professional and amateur athletes across all sports and levels of competition.<sup>[2]</sup> Use of NSAIDs is not prohibited by the World Anti-Doping Agency.<sup>[3]</sup> NSAIDs are consistently the most declared medication on doping control forms at the Olympics, Paralympics and FIFA World Cup tournaments.<sup>[4]</sup>

Concern about the potential of analgesics to provide an ergogenic effect remain,<sup>[5]</sup> and their usage may be

indicative of a doping attitude of mind.<sup>[6]</sup> Their use is not without risk of harms, with the established risks of NSAIDs, such as acute renal impairment and gastrointestinal problems, potentially heightened when used by athletes during endurance events. Specific risks such as hyponatraemia can also occur, with variables such as hydration and temperature modifying the risk.<sup>[7]</sup> NSAIDs are also associated with a dose-related risk of cardiovascular events.<sup>[8]</sup>

Between 2009 and 2014 marathon participation increased worldwide by 13.25%, with average completion times indicating a high proportion of non-elite athletes.<sup>[9]</sup> This more diverse range of runners, with a wider range of co-morbidities, may include individuals more at risk from

NSAID adverse effects, and the use of analgesics before a marathon appears associated with adverse effects.<sup>[10]</sup>

NSAID use is high in other endurance athletes. Ironman professional triathletes are high users of NSAIDs, with injury prevention, fatigue, and pain prevention and relief cited as reasons for use.<sup>[11]</sup> These perceived benefits have been questioned<sup>[12]</sup> with NSAID usage resulting in increased harms with minimal benefit.<sup>[13]</sup> However, it is possible that the use of NSAIDs may enable participation in exercise. How NSAIDs are used by recreational runners is unknown. In the UK, only ibuprofen and naproxen are available as oral preparations without prescription, with naproxen being sold only for the relief of period pain. The aim of this study was to explore the pattern of use of NSAIDs (both prescribed and over-the-counter), the purpose of use and knowledge of the adverse effects of oral NSAID use in a population of recreational runners.

## Methods

The study was an observational non-interventional cross-sectional survey, conducted using a self-completed online questionnaire distributed to runners online via Parkrun UK.<sup>[14]</sup> Parkrun UK organises free to enter 5 km runs every Saturday in the UK. Founded in 2004, it has 593 different locations in the UK, with 130 000 completed runs to date, with over 1.9 million people, of all running abilities,<sup>[15]</sup> having participated in at least 1 event.

The self-completed questionnaire was informed by a review of the current literature and piloted with sports medicine doctors ( $n = 5$ ), physiotherapists ( $n = 4$ ), pharmacists ( $n = 4$ ) and runners ( $n = 10$ ) to check face validity. The survey consisted of demographics, general NSAID use, history of sporting injury, use of NSAIDs before, during, and after exercise, reasons for taking NSAIDs, and adverse effects of NSAIDs. A copy of the survey instrument is provided as Appendix S1. The questionnaire was also assessed by Parkrun UK. Some minor changes were implemented as a result of this.

Inclusion criteria were as follows: participants being over the age of 18, on Parkrun UK's mailing list, and residing in the UK. The questionnaire was hosted on Jisc Online Surveys.<sup>[16]</sup> The survey was advertised in the Parkrun UK newsletter and was open from the 31st of October 2016 to the 30th of November 2016. No incentive was given for participation. Participants remained anonymous, with no identifiable data requested. Ethical approval was granted by both Queen Mary's University (QMREC1484) and Birmingham University's School of Pharmacy Research Ethics Committee (2017). Consent was given by questionnaire completion.

Data were imported into Statistical Package for Social Scientists for data analysis.<sup>[17]</sup> Non-UK survey responses

were removed, along with non-responses with major data absence. Statistical analysis included Pearson's chi-squared test ( $\chi^2$ ), a  $P$  value of less than 0.05 was accepted as statistically significant in all tests.

## Results

There were 806 responses suitable for analysis, after removal of 14 non-UK responses and 5 responses with major data absence. Due to the method of recruitment, no reliable response rate can be calculated. The overall mean age of respondents was 48.39 (SD = 12.39, range of 18–82 years), with a roughly even gender split (female 46%) (Table 1). Male participants reported higher weekly running mileage than women (Pearson  $\chi^2 = 19.153$ ,  $df = 6$ ,  $n = 804$   $P = 0.004$ ), with the modal reported distance per week being in the range of 11 to 20 km per week. There was a significant association between injury and distance covered in a week (Pearson  $\chi^2 = 15.46$ ,  $df = 5$ ,  $n = 682$   $P = 0.009$ ), with 70% ( $n = 557$ ) having a sporting injury in the past 12 months.

The majority of respondents (87.8%,  $n = 708$ ) indicated they had used oral NSAIDs in the past 12 months with no difference between gender, distance run per week or membership of an athletic club. There was a significant association between those that had taken an oral NSAID in the last 12 months and those that had a sporting injury

**Table 1** Characteristics and NSAID use of respondents

Mean age	48.39 (SD = 12.39, range of 18–82 years)
Mean Male age ( $n = 394$ )	50.46 years (SD = 12.29, range of 18–82)
Mean Female age ( $n = 410$ )	46.44 years (SD = 12.19, range of 18–79)
Running Club Member	381 (48%)
What distance do you cover a week?	
5 km (3.1 miles) or less	54 (6.7%)
6–10 km (3.7–6.2 miles)	121 (15%)
11–20 km (6.3–12.9 miles)	244 (30.3%)
21–30 km (13–19.2 miles)	175 (21.8%)
31–40 km (19.3–25.4 miles)	106 (13.2%)
41–50 km (25.5–31 miles)	43 (5.3%)
50 km (31.1 miles) or more	61 (7.6%)
Sporting injury in the past 12 months	Yes: 557 (70%) ( $n = 557$ ) No: 240 (30%)
NSAIDs used in last 12 months	708 (88%)
Ibuprofen	565 (79.8%)
Naproxen	78 (11%)
Diclofenac	24 (3.4%)
Aspirin	15 (2.1%)
Celecoxib	6 (0.9%)
Etoricoxib	5 (0.7%)
Meloxicam	4 (0.6%)
Unspecified	11 (1.5%)

in the past 12 months ( $\chi^2 = 10.89$ ,  $df = 1$ ,  $n = 797$ ,  $P = 0.001$ ).

Of the 697 NSAID users who could identify the specific NSAID they used, ibuprofen was the most commonly used (79.8%), followed by naproxen (11%), and diclofenac (3.4%), with minor use of aspirin, celecoxib, etoricoxib and meloxicam (Table 1). Twenty-four per cent ( $n = 171$ ) of NSAID users used oral NSAIDs on prescription for a non-exercise-related medical condition. Twenty-four (3.4%) of NSAID users reported that they had exceeded the recommended daily dose of NSAIDs, 75% of whom were male.

Of runners who had taken NSAIDs in the past 12 months, 693 (98%) supplied information on NSAID consumption over the past month. 70.7% had not taken an oral NSAID more than for 7 days in the last month, with 13.1% taking them for more than 15 days (Table 2). Those using ibuprofen used it less frequently than other NSAID users with only 2.7% taking ibuprofen for more than 21 days in the last 28 days, compared to 25% of those that took diclofenac and 27.3% of those that took naproxen.

Oral NSAID usage before, during and after running varied with 57% of respondents having taken NSAIDs before a run/race, 11% during, and 67.7% afterwards. Women were more likely to use NSAIDs after a run or

race (73%) than men (62%). As the longest event distance increased, the use of NSAIDs during races increased (Table 3). Respondent's reasons for using NSAIDs before, during and after a race/run varied (Table 4).

Thirty-two per cent ( $n = 234$ ) of respondents experienced a suspected adverse drug reaction (ADR) a result of NSAID use, including gastrointestinal discomfort ( $n = 99$ ), heart burn ( $n = 67$ ), nausea and vomiting ( $n = 34$ ), diarrhoea ( $n = 11$ ) and gastrointestinal bleeding ( $n = 11$ ). Over half of respondents were aware of the risk of gastrointestinal ADRs (Table 5), few were aware of the potential that NSAIDs may delay recovery time from exercise or an injury. Approximately 1 in 10 respondents were unaware of any adverse effects.

A number of respondents had pre-existing contra-indications or cautions to NSAID use: 115 NSAID users had a diagnosis of asthma, 30 had a history of gastrointestinal bleeding or ulcers, and 6 had inflammatory bowel disease.

Patient information leaflets (PILs) are the most common source of information ( $n = 104$ ), followed by doctors ( $n = 95$ ), physiotherapists ( $n = 80$ ), the Internet ( $n = 66$ ), friends and family ( $n = 61$ ), pharmacists ( $n = 51$ ), coaches ( $n = 9$ ) and osteopaths/podiatrists ( $n = 5$ ). Nine runners were healthcare professionals. Many consulted no information sources about NSAIDs

**Table 2** Self-reported NSAID consumption over past 28 days by NSAID

NSAID	In the past four weeks, on approximately how many days have you taken oral NSAIDs?										Total <i>n</i>
	None		1–7 days		8–14 days		15–21 days		22–28 days		
	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%	
Ibuprofen	124	22.1	306	54.4	91	16.2	26	4.6	15	2.7	562
Naproxen	11	14.3	21	27.3	15	19.5	9	11.7	21	27.3	77
Diclofenac	3	12.5	11	45.8	3	12.5	1	4.2	6	25.0	24
Aspirin	1	6.7	9	60.0	1	6.7	0	0.0	4	26.7	15
Celecoxib	1	16.7	1	16.7	0	0.0	0	0.0	4	66.7	6
Etoricoxib	1	20.0	1	20.0	1	20.0	1	20.0	1	20.0	5
Meloxicam	0	0.0	0	0.0	1	25.0	1	25.0	2	50.0	4
Total	141	20.3	349	50.4	112	16.2	38	5.5	53	7.6	693

**Table 3** Before, during and after run/race NSAID use by longest race distance

Longest event the person participated in	Do you ever take oral NSAIDs BEFORE a run or race?		Do you ever take oral NSAIDs DURING a run or race?		Do you ever take NSAIDs AFTER a run or race?	
	Yes		Yes		Yes	
	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%
None ( $n = 35$ )	19	54.3	3	8.6	24	68.6
5K ( $n = 184$ )	104	56.5	6	3.3	122	68.5
10K ( $n = 201$ )	109	54.8	8	4.0	134	67.0
Half-Marathon ( $n = 98$ )	68	68.7	16	16.3	63	64.9
Marathon ( $n = 246$ )	137	56.1	43	17.5	167	68.7
Ultra ( $n = 36$ )	18	50.0	12	33.3	25	69.4

**Table 4** Reasons for taking an NSAID before, during, and after a run or race event

Reason for use of NSAID before a race event (n = 240)	Reason for use of NSAID during a race event (n = 43)	Reason for use of NSAID after a race event (n = 352)
(1) To reduce inflammation/swelling 58%	(1) To increase pain tolerance 54.1%	(1) To reduce inflammation/swelling 70.5%
(2) To increase pain tolerance 42.7%	(2) To reduce inflammation/swelling 50.6%	(2) To treat an injury 48.3%
(3) To continue running through an injury 42.7%	(3) To continue running through an injury 49.4%	(3) To reduce muscle soreness 34.1
(4) To treat an injury 25.1%	(4) To treat chronic pain or ongoing medical issues 24.7%	(4) To continue running through an injury 13.8%
(5) To reduce muscle soreness 22.7%	(5) To reduce muscle soreness 21.2%	(5) To increase pain tolerance 12.8%
(6) To treat chronic pain or ongoing medical issues 3.9%	(6) To treat an injury no data collected	(6) To treat chronic pain or ongoing medical issues - no data collected.

**Table 5** Awareness of Adverse Drug Reactions of NSAIDs (n = 779)

Adverse drug reaction	n	%
Cardiovascular events (e.g. heart attack)	335	43.0
Gastrointestinal damage (ulcers/ discomfort/ bleeding)	482	61.9
Kidney damage	330	42.4
Increased recovery time from exercise	24	3.1
Increased recovery time from injury	77	9.9
Not aware of any adverse drug reactions	85	10.9

(n = 393). A majority of respondents (795, 94.2%) indicated that they would read information about the benefits and risks of using NSAIDs during exercise if provided to them.

## Discussion

There is a high usage of NSAIDs in this sample of Park-run UK participants, with nearly 9 out of 10 respondents having used an NSAID in the last year. Eight out of ten included NSAID use in the 28 days prior to completion of the survey. Self-reported use of NSAIDs around race events (pre, during and after) was similar to found in other studies.

## Limitations

Runners sampled were self-selecting, and therefore, our study may over-estimate NSAID usage and injury rates through selection bias. Despite the large number of active UK park run attendees, the absolute number of respondents might reflect that non-NSAID users did not participate, skewing the data. Our study may have also attracted those more prone to injury, reflected in the older age profile of respondents (mean age of 48), although Parkrun UK is known to attract a high percentage of older runners.<sup>[15]</sup>

Our survey did not allow multiple NSAID entry, so potentially dangerous double-dosing with multiple NSAIDs was not detected. Doses of single NSAIDs exceeding the recommended dosage may have been underestimated, since judgements on dosage were left to

respondents. The reports of suspected adverse drug reactions were self-reported, and we cannot provide definitive proof of causality.

Our project design was not based on a specific running event, compared to the majority of the published survey data. However, a strength of the data is that it provides information on a recreational running community across a range of activity levels and demographics, and is arguably a fairer representation of the general recreational running population, compared to other more specialist event-based surveys.

## NSAID usage

Ibuprofen was the most common NSAID used in our study, reflecting that in the United Kingdom only ibuprofen, naproxen and aspirin are available without prescription. Previous studies have shown diclofenac to be the most commonly used by runners,<sup>[10,18]</sup> but such use is declining following awareness of a higher risk of cardiac ADRs with diclofenac.<sup>[19]</sup> Between September 2014 and August 2019 prescribing of oral diclofenac sodium fell by 60%.<sup>[20]</sup> The higher use of diclofenac and naproxen in the past month, compared to ibuprofen, may indicate these are prescribed for chronic conditions and therefore are more likely to be used regularly.

High levels of NSAID use have been reported in amateur athletic club members,<sup>[21]</sup> but most evidence comes from endurance running events. Mohseni and colleagues reported 40% of participants in a half-marathon/marathon event used NSAIDs regularly, with 17% using on the morning of the event, or during the event.<sup>[22]</sup> Tillander and colleagues reported that 42% of runners at a marathon event used NSAIDs in the 12 months leading up to the event.<sup>[23]</sup> A small survey of London Marathon participants found 46% planned to take an NSAID during the marathon, with 34% having taken an NSAID in the morning.<sup>[24]</sup> A large study of the Bonn marathon in Germany found that 49% of runners had used analgesics, mainly diclofenac and ibuprofen.<sup>[10]</sup> A more recent study

at the Hannover marathon suggested lower rates of use of analgesic use (17%).<sup>[25]</sup>

Joslin and colleagues examined analgesic use in endurance runners and found a similar use of NSAIDs by half-marathon/marathon runners and ultramarathon runners during training (59% versus 63%), but higher use of NSAIDs during event, with 70% of ultra-runners using NSAIDs compared to 26% of other runners.<sup>[26]</sup> Other studies of ultra-runners have confirmed significant use of NSAIDs,<sup>[13,27-30]</sup> along with studies of adventure racing<sup>[31]</sup> and Ironman triathlon events.<sup>[11,32]</sup> This matches the high usage of NSAIDs by endurance runners in our study, with 1 in 3 ultra-runners reporting taking NSAIDs during events.

### Reasons for NSAID use

Our study found NSAID usage was higher in injured respondents. Running related injuries are more common in new inexperienced runners.<sup>[33]</sup> Over half of Parkrun UK attendees had a current injury in a recent study, and the majority run through injuries, with novices more at risk of injury.<sup>[34]</sup> Our study had a 70% prevalence of injuries over the past 12 months, which could reflect the type of runners who might respond to a survey on NSAID use. However, running through an injury was a common reason cited for use of NSAIDs in our study. In addition, the age profile of our sample, and increased chance of co-morbidities, may have made the use of NSAIDs more likely.

Fifty-seven per cent of respondents answered yes to taking an NSAID before a run/race, with little difference between event length. This is similar to a study which found 49% of runners took an NSAID immediately before a marathon.<sup>[10]</sup> Other published figures include 38% of runners taking an NSAID in the 2 weeks prior to a marathon,<sup>[35]</sup> and 35% of ultramarathon runners and 13% of marathon runners taking an NSAID in the 24 h preceding a race.<sup>[18,36]</sup>

Overall 11% of our respondents said they had used an NSAID during a race/run with rates of use increasing in the groups that had participated in longer distance events. Half-marathoners and marathon runners were roughly 4 times more likely to use NSAIDs than 10 km runner, but ultramarathoners were 8 times more likely to use NSAIDs during an event with 1 in 3 using NSAIDs during an event. A culture of reliance on NSAIDs appears prevalent.

A study in professional triathletes found that NSAID users had a high expectation of an anti-inflammatory effect (79%) and an analgesic effect (64%). This is seen in our data set with 58% of runners taking an NSAID before a race/run, 51% during and 71% after a race/run expecting it to reduce swelling or inflammation.

In our study, 42–54% of runners who would take an NSAID before or during a race did so believing it would increase pain tolerance, with 43–49% believing it would allow them to continue running through an injury. In a professional triathlete population, 62% of those that took NSAIDs immediately before or during the race expected that it would prevent pain during the race.<sup>[11]</sup> Our results would tend to support Holgado and colleague's position that NSAIDs may be used by some for a perceived ergogenic benefit.<sup>[5]</sup>

We found no widespread use of NSAIDs outside of their recommended dosages, compared to Kuster and colleagues who found over 1 in 4 users did so<sup>[10]</sup>; such runners were 4–10 times more likely suffer adverse effects during the event. Similar overuse was found during the London Marathon.<sup>[24]</sup>

Low mileage runners in our study were using NSAID for chronic pain, current injuries or ongoing medical issues, suggesting the use of NSAIDs is to facilitate participation in running activities. This suggests some recreational runners are using NSAIDs chronically to enable participation in exercise, despite possible increased risks of long-term adverse effects associated with chronic dosing such as cardiovascular events.<sup>[37]</sup> In contrast, higher distance high endurance event runners, such as ultramarathoners, are interested in the reduction of swelling/inflammation and reduction of muscle soreness.

This differential in use is of interest. Those engaged in longer endurance events may be looking for an ergogenic performance enhancement, including the reduction in pain that might allow them to push harder during a race. In contrast, more recreational runners may be seeing a solution to maintain a minimum baseline physical activity to preserve their health status. Therefore, NSAIDs may provide a paradoxical dual role, in endurance runners being tied to performance goals, but in recreational runners as an enabler of a healthy activity.

There is currently interest in the prescribing of physical exercise to maintain health status<sup>[38,39]</sup> and a willingness from pharmacists to become involved in such social prescribing.<sup>[40]</sup> Given the pharmacists' role in the supply of over-the-counter medicines, they may be well placed to discuss the place of NSAIDs in enabling exercise, while also reducing the risk of associated harms.

### Adverse effects of NSAIDs

A quarter of runners in this study experienced a suspected ADR over the prior 12 months, similar to an Olympic and Paralympic study which found 19% reporting NSAID related ADRs, with ibuprofen having lower reported ADRs.<sup>[41]</sup> One in five of our NSAIDs users had a pre-existing contra-indication or caution to use of NSAIDs, yet

still used NSAIDs either through ignorance or through their own assessment of the benefit–harm balance.

NSAIDs are associated with serious ADRs<sup>[42]</sup> and are responsible for 30% of hospital admissions due to adverse drug reactions.<sup>[43]</sup> Co-use during physical activity carries long established risks.<sup>[7]</sup> While runners may not be considered to have the risk factors that elderly non-athletic patients have, our study shows the use of NSAIDs in sport occurs outside of elite athletics in an increasingly active older population.

The use of NSAIDs for short-term pain and soreness relief may be to the detriment of long-term healing and outcomes related to training<sup>[44]</sup> or allow an athlete to put undue strain on an injury prematurely by the suppression of pain.<sup>[45]</sup> NSAIDs may also affect bone consolidation, potentially delaying healing or adding to the dangers of stress fractures.<sup>[7]</sup> Since muscle regeneration is partly dependent on prostaglandins, long-term NSAID use may impair the adaptive response to exercise.<sup>[44]</sup>

There is therefore a balance to be struck between any short-term benefits of NSAIDs on performance and pain, versus a potentially reduced quality of healing or training response. Concern exists that NSAID use increases health risks for no or little benefit.<sup>[13]</sup>

### Endurance runners

A subset of the runners in this study ran at marathon length or higher, alongside their Parkrun UK activity. Their high use of NSAIDs during longer endurance events carries additional risk of more acute adverse effects such as acute gastrointestinal haemorrhage,<sup>[10]</sup> acute renal impairment<sup>[37]</sup> and hyponatraemia.<sup>[32]</sup>

During exercise, gastrointestinal blood flow is reduced,<sup>[46]</sup> and gastrointestinal symptoms are common in runners even in the absence of NSAIDs. Serious gastrointestinal bleeding associated with NSAID use has been reported following a marathon,<sup>[10]</sup> and NSAID use has been associated with endotoxaemia during an ultramarathon.<sup>[12]</sup>

Reduced blood flow to the kidneys during exercise, combined with the NSAID inhibition of renal prostaglandins, has been associated with acute renal impairment since the late 1970s.<sup>[47]</sup> Faster runners with higher weight loss during the race are more at risk, suggesting dehydration is a risk factor.<sup>[37]</sup>

Exercise-associated hyponatraemia is associated with overhydration and inappropriate secretion of arginine vasopressin leading to water retention.<sup>[48]</sup> Water retention is a known effect of NSAIDs and may increase the risk of hyponatraemia. A statistically significant association between NSAID use and hyponatraemia in Ironman triathletes has been described.<sup>[32]</sup>

### Informational requirements of runners

The awareness of the risk of ADRs was high in our study (89.1%), in contrast to a study of marathon runners which found 93% of runners were not informed of the risk associated with NSAID use and exercise.<sup>[10]</sup> Other studies have shown higher awareness of risk: a study of professional triathletes which found awareness of gastrointestinal effects 59%, renal complications 27%, kidney failure 18% and stomach bleeding 24%.<sup>[11]</sup> However, significant numbers of NSAID users remain unaware of some of the more serious adverse drug reactions associated with NSAIDs, and runners should be educated about the particular risks associated with their use. For high mileage and longer event runners, the most likely to use NSAIDs during prolonged physical exertion, the acute risks of exertional hyponatremia and acute kidney failure during endurance events should be highlighted. For more recreational and novice runners, the more long-term health risks, such as cardiovascular disease, need to be explained clearly.

Our respondents would welcome further information about the benefits and risks of using NSAIDs in combination with exercise. Patient information leaflets distributed with NSAIDs do not provide specific information about additional risks associated with exercise. Advice to ‘drink according to thirst’ to prevent hyponatraemia has become more common<sup>[49]</sup>; more explicit advice on the avoidance of NSAIDs, particularly in longer duration events, should follow. In recent years, the London Marathon organisers have informed participants about the risks of NSAIDs for the first time and advise avoidance of their use within 48 h of the race.<sup>[50]</sup> The high level of NSAID use in longer endurance race runners we have found would suggest this is reasonable advice.

### Conclusion

Use of NSAIDs in this first study of recreational runners is high and appears to be chronic in nature. Our rates of self-reported use around race events are broadly in line with previous studies of NSAID use in elite athletes. NSAID use could be both a public health risk and a confounder in studies of the health effects of running.

While injury is, as expected, associated with NSAID use, runners are also using NSAIDs to facilitate participation in events, to push through injuries by increasing pain tolerance and to deal with post-event soreness. The high usage of NSAIDs without full knowledge of adverse effects, contra-indications or cautions for use, is of concern. On the other hand, NSAIDs may be playing a valuable role in enabling individuals participate in exercise.

The lack of evidence for benefits of NSAIDs in exercise means some runners may be making poor benefit–harm decisions. An unmet desire for information about NSAID by recreational runners exists. Health professionals, particularly pharmacists in an over-the-counter setting, should be aware of this subset of NSAID users. The use of NSAIDs before races and during races by those undertaking longer endurance events is concerning given the greater physiological stresses of those events. Organisers of longer endurance events should consider providing evidence-based advice on the use of NSAIDs.

## Declarations

### Conflict of interest

The Author(s) declare(s) that they have no conflicts of interest to disclose.

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## Authors' contributions

ARC and CR conceived the study. CR, ARC, FM and IA contributed to the design, execution, analysis and interpretation of the study. ARC and CR drafted the paper. All authors edited and gave final approval of the version published. All Authors state that they had complete access to the study data that support the publication.

## Ethical approval

Ethical approval was granted by both Queen Mary's University (QMREC1484) and Birmingham University's School of Pharmacy Research Ethics Committee (2017). Consent was given by questionnaire completion.

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## Supporting information

Additional Supporting Information may be found in the online version of this article at the publisher's web-site:

**Appendix S1.** Drug Utilisation Review of NSAIDs by Runners.