Gastrointestinal illnesses in endurance sports women: a review

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Summary

It has been found that gastro-intestinal disorders are limiting factors in both endurance and ultra-endurance sports performance. Studies on the likely causes of such health conditions show that several elements are involved. It is estimated that 30% to 90% of runners suffer from digestive conditions leading to the detriment of both performance and rehabilitation. Considering the increase in the number of long-distance runners with a focus on females, it is of particular interest to analyse the presence of a greater percentage of such health problems in women. Therefore, it raises the hypothesis that women are more affected by gastrointestinal conditions than men in endurance sports. The aim of this review is to appreciate if there is a higher percentage of gastrointestinal problems in endurance sportswomen compared to that in endurance sportsmen. Results suggest that the numbers are high in percentage terms for woman compared to men presenting gastrointestinal symptoms. Although a study suggests there is evidence on the contrary, others report that there are no differences between the sexes. Women suffer more from diarrhea, flatulence, urge to defecate, etc (lower digestive tract) than vomiting, reflux, nausea etc (upper digestive tract). Other risk factors can be considered, namely younger age and a lack of experience in running. Even though there are no studies that analyse such cases, there is a marked tendency to affect women. However, it is of vital importance to carry out studies on greater populations with an emphasis on the sexes.

Key words:
Physical endurance. Gastrointestinal diseases. Inflammatory bowel diseases. Gastrointestinal distress.

Problemas gastrointestinales en deportes de resistencia en mujeres: revisión de literatura

Resumen

Los problemas gastrointestinales en los deportes de resistencia y ultra-resistencia se encuentran entre los factores limitantes del rendimiento deportivo. Se han estudiado las posibles causantes de estas afecciones y se plantea una situación multifactorial. Es cada vez más habitual el número de personas que practican deportes de resistencia, y se estima que entre el 30 y 90 % de ellos presentan problemas GI de diversa gravedad. Esto implica una limitación del rendimiento y también condiciona la recuperación posterior al esfuerzo. Dado el aumento de población que practica este tipo de deportes de resistencia a largas distancias, y en concreto del género femenino, resulta de interés estudiar el alcance de estos problemas en mujeres. Se plantea la hipótesis de que la mujer sufre más problemas gastrointestinales que el hombre en deportes de resistencia. Esta revisión pretende conocer si existe mayor frecuencia de problemas gastrointestinales asociados a la práctica de deportes de resistencia en mujeres. Los resultados de la presente revisión parecen mostrar que las mujeres presentan síntomas gastrointestinales con más frecuencia que los hombres, aunque uno de los estudios obtiene el resultado contrario y otros no ven diferencias. Parece que la mayor incidencia se da en problemas gastrointestinales del tracto bajo (diarrea, flatulencia, urgencia para defecar…) más que en el tracto alto (reflujo, náuseas, vómitos…). Otros factores de riesgo asociados encontrados son edades más jóvenes y menor experiencia en carreras a pie. Aunque no existen estudios específicos para la evaluación de estas afecciones y su incidencia por sexos, se puede observar una clara tendencia en la mayor presencia de estas afecciones en mujeres, si bien es preciso realizar estudios con muestras más grande de ambos grupos y que tengan en cuenta las diferencias fundamentales de ambos. Se requieren investigaciones específicas para una mejor evaluación de las afecciones gastrointestinales en función del sexo.

Palabras clave:
Resistencia física. Enfermedades gastrointestinales. Enfermedad intestinal inflamatoria. Estrés gastrointestinal.

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Introduction

The annual report published by the Ministry of Education, Culture and Sport in 2017 shows that the weekly pursuit of all kinds of sports has increased. This is particularly true of endurance sports, with 10.6% of the population engaging in running and 10.3% in cycling in 2015, compared to figures of 4.8% and 6.7%, respectively, in 2010. This growing interest in sporting activity and especially endurance sports, which occupy both the 2nd and 3rd positions in the ranking, is notable[1].

The 2015 survey on Sporting Habits in Spain (included in the 2017 report) shows that, although the number of men who do sport is still higher, 42.1% of women pursue sporting activities on a weekly basis, marking a significant increase on the figures in the previous survey conducted in 2010. The report also indicates that this increase in sporting activities among women is particularly notable in the younger age ranges.

Puig and Soler (2012) point out that men have engaged in sports more than women ever since records of sporting habits began and also that significant differences regarding the type of sporting activity pursued have always existed. Football, swimming and cycling are the most popular sports among men, while women prefer recreational or keep-fit swimming in first place, followed by aerobics, rhythmic gymnastics, dance and keep-fit gymnastics[2].

As for high-performance sports in Spain, men have taken part in the Olympic Games without fail since the start of the 20th century, while the first women did not compete until Paris 1924. It was not until the 1960 Rome Games that women reappeared and their presence has grown since then, at times even exceeding the number of men (Barcelona 1992, 141 women and 78 men in the Spanish team).

According to the latest annual report on sporting habits, the number of women who engage in the endurance sports of running and cycling increased from 3.4% to 8% in the former and from 3.2% to 5.5% in the latter between 2010 and 2015[1].

An endurance sport is anything from a sport which requires aerobic metabolism and lasts 60-90 minutes (10 km, half marathon, short road or mountain bike rides, depending on the level of training) to the so-called ultra-endurance sports, where the distances covered are superior to those of a marathon (42,195 km) or more than 160 km by bicycle.

From a metabolic point of view, endurance and ultra-endurance sports consume large amounts of energy and the role of carbohydrates and/or lipids during exercise and how they are regulated has been a subject of research for decades. We now know that the energy substrate source used depends on the intensity (%VO_2max.) and duration of the exercise, i.e. whether carbohydrates or lipids are used as an energy source[3,4].

At low levels of VO_2max., fat supplies the largest share of energy, losing prominence as VO_2max. increases and the exercise lasts, giving way to greater carbohydrate oxidation[3,4]. It has been seen that lipid oxidation peaks at mean intensities of 45% to 65% VO_2max., depending on sex, level of training, VO_2max. and diet.

Higher training levels result in improved use of fats as an energy source as training causes physiological adaptations associated with an increase in oxidative enzymes and mitochondrion content in muscle cells, regulation of lipid uptake in muscle fibres and the transportation of fatty acids (FA) through the mitochondrial membranes, and regulation of the hydrolysis of intramuscular triacylglycerols[3-5].

Exercise has a direct positive effect on health[6,7], although it may have less healthy implications at cardiac, musculoskeletal and renal levels[7,8].

At a digestive level, it may cause increased intestinal motility as a result of increased peristalsis, improved intestinal microbiota or normalisation of intestinal transit[9,10]. However, as the intensity of exercise is increased, these changes, which could be of benefit to the athlete a priori, may represent a limiting factor, between 20% and 50% of athletes experiencing gastrointestinal (GI) discomfort[6,11].

In the late 1980s, Rehrer studied the relationship between GI problems in long-distance runners and their hydration status, concluding that they were not so much related to high fluid intake when running as to the runner's hydration status[12]. Similarly, it would seem that a high level of dehydration coupled with a decrease in blood flow in the intestinal tract induced by exercise itself may be directly related to GI dysfunction[8,12].

The controlled intake of carbohydrates in the diet and its relationship with the onset of GI problems in endurance athletes has also been studied, suggesting that controlling the concentration and type of carbohydrates consumed, together with other dietary components, such as fibre, may be one of the keys to managing the onset of GI disturbances[13-16].

At high intensities, our GI system finds itself compromised at various levels. These intensities increase sympathetic tone, which may lead to an increase in peristalsis to extraordinary levels, alter GI secretions, compromising nutrition absorption pathways, and increase intestinal mucosal permeability, which may lead to bouts of diarrhoea or, contrarily, constipation, which may be accentuated if the individual is not properly hydrated[17].

The specific causes of these problems are not fully known[11,18], yet we do know that they multifactorial and, therefore, it is useful to study each individual in particular in order to offer him/her better advice about his/her sporting activity and diet.

Oliveira, Burini and Jeukendrup (2014) studied the causes and prevalence of GI problems during endurance exercise and found that depending on the methodology used and type of sport studied, 30–90% of participants experience GI problems[17].

Their study analysed the direct influence of exercise on intestinal function, possible mechanical factors and nutrition as the possible causes of GI problems.

In order to study GI disturbances, problems such as reflux, nausea, vomiting, stomach ache, belching and bloating were defined as "high GI symptoms", while stomach cramps, side stitch, flatulence, intestinal bleeding, the urge to have a bowel movement and diarrhoea were defined as "low GI symptoms"[19].

Due to the morphological and hormonal differences between men and women, the hypothesis of this review is that female endurance athletes suffer GI problems directly related to exercise more often than their male counterparts.

The objective of this review is to determine whether women are more prone to GI problems when they engage in endurance sports

Methodology

An exhaustive search was conducted in the PubMed database in May 2018 and the search strategy was translated to Google Scholar. Articles were also added using the snowball method.

The formula used to search PubMed was:

("Physical endurance" [mesh] OR "physical endurance" [tiab] OR "endurance" [tiab]) AND ("gastrointestinal diseases" [mesh] OR "gastrointestinal diseases" [tiab] OR "gastrointestinal disease" [tiab] OR "inflammatory bowel diseases" [tiab] OR "inflammatory bowel disease" [tiab] OR "gastrointestinal distress" [tiab]).

The eligibility criteria taken into account to discriminate studies for the review were described. A table was created using the PICOT method (Table 1) to better establish these criteria.

The data extracted from each article finally selected for this review (adapted from MacMaster University[20]) were: size of population, author/s and year of publication, type of intervention, what data they are compared with, what outcomes are measured in the study, what the study design was and what the main findings were.

Results

The search formula in the PubMed database and Google Scholar threw up a total of 227 articles. After screening and the inclusion of two articles through snowballing, a total of 9 scientific articles were included in this review.

Table 2 shows the data extracted from the articles discussed in the review.

Discussion

No specific research aimed at studying the significantly different incidence of GI problems in men and women were found, but research involving symptoms which revealed gender-based differences in results was.

In the literature, we found mixed results: GI problems are more prevalent in women than men[21-24,27], GI problems are equally prevalent in women and men[26,28,29], and GI problems are less prevalent in women than men[25].

Of those which revealed a prevalence in women, the first were conducted with marathon runners by Keeffe (1984) and Riddoch (1988)[21,22], both employing a basic study methodology: the existence or non-existence of GI problems after a run.

Using a simple questionnaire on completion, Keeffe[21] gauged the existence of GI disturbances during and after a run. 707 questionnaires (85.2% men and 14.8% women) were collected, addressing three areas: (a) demographic data -age, sex, years running, average weekly km run-, (b) GI habits- average number of daily bowel movements, frequency of abdominal cramps or diarrhoea- and (c) symptoms associated with running, during easy runs, during hard training or runs, or immediately after an easy or hard run, with four possible answers: never, rarely, occasionally or frequently. The frequency of the appearance of "high" and "low" symptoms was differentiated for each of the running categories (easy, hard and immediately after). Regarding "high" symptoms, no significantly higher frequency was observed in women except in the case of nausea during both easy and hard runs. No numerical data are provided for this observation. For "low" GI symptoms, however, the percentage of positive responses (sum of occasionally and frequently divided by total responses) was higher for women than for men in all 3 running categories (easy, hard and immediately after). The results are shown in Figure 1 (extracted from reference 21).

It was also observed that the <20 age group experienced "low" GI problems more frequently than the 20-40 age groups and significantly more frequently than the >40 age group.

Riddoch[22] sent runners his questionnaire with the final race information pack and the data were collected prior to the start of the run. The questionnaire was completed by 471 participants (92% men and 8% women). It consisted of 2 parts: (a) personal profile of the runner -age, sex, running experience, average weekly km run, dietary habits and best personal time- and (b) the frequency of a range of GI symptoms during easy runs, during hard runs and after runs, with four possible answers: never, rarely, occasionally or frequently. "High" GI symptoms were less common than "low" GI symptoms in all 3 running categories (easy and hard runs, and after hard runs) and, with the exception of dark urine measurements, the women showed a statistically higher frequency than the men. The results are shown in Figures 2 and 3 (extracted from reference 22).

Table 1. Eligibility criteria according to the PICOT method.

Population	Intervention	Comparison	Outcome	Type of study
Women	Endurance sports Ultra-endurance sports	Men	Gastrointestinal problems	Prevalence studies Randomised clinical trials

17% of all the participants were asymptomatic, responding that they had never or rarely experienced GI symptoms. Of those who had suffered GI symptoms, 73% thought that it could be directly related to physical activity and the most common strategies employed to prevent them included running on an empty stomach and being sure to have a bowel movement before a run. Only a small percentage of those affected were aware of their problem and took measures to prevent it (medications or nutritional strategies, such as decreased dietary fibre or fat intake).

Table 2. Characteristics of the studies included.

Number of participants	Author/s (year)	Intervention	Comparison	Results measured	Research design	Results (in women)
103 women (707 total)	Keeffe, E.B.; Lowe, D.K.; Goss, J. R.; Wayne, R. (1984)[21]	13th Annual Trail's End Marathon in Seaside (1982)	Men	"High" and "low" GI symptoms during easy and hard runs, and after runs	Retrospective prevalence study	– Women do not have significantly more "high" GI symptoms than men, except nausea in easy and hard runs – All the "low" GI symptoms were more common in women than men – > "low" GI symptoms in under-20s
38 women (471 total)	Riddoch, C.; Trinick, T. (1988)[22]	Questionnaire prior to the 1986 Belfast marathon	Men	"High" and "low" GI symptoms during easy and hard runs, and after runs	Retrospective prevalence study	– 60% ≥1 "high" GI symptom – 87% ≥1 "low" GI symptom – 74% urge to have a bowel movement – 68% diarrhoea – >% GI symptoms in woman than men, except dark urine – > "high" GI symptoms in younger participants – Only 2 women were symptomatic
74 female long-distance runners (164 total) + 89 female cyclists (169 total) + 63 female triathletes (142 total)	Peters H.P.; Bos, M.; Seebregts, L.; Akkermans, L.M.; van Berge Henegouwen, G.P.; Bol, E.; Mosterd, W.L.; de Vries, W.R. (1999)[23]	Questionnaire on GI symptoms in the last 12 months. Runners and cyclists, same questionnaire bar certain details. Broader questionnaire for triathletes	Men	"High" and "low" GI symptoms during and after training and races	Retrospective prevalence study	– Female long-distance runners: no significant differences in prevalence of GI symptoms compared to men – Cyclists: more nausea, belching, bloating than men – Triathletes: side stitch and acidity during training, and more nausea 2 hours after racing than men – No difference in GI symptoms in women with/without menstrual period – > symptoms in cyclists, lower mean age than the others
10 km, 123 (total 261) 21 km, 222 (total 766) 42 km, 25 (total 227)	ter Steege, R.W.F.; Van der Palen, J.; Kolkman, J.J. (2008)[24]	Enschede Marathon 2006, 5-, 10-, 21- and 42-km races Online questionnaire 48 hours after the event: Demographic data + GI symptoms during the race, food/ drink intake, time or reason for withdrawal, if relevant + GI symptoms 24 hours after the race	Men	"High" and "low" GI symptoms during runs	Retrospective prevalence study	– 10 km: 13% GI symptoms vs. 7% men – 21 km: 22% GI symptoms vs. 8% men – 42 km: 31% GI symptoms vs. 6% women, 3 times greater risk of having GI symptoms after a run – Independent factors in serious GI symptoms during a run: woman <age <level of training
5 women (15 total)	Stuempfle, K.J.; Hoffman, M.D.; Hew-Butler, T. (2013)[25]	Proposed food/fluid intake during the Javelina Jundred 100 Mile Endurance Run, where GI symptoms were measured after each 25-km loop	Men	"High" and "low" GI symptoms during the 161-km run	Cross-sectional prevalence study	– 1 woman (20%) had GI symptoms – 80% women had no GI symptoms – 80% men had GI symptoms – No significant differences between finishers and non-finishers

(follow)

(continuation)

Number of participants	Author/s (year)	Intervention	Comparison	Results measured	Research design	Results (in women)
14 women surveyed (68 total) 8 women in 60-km race (41 total)	Wardenaar, F.C.; Dijkhuizen, R.; Ceelen, I.J.; Jonk, E.; de Vries, J.; Witkamp, R.; Mensink, P. (2015)[26]	Texel Ultra-marathon, 60 or 120 km Survey of habitual dietary intake 2 months before the race + Questionnaire on dietary intake the day after the race and GI symptoms in 120-km runners + Continuous in-situ observation during 120-km race	Men	"High" and "low" GI symptoms during the 60-km and 120-km runs Percentage of compliance with the diet proposed diet for the day of the run	Combined prevalence study (cross-sectional and retrospective)	– 7/8 women reported GI symptoms (87% vs. 81% men) – Women and men reported practically the same amount of distress – Daily CHO consumption was lower in women
8 women (18 total)	Miall, A.; Khoo, A.; Rauch, C.; Snipe, R.M.J.; Camões-Costa, V.L.; Gibson, P.R.; Costa, R.J.S. (2017)[27]	120 minutes treadmill running at 60% VO_2 with CHO consumption (90 g CHO hour-1) or placebo + 60 minutes running at maximum effort without CHO + 2-weeks training + Treadmill running, same conditions	Men and placebo.	GI symptoms food tolerance during exertion caloric intake state of hydration	Randomised clinical trial	– In trial 1: all the women reported at least 1 GI symptom – Tendency to present > GI symptoms and intestinal discomfort in trial 1 – In trial 2: women improved less than men – In the placebo group, no improvement was seen between trials 1 and 2
75 mujeres (145 total)	Wilson, P.B. (2017)[28]	Training and GI symptoms + at the end of 30 days, retrospective questionnaire on the period + new retrospective questionnaire on 30-day period 24-36 hours later to establish reliability of GI symptoms	Men	GI symptoms during training	Combined prevalence study (retrospective and prospective)	– At least 1 GI symptom in 78.3% of runs (vs. 84% men, non-significant difference) – 47.6% had symptoms scored as ≥3 (vs. 43.1% men) – 27.3% had symptoms scored as ≥5 (vs. 13.8% men)
76 women (150 total)	Wilson, P.B. (2018)[29]	Training journal/GI symptoms for 30 days + Retrospective questionnaire: demographic data, training experience, presence of any medical condition related to the GI system, eating habits, use of medication, caffeine and sports drinks, and data related to level of stress and anxiety	Men	GI symptoms related to stress and anxiety level	Combined prevalence study (retrospective and prospective)	– No significant differences between men and women were found in incidence of GI problems – < age and < experience: negative correlation with GI problems

As for age groups, it was observed that the younger participants (<34) suffered more frequently from nausea, abdominal cramps, loss of appetite, the urge to have a bowel movement and diarrhoea.

As occurred with Keeffe (1984), a clear trend for more frequent GI problems was observed in women and younger participants.

More recent studies introduce other variables[23,24,27]. These new variables, starting with those included by Peters, also consider the appearance of "high" and "low" symptoms during training (thus differentiating it from competition), after competitions and training, and during rest periods.

Figure 1. Percentage of positive responses for "low" GI symptoms in men and women during and immediately after an easy and hard run. Symptoms studied: abdominal cramps, urge to defecate, bowel movements, diarrhoea and bloody stools.

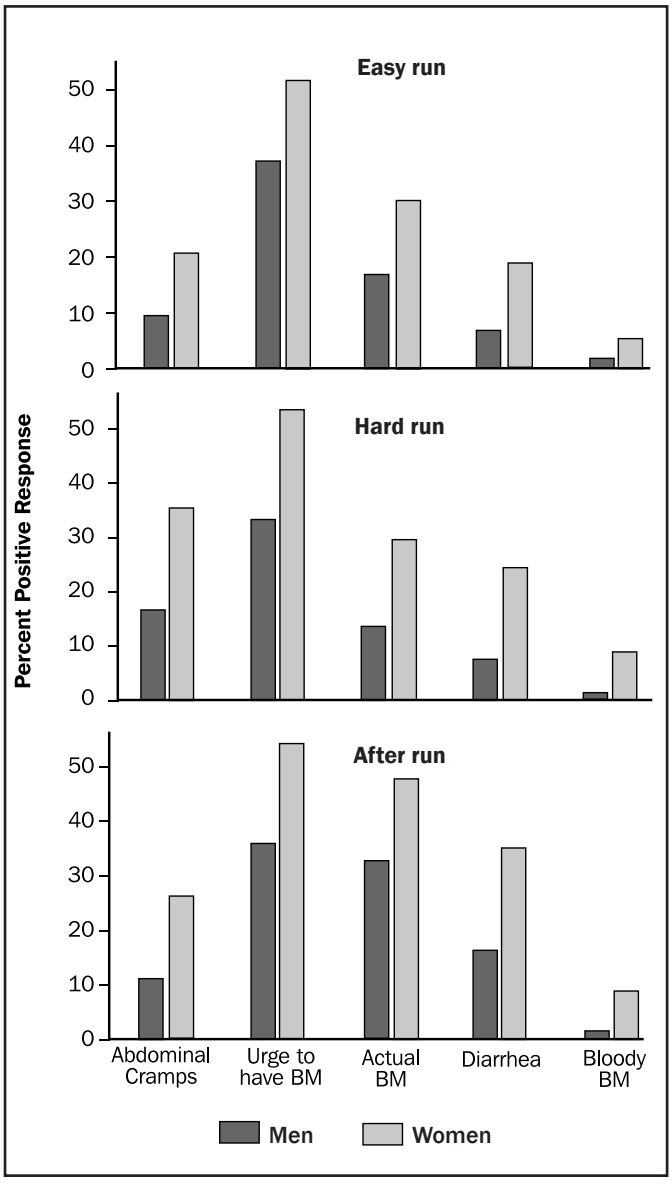
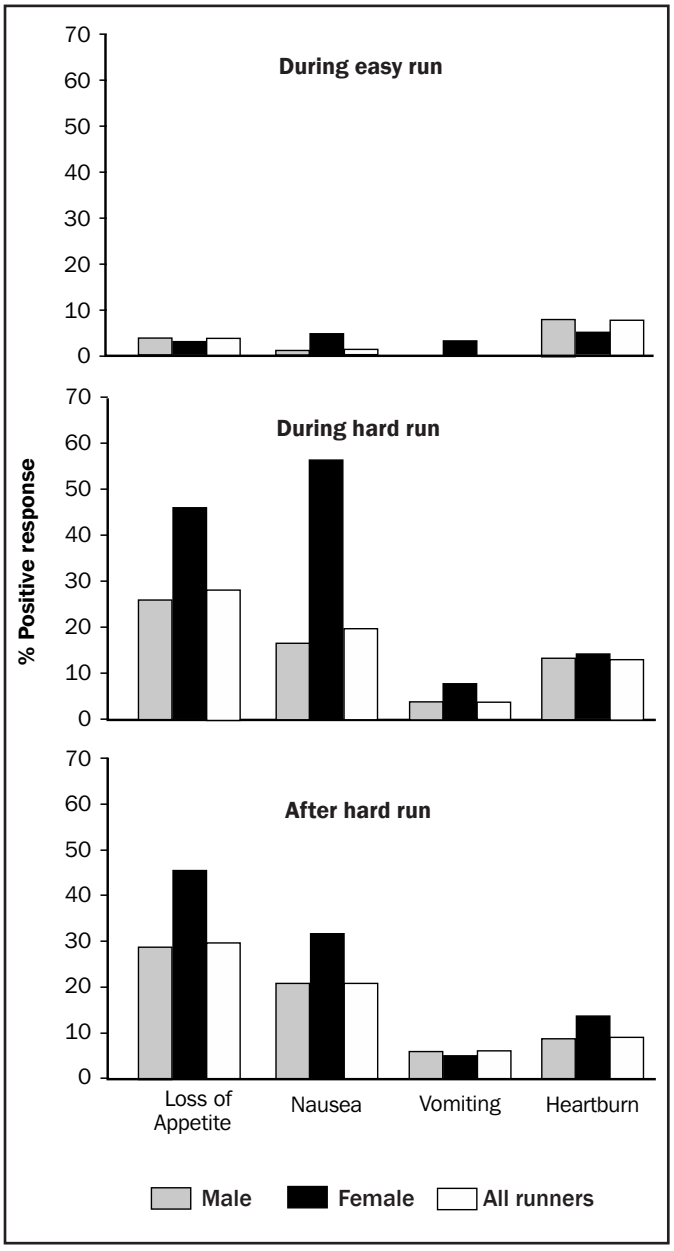


Figure 2. Percentage of positive responses for "high" GI symptoms in men and women during an easy run and during and after a hard run. Symptoms studied: loss of appetite, nausea, vomiting and heartburn.



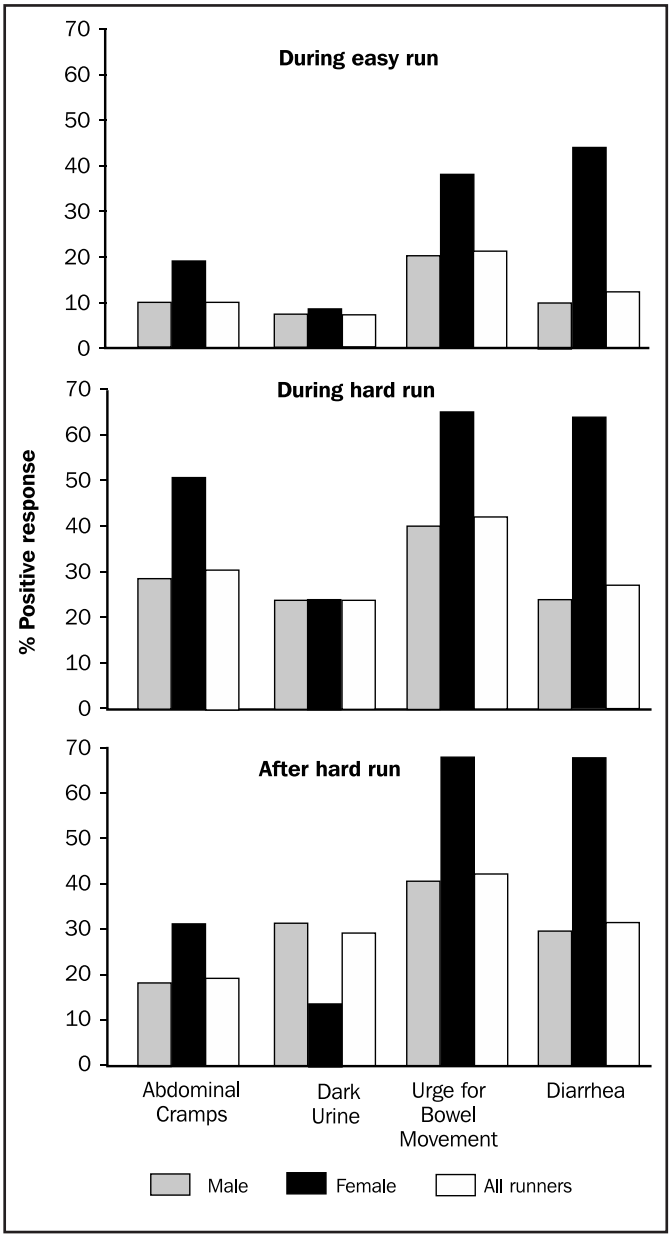
In Peters' study (1999), questionnaires were sent to long-distance runners, cyclists and triathletes to assess the prevalence of GI symptoms. Questions were asked about training, medication, GI symptoms and diet over the previous 12 months. The onset of GI symptoms was studied during periods of rest, training, competition and the 2 hours following training and competition.

Participation by gender and sport was: 1: 45% female and 55% male long-distance runners, 2: 53% female and 47% male cyclists, 3: 44% female and 56% male triathletes.

More "low" symptoms than "high" symptoms were observed during rest, training, competition and the 2 hours after training and completion, except in female cyclists during competitions and male cyclists in the 2 hours following competition. Female long-distance runners experienced more "high" and "low" GI symptoms than their male counterparts during competitions and in the 2 hours following competition, while the men had more problems during training.

They concluded that, in general, female cyclists had more complications of this kind than male cyclists 23 and that although there were women who said that they had not had a period in the last 12 months,

Figura 3. Porcentaje de respuestas positivas para sintomatología GI "baja" en hombres y mujeres durante carrera ligera, dura y post carrera dura. Sintomatología estudiada: rampas abdominales, orina oscura, urgencia para defecar y diarrea.



there was no greater prevalence of GI symptoms among these women than among those who had had a period.

No significant differences between male and female triathletes were observed. Broadly speaking, both "high" and "low" symptoms were less common in these athletes compared to long-distance runners and cyclists, and most complaints referred to "low" symptoms when running. The prevalence of "high" and "low" symptoms is shown in Table 3 (adapted from reference 23).

Ter Steege (2008) also took into account food and fluid ingestion before and after competitive races and training, and the general nutritional status of the participants, but found no positive correlation. Worse symptoms were found among those who did not habitually eat/drink during a race than among those that did[24].

Ter Steege (2008) was the first to suggest a possible relationship between the higher prevalence of intestinal ischemia in women, for reasons not entirely understood,[24] and the prevalence of GI problems associated with sports of this kind. He also refers to a possible similarity with the higher incidence of irritable bowel syndrome in women due to the relationship between gender, menstruation and hormonal differences, and intestinal motor and sensory function[24]. Ouyang (2006) previously related oestrogens and gonadal hormones with changes in bowel motility and autonomic nervous system and gastric smooth muscle function[30], suggesting that this may be the cause of the higher incidence.

Ter Steege's study (2008) consisted of an online questionnaire for participants in the *"Enschede Marathon"* 5-, 10-, 21- and 42-km races, focusing on perception of GI symptoms during and after running. It consisted of 3 parts (a) demographics of age, gender and level of training, (b) questions on the day of the competition, which included time achieved, whether they had dropped out of the race, why, what they had drunk and eaten (type and amount) during the race, and the presence of GI symptoms, and (c) the presence of GI symptoms 24 hours after the race.

45.2% of the runners experienced GI complaints during the race, side stich being significantly more common in 10-km runners compared to 42-km runners and more common in women than in men (8.2% *vs* 1.8%). The incidence of GI problems was greater in women than it was in men in all the race categories. A greater incidence in the under-25s than in the other age groups (25-45 and over-45s) was also observed[24].

Miall *et al.* (2017) also found that the prevalence of GI symptoms was higher in women than it was in men[27]. Their study tested "gut training" as a way to avoid GI problems and carbohydrate tolerance when running.

The study consisted of three stages:

- Gut challenge trial 1: 120 minutes running exercise at 60% VO_2max whilst consuming 30 g carbohydrates every 20 minutes, and 60 minutes at maximum exertion without carbohydrate intake, but with fluid as the participants wished.
- 2 weeks of gut training: the control group ran for 60 minutes at 60% VO_2max without carbohydrate intake on 5 consecutive days (2 days of rest between week 1 and week 2); the intervention group ran for 60 minutes at 60% VO_2max on 5 consecutive days (2 days of rest between week 1 and week 2), consuming 30 g carbohydrates every 20 minutes.
- Gut challenge trial 2: repetition of trial 1. 120 minutes running exercise at 60% VO_2max whilst consuming 30 g carbohydrates every 20 min, and 60 minutes at maximum exertion without carbohydrate intake, but with fluid as the participants wished.

The fact that the gastrointestinal tract can be trained and adapted to different situations means it may be a key target when it comes to

Table 3. Prevalence (in %) of "high" and "low" GI symptoms by sex in different periods. * Significant difference between men and women.

		Long-distance runners		Cyclists		Triathletes (cycling stage)		Triathletes (running stage)	
		"High" symp.	"Low" symp.	"High" symp.	"Low" symp.	"High" symp.	"Low" symp.	"High" symp.	"Low" symp.
Rest	Men	46	66	66	73	60		84	
	Women	46	75	67	84	46		78	
During training	Men	44	84	46	**64***	44	62	49	95
	Women	46	88	79	78	48	56	59	94
2h after training	Men	23	**46***	33	**51***	19	42	29	63
	Women	51	74	51	60	24	35	35	62
During run	Men	31	**69***	53	**60***	52	47	51	76
	Women	46	74	80	69	52	43	59	83
2h after run	Men	29	**42***	45	**39***	39		60	
	Women	58	65	64	54	35		48	

improving the delivery of nutrients during exercise and relief from intestinal discomfort[31].

Mach (2016) directly relates health and athletic performance with the state of the intestinal microbiota[7]. Although the role of the microbiota in individual athletic performance is unclear, there is sufficient evidence to support the claim that exercise itself induces changes in it[7].

Training the gut consists of (a) training with large volumes of fluid in the stomach, (b) training quickly after meals, (c) training with high carbohydrate intake during exercise, (d) race simulations following a competition diet plan, and (e) an increase in the total consumption of carbohydrates in the diet[31]. All this produces physiological effects which can result in a reduction of GI symptoms and consequent improvement in athletic performance.

Training the gut aims to improve tolerance to higher volumes of fluid during exercise and consequent gastric emptying, and tolerance to greater quantities of carbohydrates and their better assimilation by different routes depending on the type of sugar in question[31].

They found a tendency to report more GI problems among women compared to all the participants, especially concerning "high" symptoms in gut challenge trial 1. Improvements were observed in the intervention group in all the stages of gut challenge trial 2, whereas no improvements were noted in the control group. A greater improvement in symptoms was also noted in men compared to women.

Miall (2017) included the participants' history of recurring GI episodes during training/competitions in their baseline characteristics and saw that they were more frequent among women than among men, thereby predisposing the former to a greater percentage of problems[27], as occurred in the cross-sectional survey in the Marikenloop study[32]. Diduch stated that sport might attenuate GI conditions, but that strenuous exercise might actually aggravate them[10].

Age was also considered an aggravating variable, with greater GI problems appearing in younger age groups than in older ones[21-24,29]. This trend was seen by Keeffe (1984), Riddoch (1988), Peters (1999), ter Steege (2008) and Wilson (2017).

The mean age of the participants in those studies which conclude that women have more GI problems was approximately[33].

Those studies which do not observe significant differences between men and women have similar designs. They consist of a prospective training/GI symptoms journal kept for 30 or 60 days, followed by a survey (retrospective) on the period recorded[26,28,29].

The only study which records nutrition in women during ultra-endurance exercise was conducted in 2015[33], only one case-study having been carried out before that[34]. It is also the only one whose design considers these nutritional aspects, one of its objectives being to study the percentage of compliance with nutritional recommendations for ultra-endurance athletes.

Wilson (2017) related other everyday aspects such as stress and anxiety levels with a higher or lower prevalence of GI problems associated with exercise. Although he did not observe any differences between men and women, he did associate, in general, higher levels of stress and anxiety with an increase in the appearance of complications[29].

He also noted that age and years of running experience were negatively correlated with GI problems. Although the correlations found cannot explain any kind of cause and effect in the associations, they are significant in the correlation analysis of the data.

The mean age of the participants in those studies which conclude that women have the same likelihood of GI problems as men was approximately[44].

In 2015, Wardenaar studied ultramarathon runners to see if they complied with the nutritional recommendations for the sport[26]. The study consisted of 3 stages, (a) a questionnaire on dietary habits 2 months before the race, (b) a questionnaire on dietary intake on the day of the 60-km run and GI symptoms before and during the competition,

and (c) continuous observation during the 120-km run (in which no women took part).

Generally speaking, the nutritional recommendations for ultra-endurance sports were not met. The women studied did not reach the protein recommendations set by the literature. Both the men and the women ingested fewer carbohydrates than those recommended in the literature. Fluid intake during the run did not cover the recommendations either, both men and women ingesting a lower percentage than recommended[26].

During the run, 82.9% of the runners reported GI discomfort (scored from 0 to 9), with no significant difference between men (81.8%) and women (87.5%). In his conclusions, Wardenaar stresses that all >0 scores were considered positive (presence of GI distress), regardless of whether it caused moderate or more severe discomfort, questioning whether the severity of these symptoms might affect athletic performance[26].

Another 2017 study by Wilson looked into the validity and reliability of retrospective questionnaires to study the frequency of chronic GI distress in runners. He combined a prospective questionnaire via a 30-day journal recording data on training and GI symptoms, and a retrospective questionnaire 30 days after completion of the journal (to study the validity of the data obtained), which was resent 24-36 hours later (to study the reliability of the data obtained) to be completed within 7 days.

The questionnaires measured the appearance of defined "high" and "low" GI symptoms on a scale of 0 to 10.

Both men and women experienced at least one GI symptom during training, but no significant gender differences were recorded (84% male, 78% female)[28]. When compared with daily journals, retrospective questionnaires seemed to offer valid and reliable information with which to quantify GI symptoms over 30 days.

The results of Stuempfle's study (2013), by contrast, suggested than women were less likely to have GI symptoms associated with exercise[25].

This study was conducted in the Javelina Jundred 100 Mile Endurance Run, a 161-km run made up of 6.5 loops of a 25-km circuit.

A questionnaire was sent to the participants 1 week before the run with a proposed diet to consume during it. Food intake before the run was not taken into account. After each loop, their body mass was measured, they were asked about food, fluid and electrolyte capsule intake, and GI symptoms (separately), and all packaging of the food consumed was collected. A week after the run, they were sent all the data collected during the run and asked to add any food, fluid or electrolyte capsules that they might have forgotten to mention during the run.

The men had more GI problems than the women (80% *vs* 20%). All the participants were of a similar age and had similar running experience, distance completed and pace. There were no significant changes in body mass among those participants who did not suffer GI symptoms, whereas there were among those who did report GI problems[25].

Stuempfle (2013) found no difference in the incidence of GI problems between men and women, although she stresses that female participation in the study was low, which may have hindered the identification of any such differences. She also names hormonal differences, nutrition during the run and difference of pace during the run as factors which may contribute to this difference[25].

Since the diet followed on the day of the competition did not correspond to the participants' usual diet, better management of nutritional strategies may have led to a lower incidence in women.

Considering that most of the competitors were possibly amateurs and nutrition during the run was not measured thoroughly, it would be interesting to have a control group with no intervention in this aspect, especially if we consider that nutrition is one of the predisposing factors for GI distress during prolonged exercise indicated by Oliveira, Burini and Jeukendrup[17].

Limitations of the studies and research

Most of the studies found focused on running as a sport related to GI problems, although others such as cycling or swimming can also cause complications of this kind, but with a lower probability[6].

One of the greatest limitations of these studies, bar one randomised controlled study, is their observational design. Another major problems is the subjectivity of the participants when defining GI symptoms, using scoring scales and perceiving exertion.

The authors themselves refer to the limitations which come with using surveys; they may be more attractive to that part of the population that has experienced gastrointestinal problems and their validity may be compromised due to their retrospective nature.

The retrospective design of the research may lead to a lack of reliability and, although Wilson has confirmed the validity and reliability of questionnaires over 30-day periods[28], some of the studies reviewed involve recalling 12 months.

For this review, only two databases were researched and 13 articles selected after the first screening could not be consulted. Critical appraisal tools were not used to determine the quality of the studies reviewed nor was double-blind screening employed.

Conclusion

The current literature does not specifically study the difference in the incidence of gastrointestinal problems associated with endurance sports by sex, but differences between men and women have been observed in studies of sports-related conditions of this type.

Hormonal differences, nutritional strategies, age and running experience would appear to be important factors which predispose females to greater digestive stress and, consequently, more gastrointestinal symptoms related to sport. Women are more liable to suffer lower GI tract conditions in the form of abdominal cramps, side stitch, flatulence, intestinal bleeding, the urge to have bowel movements and diarrhoea.

As stated, age would seem to play a protective role in the development of symptoms and the participants in those studies which did not observe significant differences between men and women were of a higher mean age than the participants in those which did. This age

difference in the groups studied may bring to the fore this protective role, thus resulting in fewer digestive problems related to exercise.

In view of everything, the main contributions of this review for future research can be specified as follows:

- Specific studies to differentiate the prevalence of GI problems by sex are essential.
- The possible causes of these conditions advanced to date need to be taken into consideration in all groups under research.
- A methodology not limited to observational studies should be designed that caters for larger-scale studies in which, in addition to observing the participants' baseline, different interventions can be performed, with control groups and taking into account factors such as hormonal differences (and state), nutrition, hydration, etc.
- These studies should be applied not only to running, but also to other endurance sports in order to observe any differences (nutrition, hydration, level of impact, duration, etc.).

Conflict of interest

The authors have no conflict of interest whatsoever.

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