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REVIEW ARTICLE

Prevalence of urinary incontinence in female CrossFit athletes: a systematic review with meta-analysis

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Abstract

Introduction and hypothesis Studies on the prevalence of urinary incontinence (UI) among CrossFit practitioners are on the rise. This systematic review with meta-analysis was aimed at determining the prevalence of UI among CrossFit practitioners.

Methods A systematic review of the literature was performed by searching MEDLINE/PubMed, Scopus, and SPORTDiscus through January 2021. The search strategy included the keywords CrossFit, urine incontinence, exercise, high impact and pelvic floor dysfunction. The inclusion criterion was any study with a sample of CrossFit practitioners and results separated from the other fitness modalities analysed. The subjects were women with no restriction of age, parity, experience or frequency of training. Quality assessment of the studies included was conducted using the Oxford Centre of Evidence-Based Medicine scale and the Newcastle–Ottawa Scale (NOS) adapted for cross-sectional studies.

Results Thirteen studies (6 comparative and 7 non-comparative) were included for the systematic review, all using a cross-sectional design. The level of evidence was 4, with their quality ranging from poor ($n = 10$) to fair ($n = 3$). A total of 4,823 women aged 18 to 71 were included, 91.0% participated in CrossFit, and 1,637 presented UI, which indicates a prevalence of 44.5%. Also, 55.3% and 40.7% presented mild or moderate UI respectively. Stress UI was the most common type reported (81.2%).

Conclusions The factors that increased the likelihood of UI were age, body mass index and parity. Exercises based on jumps were commonly associated with urine leakage. CrossFit practitioners presented higher UI than control groups.

Keywords Fitness · High-intensity functional training · Pelvic floor · Stress incontinence · Women's health

Introduction

CrossFit is an exercise regimen that has become the biggest fitness trend of the twenty-first century, and it is now considered a multi-million-dollar industry [1]. Despite its growing success and reported beneficial effects, current literature has questioned the safety of CrossFit practice based on a considerable injury risk owing to the high intensity at which exercises must be performed [2].

Regrettably, the potentially harmful effects of CrossFit practice might not end here. This fitness modality proposes the performance of high-intensity exercises executed repeatedly that demand high-impact movements. This training pattern may cause an increase in intra-abdominal pressure that in turn leads to an overload on the pelvic muscle floor [3, 4]. In addition, as there are few or no rest pauses during and between CrossFit workouts, neuromuscular fatigue is relatively present. This combination of increased intra-abdominal pressure, neuromuscular fatigue, and overloaded pelvic floor musculature due to strenuous exercise might lead to involuntary urine leakage, i.e. urinary incontinence (UI) [5]. Besides, other training characteristics common in CrossFit practitioners, such as the volume of weekly practice or the performance of heavy weightlifting exercises, can also be

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considered a predisposing factor for UI, especially among competitors [6, 7].

Studies on CrossFit users' profiles have indicated the existence of a high body mass index (BMI) among them, with mean values around 25 $kg \cdot m^{-2}$, and have also shown that people up to 58 years old are involved in its practice [8]. Similarly, there seems to be a considerable prevalence of multiparous women among CrossFit athletes [9]. As age and BMI have been identified as risk factors for sustaining UI, alongside parity, it is plausible that CrossFit could be associated with urine leakage among some practitioners [10].

Urinary incontinence may cause embarrassment and affect performance and quality of life [11]. It can also discourage people from participating in sport and exercise [7]. Thus, quality and up-to-date information concerning the existing risk of UI among CrossFit practitioners should be available to CrossFit trainers and sports fitness advisors in general. This goal can be achieved by conducting systematic reviews that synthesize and summarize the scientific evidence on the subject. Although several systematic reviews on the prevalence of UI among sports practitioners have been published [4, 5, 11–14], to our knowledge, none of them has provided specific information or have particularly focused on CrossFit so far. In the light of all the above issues, this systematic review and meta-analysis was aimed at determining the prevalence of UI and associated risk factors among CrossFit practitioners.

Materials and methods

A systematic review was carried out following the latest Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [15]. The PRISMA 2020 27-item checklist is presented in Appendix 1. A protocol for this review is registered with the Open Science Framework (OSF), https://doi.org/10.17605/OSF.IO/EQ4YX.

Search strategy

The following electronic databases were searched from their respective inceptions through January 2022: MEDLINE/PubMed, SPORTDiscus and Scopus. The following search terms, Boolean operators, and combinations were used: “CrossFit” (keyword alone) OR “Urine Incontinence” AND “Exercise” OR “Urine Incontinence” AND “High Impact” OR “Pelvic floor dysfunction” AND “Exercise”. Search strategies can be found in Appendix 2.

Eligibility criteria

To be selected for further analysis, the studies had to meet the following selection criteria:

1. To include CrossFit practitioners in their sample regardless of their age and sex.
2. To provide information on UI prevalence, severity and/or associated risk factors.
3. To be an observational or cross-sectional investigation.

Studies were excluded if:

1. The sample included athletes from several fitness or sport modalities and separate results were no provided for CrossFit practitioners.
2. The full text of the study was not available.
3. The research was not published in a peer-reviewed journal written in English, Portuguese or Spanish language.
4. The research was a review, a case report, a doctoral thesis, a letter to the editor or a conference abstract.

Study selection

Titles and abstracts of search results were screened for relevance, with full-text versions of potentially relevant articles obtained and assessed for inclusion. Eligibility was assessed independently by two authors with discrepancies resolved through discussion with a third researcher. The reference lists of the selected articles, as well as studies that quoted them, were checked for potential articles eligible for this review.

Data extraction

Information on CrossFit practitioners (mean age, parity, number of years performing CrossFit, recreational/competitive status), variables assessed (prevalence, severity and type of UI), associated factors with UI and outcomes were extracted from the original reports by one researcher and checked by a second investigator. Missing data were obtained from the study authors whenever possible.

Quality appraisal

According to a previous study [12], two researchers independently rated the quality of evidence according to the Oxford Centre of Evidence-Based Medicine (OCEBM) scale [16]. The assessment considered the thematic area and the type of the study, grading the evidence based on the best design for the “symptom prevalence study” scenario. Moreover, the quality of the included studies was evaluated as good, fair or poor based on thresholds described previously [17], using the Newcastle–Ottawa Scale adapted for cross-sectional studies [18]. The inconsistencies in coding process and quality assessment between the two researchers were resolved by consensus.

Statistical analysis

Data extracted from the articles were processed in an Excel spreadsheet, and we performed the statistical analysis using RevMan v5.4.1 software. We calculated the odds ratio (OR) with 95% confidence interval (CI) for dichotomous variables using a random-effects Mantel–Haenszel model. We used inverse variance or generic inverse variance to report mean differences for continuous data and their 95% CIs. We assessed heterogeneity using the Chi-squared test and I^2 test.

Results

Study selection

On the one hand, in identifying studies via databases and registers, 36,644 records were found (PubMed, Scopus and SPORTDiscus). After eliminating duplicates, 31,532 records were selected, of which 30,723 were excluded based on their title and abstracts. Thereafter, 15 full-text documents were reviewed, and 3 more documents were excluded. One was a commentary on a paper by Forner et al., entitled "Do women runners report more pelvic floor symptoms than women in CrossFit? A cross-sectional survey" [19]. Further, the study by Lúdvíksdóttir et al. [20] did not clarify whether CrossFit practitioners performed other sports activities concurrently. Another study analysed CrossFit training during the COVID-19 quarantine [21], so their participants were conditioned by the availability of home equipment. On the other hand, an additional record was identified through a website and assessed for eligibility. In the last stage, a total of 13 articles were included for the systematic review (Fig. 1).

Designs and samples

The studies were categorised into comparative ($n = 6$) [22–27] and non-comparative ($n = 7$) [7, 9, 28–32]. All of them used a cross-sectional design. The pooled sample size was 4,823 individuals with 91% in the CrossFit group; all participants were females. The sample was composed of adults (18–71 years of age), and the mean age was 31.1 years.

Methodological quality assessment

Table 1 details the design of the studies, if they performed sample calculation and their sources of bias. It also reflects that all studies showed a level of evidence 4, because they

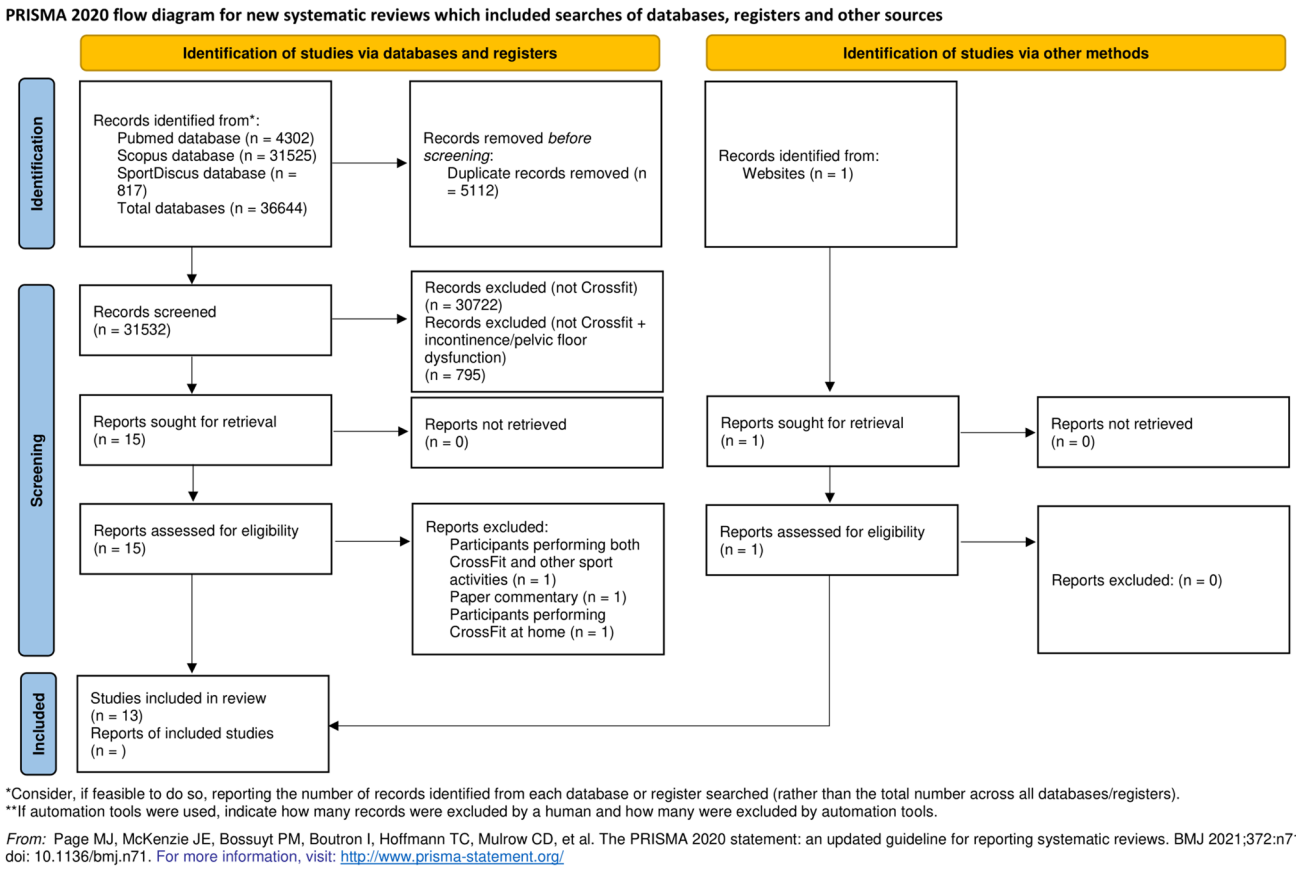

Fig. 1 Flow diagram of the search and selection process for the inclusion of articles

were cross-sectional studies. Thus, the respective grade of recommendation is C, based on the criteria set forth by the OCEBM [16].

Furthermore, a summary of the quality assessment using the Newcastle–Ottawa Scale adapted for cross-sectional studies is shown in Table 2. The 13 included studies obtained fair or poor ratings. In the selection domain, ascertainment of exposure was well demonstrated across all studies. On the contrary, none of the included studies disclosed the response rate. Seven studies were considered somewhat representative of the average in the target population; however, the remaining six were based on a selected group of users. Also, only six studies conducted power analysis for sample size estimation or justified their sample size. Regarding comparability, controlling for age was deemed the most important factor, followed by parity or body mass index. Six of the studies controlled for a combination of these factors, whereas the other seven studies lacked adjustment for possible confounders. In the outcome domain, the 13 studies performed well in

Table 1 Methodological quality assessment

Reference	OCEBM level of evidence	Study design	Sample size calculation	Sources of bias
Comparative studies				
Elks et al. [22]	4	Cross-sectional	Yes	Selection bias (i.e. voluntary response); unequal group size; self-reported data; exercise intensity was not controlled; inability to assess the survey participation rate
Forner et al. [23]	4	Cross-sectional	No	Selection bias (i.e. voluntary response); unequal group size; self-reported data; lack of questions about urine leakage during CF exercises; inability to assess the survey participation rate
Khowailed et al. [27]	4	Cross-sectional	No	Selection bias (i.e. voluntary response); small sample size; self-reported data; multigravida women were not adequately controlled; inability to assess the survey participation rate
De Machado et al. [26]	4	Cross-sectional	Yes	Selection bias (i.e. only nulliparous women aged between 18 and 35 years with a body mass index ≤ 30 kg/m^2 were included; the folder disclosure was carried in a single institution of higher education); small sample size; sample size calculation based on a measure not used in the study; self-reported data; the recruitment rate was not assessed
Middlekauff et al.[25]	4	Cross-sectional	Yes	Selection bias (i.e. only nulliparous women aged between 18 and 35 years were included); self-reported data; the recruitment rate was not assessed
Yang et al. [24]	4	Cross-sectional	No	Selection bias (i.e. regional sample; voluntary response; some women did not participate in specific exercises); small sample size; unequal group size; self-reported data; the recruitment rate was not assessed
Non-comparative studies				
Poli De Araújo et al. [28]	4	Cross-sectional	Yes	Selection bias (i.e. voluntary response; heterogeneity of CF training experience); questionnaire not validated; self-reported data; inability to assess the survey participation rate
Dias et al. [29]	4	Cross-sectional	No	Selection bias (i.e. recruitment from a single CF centre; voluntary response; included women with only 1 month of CF practice); small sample size; the recruitment rate was not assessed
High et al. [9]	4	Cross-sectional	No	Selection bias (i.e. voluntary response); self-reported data; inability to assess the survey participation rate
Lopes et al. [30]	4	Cross-sectional	No	Selection bias (i.e. recruitment from only two CF centres; only women aged between 18 and 35 years were included; voluntary response; the majority of the sample had less than 1 year of experience in CF training); small sample size; self-reported data; the recruitment rate was not assessed
Pisani et al. [31]	4	Cross-sectional	No	Selection bias (i.e. voluntary response); self-reported data; inability to assess the survey participation rate
Pisani et al. [32]	4	Cross-sectional	No	Selection bias (i.e. voluntary response); self-reported data; inability to assess the survey participation rate
Wikander et al. [7]	4	Cross-sectional	No	Selection bias (i.e. competitive women CF participants were included; voluntary response); self-reported data; inability to assess the survey participation rate

Abbreviations: CF CrossFit, *OCEBM* Oxford Centre of Evidence-Based Medicine, *UI* urinary incontinence

Table 2 Newcastle–Ottawa Scale, adapted for quality assessment of cross-sectional studies

Reference	Selection (maximum 5 stars)				Comparability (maximum 2 stars)[a]	Outcome (maximum 3 stars)		Quality rating (maximum 10 stars)[b]
	Representativeness of the sample (☆)	Sample size (☆)	Non-respondents (☆)	Ascertainment of the exposure (☆☆)	Based on design and analysis (☆☆)	Assessment of the outcome (☆☆)	Statistical test (☆)	
Elks et al. [22]	☆	☆		☆	☆☆	☆		Poor (6/10 stars)
Forner et al. [23]	☆			☆		☆		Poor (3/10 stars)
Khowailed et al. [27]				☆		☆		Poor (2/10 stars)
De Machado et al. [26]		☆		☆		☆		Poor (3/10 stars)
Middlekauff et al. [25]	☆	☆		☆		☆		Poor (4/10 stars)
Yang et al. [24]				☆	☆☆	☆	☆	Poor (5/10 stars)
Poli De Araújo et al. [28]	☆	☆		☆	☆☆	☆	☆	Fair (7/10 stars)
Dias et al. [29]				☆		☆		Poor (2/10 stars)
High et al. [9]	☆			☆	☆☆	☆	☆	Poor (6/10 stars)
Lopes et al. [30]				☆		☆	☆	Poor (3/10 stars)
Pisani et al. [31]	☆	☆		☆	☆☆	☆	☆	Fair (7/10 stars)
Pisani et al. [32]	☆	☆		☆	☆☆	☆	☆	Fair (7/10 stars)
Wikander et al. [7]				☆		☆		Poor (2/10 stars)

Abbreviations: max, maximum [a]One ☆ was allocated if the study adjusted for age, with an additional ☆ given if adjusted for parity or body mass index

[b]Scores were allocated for urinary incontinence outcomes. Good quality: 4–5 stars in the selection domain, 1–2 stars in the comparability domain, and 2–3 stars in the outcome domain. Fair quality: 3 stars in the selection domain, 1–2 stars in the comparability domain and 2–3 stars in the outcome domain. Poor quality: 1–2 stars in the selection domain or 0 stars in the comparability domain or 0–1 star(s) in the outcome domain

assessment of the UI outcomes. Finally, seven of the studies did not perform well in statistical tests, as they did not provide confidence intervals. Overall, 10 out of 13 studies achieved a poor quality rating, whereas 3 studies received a fair quality rating.

Overview of study characteristics

Ten studies (77%) were aimed at determining the prevalence of UI among CrossFit practitioners, whereas the remaining three (23%) analysed prevalence data as a secondary outcome. Great heterogeneity was detected, mainly because different questionnaires were used and because of the lack of a standardised definition of UI. The severity and type of UI were analysed in five and six investigations respectively. Again, heterogeneity was observed in the questionnaires and classifications employed to collect data. Only two out of the five studies that included UI severity as an outcome used a standard definition, which was adapted from the International Urogynecological Association and the International Continence Society. Four investigations administered the Incontinence Symptoms Severity Index, whereas the remaining study used the International Consultation of Incontinence Questionnaire-Short Form (ICIQ-SF). All studies included parity information, and only one article reported data on the prevalence of UI before the beginning of CrossFit practice.

The following variables related to CrossFit practice were included in the scientific literature: training load ($n = 10$), CrossFit experience ($n = 9$), most common exercises associated with UI ($n = 6$) and competitive experience ($n = 2$). Hardly any associations between these factors and UI were found, except for the type of exercise performed. A total of seven investigations revealed that CrossFit exercises based on jumps (single jump rope and double unders, as well as box jumps) increased the likelihood of urine leakage. The characteristics and main findings of the studies reviewed are depicted in Table 3 (comparative studies) and Table 4 (non-comparative studies).

Prevalence, severity and types of UI among CrossFit practitioners

From a total of 3,682 CrossFit practitioners assessed, 1,637 presented UI, which indicates a prevalence of 44.46%. The severity of UI was noted in five studies. A total of 55.3% and 40.7% of

the cases were deemed as mild or moderate UI respectively. Stress UI (SUI) was the most common type reported (81.2%) based on the six studies that provided data on this matter.

Meta-analysis

Findings from the six comparative studies indicated that participants were younger in control groups than in CrossFit groups, with a mean difference of 2.11 years (95% CI 1.38–2.83, $p < 0.001$), and had a lower BMI, with a mean difference of 1.03 $kg{\cdot}m^{-2}$ (95% CI 0.67–1.39, $p < 0.001$). In both cases there was substantial heterogeneity among studies ($I^2 = 92\%$ for age and $I^2 = 81\%$ for BMI, $p < 0.001$ for both comparisons).

When comparing the prevalence of UI, higher odds of presenting UI in the CrossFit groups than in the control groups (OR 1.49; 95% CI 1.24–1.79, $p < 0.001$) were identified. A considerable heterogeneity among studies was found ($I^2 = 91\%$, $p < 0.001$; Fig. 2).

The meta-analysis performed by pooling data from CrossFit practitioners showed that those reporting UI were older, with a mean difference of 2.02 years (95% CI 1.24–2.80, $p < 0.001$; moderate heterogeneity, $I^2 = 46\%$, $p = 0.14$). Also, CrossFit practitioners presenting UI had a higher BMI, with a mean difference of 0.31 $kg{\cdot}m^{-2}$ (95% CI 0.02–0.60, $p = 0.03$; substantial heterogeneity, $I^2 = 78\%$, $p = 0.003$). Parity was also related to UI, as athletes reporting UI had higher odds of having an antecedent of parity (OR 2.58, 95% CI 2.05–3.26; $p < 0.001$; moderate heterogeneity, $I^2 = 51\%$, $p = 0.13$).

Discussion

This systematic review was aimed at synthesising and critically revising the currently available scientific evidence regarding the prevalence of UI among CrossFit practitioners. The results obtained mainly came from studies that showed a low to fair methodological quality, limiting the applicability of the data analysed. Nevertheless, some interesting findings are worthy of discussion.

After pooling the data of the 13 investigations reviewed, a UI prevalence of around 45% was revealed in the first place. Studies on the presence of UI among the general female population have shown a wide range of prevalence rates. For instance, judging from the data presented in the review by Hunskaar et al. [33], UI affected between 12–42% of women below the age of 60 years, whereas, based on the results of the epidemiological survey performed by Hannestad et al. [34], a mean prevalence of around 25% was reported. A more recent review indicated a prevalence of UI ranging from 5% to 70% after analysing several population studies from different countries [35]. This disparity in UI prevalence can be attributed to differences in the methodological design and especially to different UI definitions. For instance, according to relevant and well-designed studies on the epidemiology of UI that used standardised definitions and validated questionnaires, the prevalence of UI was around 25–27% [36], which would indicate that CrossFit practitioners are more likely to present UI than women in general.

Nevertheless, prevalence rates are also affected by the target population's characteristics. Therefore, data obtained from studies with similar samples enable a more accurate discussion of the prevalence of UI observed in the present review. In this regard, population-based studies in women of around the same age interval as in the reviewed investigations indicated a prevalence ranging from 6% [37] to 42.5% [38]. Findings from meta-analyses on female athletes have pointed out a weighted average of 26–36% of UI prevalence [5, 13]. According to the data obtained in the present review, CrossFit seems to exhibit a moderate prevalence rate that somehow falls between sports with low percentages such as cycling (10%) or swimming (15%) and high-impact modalities such as volleyball (57.5%), gymnastics (61%) or trampoline (>80%) [11, 12].

Strenuous exercise has been cited as a risk factor for developing symptoms of SUI [14]. The pooled data confirmed that SUI was the most prevalent type, according to previous findings in female athletes [39] and among women who exercised regularly [40].

Our meta-analysis also showed that CrossFit practitioners had higher odds of presenting UI in comparison with the control groups included in the comparative studies reviewed. The latter is somehow an expected finding, previously reported in investigations comparing female athletes with the general population [12, 13, 41]. However, the OR results must be interpreted cautiously as significant differences in age and body composition were found between the two groups. Therefore, no causal relationship can be extracted from the data analysed as significant differences in age and body composition were found between the groups. Moreover, only one of the studies reviewed informed the prevalence of UI before women started CrossFit practice.

Age, parity and BMI are well-known risk factors for UI for several reasons. The striated urethral sphincter, which is considered a major contributor to urinary continence control (since it provides a direct closure force at the mid-urethra), experiences a decline in its function with age owing to a decrease in its relative volume [42]. Parity is consistently related to UI because of disruption of pelvic floor structures and to denervation, which cause a drop in the pelvic muscle floor functionality, especially after the first vaginal delivery [43]. Body mass index has been linked to intra-abdominal pressure and intravesical pressure, which overcomes urethral closing pressure and leads to incontinence [44]. In addition, oxidative stress from visceral adipose tissue is likely to have a negative effect on the collagen and supportive structures of the pelvic floor, which confer continence [45]. Our meta-analysis indicates that these three factors are associated with UI among CrossFit practitioners. These results can help trainers to identify women who are more prone to presenting this problem and to develop preventive strategies. In this regard, controlling contributing factors such as eating disorders, smoking or caffeine and alcohol consumption are recommended. Athletes should also be encouraged to avoid excessive fluid consumption and void shortly before training and include specific exercises to strengthen the pelvic floor musculature in their routines [46].

Table 3 Comparative studies assessing urinary incontinence (UI) among female CrossFit practitioners (CFG) and control participants (CG)

Reference, country and sample	Variables (tools)	Participants with UI, severity and type	Factors associated with UI	Comparative results CFG-CG
Elks et al. [22], USA				
423 women (mean age; range):	Prevalence:	Women with UI (*n*):	Multiparity	Prevalence (proportion of each group; *p* value):
CFG: $n = 322$ (38; 30–45 years)	UDI-6	CFG: 256	Vaginal delivery	UI: CFG 84% vs CG 48%; $p < 0.001$
CG: $n = 101$ (31; 26.5–39.5 years)	POPDI-6	Severity (*n*):	Postmenopausal status	Severity (proportion of each group; *p* value):
Parity (*n*):	Severity:	Slight: 133	Body mass index	Slight: CFG 44% vs CG 34%; $p < 0.001$
CFG: 3	ISI	Moderate: 116	Pelvic surgery	Moderate: CFG 38% vs CG 14%; $p < 0.001$
CG: 3	Type:	Severe: 7	CF exercises (*n*; proportion of CFG):	Severe: CFG 2% vs CG 0%; $p < 0.001$
CF experience: NR	Specific items	Type (*n*):	Jump rope DU: 166; 65%	Type (proportion of each group; *p* value):
Competitive status: NR		SUI: 186		SUI: CFG 73% vs CG 47%; $p < 0.001$
		UUI: 140		UUI: CFG 55% vs CG 42%; $p = 0.02$
		MUI: 128		MUI: CFG 50% vs CG 31%; $p < 0.001$
Forner et al. [23], Australia				
1,379 women (mean age ± SD):	Prevalence:	Women with UI: NR	Parity	Prevalence (proportion of each group):
CFG: $n = 858$ (38.5 ± 8.8 years)	UDI-6	Severity: NR		UI: CFG 50.4 % vs CG 51.6 %
CG: $n = 521$ (38.4 ± 9.2 years)	CRADI-8	Type (*n*):		Severity: NR
Parity (*n*):	POPDI-6	SUI: 355		Type (proportion of each group; *p* value):
CFG: 433	Severity: NR	UUI: 208		SUI:
CG: 295	Type:	MUI: 410		Parous: CFG 51.5% vs CG 8.1%; $p = 0.362$
CF experience: NR	UDI-6			Nulliparous: CFG 30% vs CG 23.9 %; $p = 0.098$
Competitive status: NR				UUI:
				Parous: CFG 29% vs CG 36.3%; $p = 0.037$
				Nulliparous: CFG 19% vs CG 21.7%; $p = 0.413$
				MUI:
				Parous: CFG 57.3% vs CG 57.3%; $p = 0.997$
				Nulliparous: CFG 37.2% vs CG 34.5%; $p = 0.502$
Khowailed et al. [27], USA				
14 women (mean age; range)	Prevalence:	Women with UI (*n*):	Parity	Prevalence (proportion of each group; *p* value):
CFG: $n = 9$ (29; 18–40 years)	Carls' UI survey	CFG: 6	CF exercises (*n*; proportion of CFG):	CFG > CG; $p = 0.023$
CG: $n = 5$ (29; 18–40 years)	Severity: NR	CG: 2	Jumps: 7; 77.8%	Severity: NR
Parity (*n*): 4	Type: NR	Severity: NR	Running: 6; 66.7%	Type: NR

Table 3 (continued)

Reference, country and sample	Variables (tools)	Participants with UI, severity and type	Factors associated with UI	Comparative results CFG-CG
CF experience: NR		Type: NR	Lifting: 3; 33.3%	
Competitive status: NR				
De Machado et al. [26], Brazil				
41 women (mean age ± SD)	Prevalence:	Women with UI (*n*):	CF exercises (*n*):	Prevalence (proportion of each group; *p* value):
CFG: *n* = 20 (27.4 ± 3.7 years)	ICIQ-SF	CFG: 12	Jumps: NR	UI: CFG 60% vs CG 9.5%; $p < 0.001$
CG: *n* = 21 (25.8 ± 3.4 years)	Severity:	Severity (*n*):	Lifting: NR	Severity (proportion of each group):
Parity (*n*): 0	ICIQ-SF	Mild: 2		Mild: CFG 9.5% vs CG 0%
CF experience (mean; range):	Type: NR	Moderate: 10		Moderate: CFG 50% vs CG 9.5%
22; 6–60 months		Severe: 0		Severe: 0
Competitive status (*n*):		Very severe: 0		Very severe: 0
CFG = 12		Type: NR		Type: NR
Middlekauff et al.[25],, USA				
70 women (mean age ± SD)	Prevalence:	Women with UI (*n*):	No statistically significant associations were found	Prevalence (proportion of each group):
CFG: *n* = 35 (26.8 ± 3.8 years)	EPIQ and POP-Q	CFG: 9		UI: CFG 27.7% vs CG 8.5%
CG: *n* = 35 (22.7 ± 3.9 years)	Severity: NR	Severity: NR		Severity: NR
Parity (*n*): 0	Type: NR	Type: NR		Type: NR
CF experience (mean ± SD):				
22.1 ± 12.3 months				
Competitive status: NR				
Yang et al. [24], USA				
149 women (mean age):	Prevalence:	Women with UI (*n*):	Parity	Prevalence (proportion of each group):
CFG: *n* = 105 (36.9 years)	ISSI	CFG: 53	Vaginal delivery	UI: CFG 55.6% vs CG 31.8%
CG: *n* = 44 (29.0 years)	Severity:	Severity (*n*):	CF exercises (*n*; proportion of CFG):	Severity: NR
Parity (*n*):	ISSI	Mild: 34	Jump rope DU: 50; 94.3%	Type: NR
CFG: 67	Type: NR	Moderate to severe: 19	Jump rope SU: 43; 81.1%	
CF experience: NR		Type: NR	Box jump: 30; 56.6%	
Competitive status: NR				

Abbreviations: CF CrossFit, *CRADI-8* Colorectal–Anal Distress Inventory-8, *DU* double unders, *EPIQ* Epidemiology of Prolapse and Incontinence Questionnaire, *ISI* Incontinence Severity Index, *ISSI* Incontinence Symptom Severity Index, *MUI* mixed urinary incontinence, *NR* not reported, *POPDI-6* Pelvic Organ Prolapse Distress Inventory-6, *POP-Q* Pelvic Organ Prolapse Quantifications System, *SU* single unders, *SUI* stress urinary incontinence, *UDI-6* Urinary Distress Inventory-6, *UUI* urgency urinary incontinence

Trainers should also pay attention to the selection of exercises for each workout of the day. This review revealed that specific CrossFit exercises, mainly those based on jumps, were frequently associated with UI. This fact might be the consequence of an increase in intra-abdominal pressure resulting from the performance of high-impact activities that, in turn, overload the pelvic floor. In addition, the force reaction of the feet with the ground transfers that shock to the pelvic organs, predisposing them to UI [13].

Several limitations should be accounted for when interpreting the findings of this review. First, considerable heterogeneity was detected in the studies. Second, data mostly came from cross-sectional designs through convenience sampling. Third, information on several confounding factors such as the use of hormones, types of birth or gynaecological surgeries was seldom given. Fourth, studies included only women. Finally, the existence of certain methodological limitations inherent to the review design (e.g. language restrictions, not having reviewed

Table 4 Non-comparative studies assessing urinary incontinence (UI) among female CrossFit practitioners

Reference, country and sample	Variables (tools)	Participants with UI, severity and type	Risk factors
Poli De Araújo et al. [28], Brazil			
551 women	Prevalence: NR	Women with UI (*n*): 165	Age
Mean age ± SD; range: 31.8 ± 7.4; 16–64 years	Severity: NR	Severity: NR	CF exercises (*n*; proportion of those with UI):
Parity (*n*): 175	Type: NR	Type: NR	Jump rope DU: 111; 67.3%
CF experience of parous women (*n*):			Jump rope SU: 44; 26.7%
< 6 months: 38			
7–23 months: 20			
24+ months: 117			
Competitive status: NR			
Dias et al. [29], Brazil			
34 women	Prevalence:	Women with UI (*n*): 5	Multiparity
Mean age ± SD: 30.3 ± 6.4 years	Questionnaire by researchers	Severity: NR	Vaginal delivery
Parity (*n*): 8	Severity: NR	Type (*n*):	CF training frequency
CF experience (*n*):	Type:	UUI: 3	
< 6 months: 8	Questionnaire by researchers		
7–23 months: 20			
24+ months: 6			
Competitive status: NR			
High et al. [9], USA			
314 women	Prevalence:	Women with UI (*n*): 82	Parity
Mean age ± SD; range: 36 ± 10; 20–71 years	PFDI-20	Severity: NR	Vaginal delivery
Parity (*n*): 180	IIQ	Type (*n*):	Age
CF experience (mean ± SD): 46 ± 30 months	ICIQ-SF	SUI: 49	
Competitive status: NR	Severity: NR	UUI: 42	
	Type: ICIQ-SF		
Lopes et al. [30], Brazil			
50 women	Prevalence:	Women with UI (*n*): 10	No statistically significant associations were found
Mean age ± SD; range: 28.6 ± 4.5; 18–35 years	ICIQ-SF	Severity: NR	
Parity (*n*): 3	Severity: NR	Type (*n*):	
CF experience (*n*):	Type:	SUI: 8	
< 12 months: 29	ICIQ-SF	UUI: 1	
12–24 months: 9		MUI: 1	
24+ months: 12			
Competitive status: NR			
Pisani et al. [31], Brazil			
828 women	Prevalence:	Women with UI (*n*): 298	Gestation
Mean age ± SD: 31.4 ± 7.6 years	ICIQ-SF	Severity of urine loss amount (*n*):	Multigravida
Parity (*n*): 98	Severity: NR	Small: 268	History of:
CF experience (*n*):	Type:	Moderate: 25	Sexual dysfunction
< 6 months: 37	ICIQ-SF	Large: 5	Pelvic organ prolapses
6–12 months: 60		Type (*n*):	Vaginismus
12–24 months: 115		SUI: 263	Dyspareunia
24+ months: 86		UUI: 16	
Competitive status: NR		MUI: 19	
Pisani et al. [32], Brazil			
828 women	Prevalence:	Women with UI (*n*): 298	Vaginal delivery: ×2.1 risk
Mean age ± SD: 30.6 ± 6.6 years	ICIQ-SF	Severity: NR	CF training frequency >5/week: ×3 risk
Parity (*n*): 212	Severity: NR	Type (*n*):	CF exercises (*n*; proportion of those with UI):
CF experience (*n*):	Type:	SUI: 263	Jump rope DU: 152; 51.0%
< 6 months: 98	ICIQ-SF	UUI: 16	Jump rope SU: 100; 33.6%

Table 4 (continued)

Reference, country and sample	Variables (tools)	Participants with UI, severity and type	Risk factors
6–12 months: 173		MUI: 19	Box jump: 63; 21.1%
12–24 months: 313			Running: 38; 12.8%
24+ months: 244			Front squat: 30; 10.0%
Competitive status (*n*):			
0 participations/year: 499			
1 participations/year: 174			
2 participations/year: 101			
>2 participations/year: 54			
Wikander et al. [7], Australia			
452 women	Prevalence: NR	Women with UI (*n*): 208	Multiparity
Mean age ± SD; range: 36 ± 9; 20–63 years	Severity:	Severity (*n*)[c]:	Exercises (*n*; proportion of those with UI):
Parity: NR	ISI	Slight: 89	Jump rope SU: 177; 85.1%
CF experience:	Type: NR	Moderate: 83	Jump rope DU: 167; 80.8%
Type 1 ($n = 44$)[a]: 4.4 ± 2.5 years		Severe: 6	Running: 93; 44.7%
Type 2 ($n = 36$)[b]: 3.7 ± 2.4 years		Very severe: 5	Box jump: 85; 40.9%
Competitive status: NR		Type: NR	Deadlift: 62; 29.8%
Previous UI (*n*; proportion): 189; 41.8%			Back squat: 57; 27.4%
			Front squat: 54; 26.0%

Abbreviations: CF CrossFit, *DU* double unders, *ICIQ-SF* International Consultation on Incontinence Questionnaire Short-Form, *ISI* Incontinence Severity Index, *IIQ* Incontinence Impact Questionnaire, *MUI* mixed urinary incontinence, *NR* not reported, *PFDI-20* Pelvic Floor Distress Inventory Short Form-20, *SU* single unders, *SUI* stress urinary incontinence, *UUI* urgency urinary incontinence

[a]UI prior to CF practice, during daily activities but not during training or competitions

[b]UI prior to CF practice, not during daily activities but during training

[c]The total number of participants reporting the severity of their UI ($n = 183$) differs from the total number of participants reporting UI ($n = 208$)

grey literature or publication bias) should be considered as well, as they may have conditioned the present results.

In summary, the prevalence of UI among CrossFit practitioners was found to be around 45%. Age, body mass index and parity appeared to be factors that increased the likelihood of UI, whereas exercises based on jumps were commonly associated with urine leakage. In comparison with control groups, CrossFit practitioners showed higher odds of presenting UI. Nevertheless, it should be taken into account that the scientific evidence found came from observational studies with great heterogeneity and wide confidence intervals. These features can result in inconsistency and imprecision in the reported outcomes. In addition, limitations with the design and execution of the study were also present as not all the investigations included a comparison group. Moreover, in very few studies, the prevalence of UI was compared before and after undergoing a CrossFit training program. Thus, the current findings must be interpreted within the context of a low quality of evidence [47]. According to the above issues, it is very difficult to draw solid conclusions to confirm whether the practice of CrossFit should not be recommended based on an increased risk of sustaining UI Table 5.

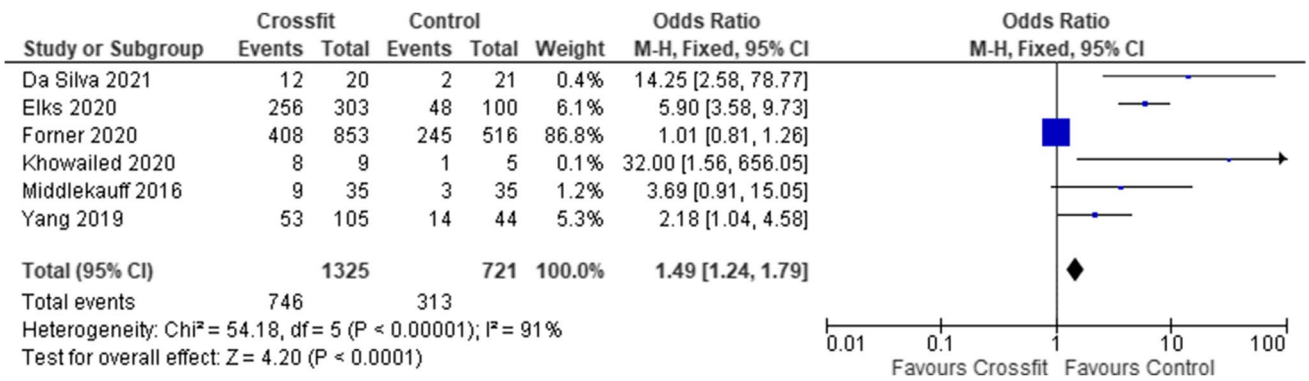

Fig. 2 Total prevalence of urinary incontinence among CrossFit practitioners

Appendix 1

Table 5 Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 27-item checklist

Section and topic	Item #	Checklist item	Page/document
Title			
Title	1	Identify the report as a systematic review	Title page
Abstract			
Abstract	2	See the PRISMA 2020 for Abstracts checklist	1–2
Introduction			
Rationale	3	Describe the rationale for the review in the context of existing knowledge	3–4
Objectives	4	Provide an explicit statement of the objective(s) or question(s) the review addresses	4
Methods			
Eligibility criteria	5	Specify the inclusion and exclusion criteria for the review and how studies were grouped for the syntheses	4–5
Information sources	6	Specify all databases, registers, websites, organisations, reference lists and other sources searched or consulted to identify studies. Specify the date when each source was last searched or consulted	26
Search strategy	7	Present the full search strategies for all databases, registers and websites, including any filters and limits used	4, Appendix 2
Selection process	8	Specify the methods used to decide whether a study met the inclusion criteria of the review, including how many reviewers screened each record and each report retrieved, whether they worked independently, and if applicable, details of automation tools used in the process	5
Data collection process	9	Specify the methods used to collect data from reports, including how many reviewers collected data from each report, whether they worked independently, any processes for obtaining or confirming data from study investigators, and if applicable, details of automation tools used in the process	5
Data items	10a	List and define all outcomes for which data were sought. Specify whether all results that were compatible with each outcome domain in each study were sought (e.g. for all measures, time points, analyses), and if not, the methods used to decide which results to collect	5
	10b	List and define all other variables for which data were sought (e.g. participant and intervention characteristics, funding sources). Describe any assumptions made about any missing or unclear information	5
Study risk of bias assessment	11	Specify the methods used to assess risk of bias in the studies included, including details of the tool(s) used, how many reviewers assessed each study and whether they worked independently, and if applicable, details of automation tools used in the process	5
Effect measures	12	Specify for each outcome the effect measure(s) (e.g. risk ratio, mean difference) used in the synthesis or presentation of results	5–6
Synthesis methods	13a	Describe the processes used to decide which studies were eligible for each synthesis (e.g. tabulating the study intervention characteristics and comparing against the planned groups for each synthesis (item #5))	NR
	13b	Describe any methods required to prepare the data for presentation or synthesis, such as handling of missing summary statistics, or data conversions	NR
	13c	Describe any methods used to tabulate or visually display results of individual studies and syntheses	NR
	13d	Describe any methods used to synthesise results and provide a rationale for the choice(s). If meta-analysis was performed, describe the model(s), method(s) used to identify the presence and extent of statistical heterogeneity, and the software package(s) used	5–6
	13e	Describe any methods used to explore possible causes of heterogeneity among study results (e.g. subgroup analysis, meta-regression)	6
	13f	Describe any sensitivity analyses conducted to assess the robustness of the synthesised results	NR
Reporting bias assessment	14	Describe any methods used to assess risk of bias due to missing results in a synthesis (arising from reporting biases)	NR

Table 5 (continued)

Section and topic	Item #	Checklist item	Page/document
Certainty assessment	15	Describe any methods used to assess certainty (or confidence) in the body of evidence for an outcome	NR
Results			
Study selection	16a	Describe the results of the search and selection process, from the number of records identified in the search to the number of studies included in the review, ideally using a flow diagram	6, Fig. 1
	16b	Cite studies that might appear to meet the inclusion criteria, but which were excluded, and explain why they were excluded	6
Study characteristics	17	Cite each study included and present its characteristics	6, Table 3–Table 4
Risk of bias in studies	18	Present assessments of risk of bias for each study included	7, Table 1–Table 2
Results of individual studies	19	For all outcomes, present, for each study: (a) summary statistics for each group (where appropriate) and (b) an effect estimate and its precision (e.g. confidence/credible interval), ideally using structured tables or plots	Table 3–Table 4
Results of syntheses	20a	For each synthesis, briefly summarise the characteristics and risk of bias among contributing studies	8
	20b	Present results of all statistical syntheses conducted. If meta-analysis was done, present for each the summary estimate and its precision (e.g. confidence/credible interval) and measures of statistical heterogeneity. If comparing groups, describe the direction of the effect	8, Fig. 2
	20c	Present results of all investigations of possible causes of heterogeneity among study results	NR
	20d	Present results of all sensitivity analyses conducted to assess the robustness of the synthesised results	NR
Reporting biases	21	Present assessments of risk of bias due to missing results (arising from reporting biases) for each synthesis assessed	NR
Certainty of evidence	22	Present assessments of certainty (or confidence) in the body of evidence for each outcome assessed	NR
Discussion			
Discussion	23a	Provide a general interpretation of the results in the context of other evidence	10–12
	23b	Discuss any limitations of the evidence included in the review	12
	23c	Discuss any limitations of the review processes used	12
	23d	Discuss the implications of the results for practice, policy and future research	10–12
Other information			
Registration and protocol	24a	Provide registration information for the review, including register name and registration number, or state that the review was not registered	4
	24b	Indicate where the review protocol can be accessed, or state that a protocol was not prepared	4
	24c	Describe and explain any amendments to information provided at registration or in the protocol	NR
Support	25	Describe sources of financial or non-financial support for the review, and the role of the funders or sponsors in the review	13
Competing interests	26	Declare any competing interests of review authors	13
Availability of data, code and other materials	27	Report which of the following are publicly available and where they can be found: template data collection forms; data extracted from the studies included; data used for all analyses; analytic code; any other materials used in the review	13

From: Page et al. [15]. For more information, visit: http://www.prisma-statement.org

NR not reported

Appendix 2

Search strategy #1 in PubMed—263 results
(CrossFit [Title/Abstract])
Search strategy #2 in Scopus—1,271 results
(CrossFit [Title/Abstract])
Search strategy #3 in SPORTDiscus—523 results
(CrossFit [Title/Abstract])
Search strategy #4 in PubMed—4,039 results
((incontinence urinary AND exercise [Title/Abstract]) OR (incontinence urinary AND high impact [Title/Abstract]) OR (pelvic floor dysfunction AND exercise [Title/Abstract]))
Search strategy #5 in Scopus—30,254 results
((incontinence urinary AND exercise [Title/Abstract]) OR (incontinence urinary AND high impact [Title/Abstract]) OR (pelvic floor dysfunction AND exercise [Title/Abstract]))
Search strategy #6 in SPORTDiscus—294 results
((incontinence urinary AND exercise [Title/Abstract]) OR (incontinence urinary AND high impact [Title/Abstract]) OR (pelvic floor dysfunction AND exercise [Title/Abstract]))

Author's participation E. Dominguez-Antuña: data collection, data analysis, manuscript writing; J.C. Diz: data analysis, manuscript writing; D. Suárez-Iglesias: data analysis, manuscript writing/editing; C. Ayán: project development, data analysis, manuscript writing.

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Data availability The data that support the findings of this study are available on request from the corresponding author.

Declarations

Conflicts of interest None.

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