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The Development of a Valid and Reliable Questionnaire to Measure Menstrual Cycle and Hormonal Contraceptive Knowledge Among Athletes and Sports Performance Support Staff

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ABSTRACT

This study aimed to develop the first valid questionnaire to assess menstrual cycle (MC) and hormonal contraceptive (HC) knowledge in athletes and sports performance support staff. Questions were developed following a literature review and four knowledge domains were identified: (1) Normal MC Function, (2) MC Dysfunction, (3) Oral Contraceptive Pills, and (4) Other HCs. Experts ($n = 6$) reviewed the initial questionnaire, followed by pre-testing with athletes and support staff ($n = 19$). Validity (item analysis, construct validity) and reliability (test–retest, internal consistency) were assessed following questionnaire administration to athletes and staff without MC education ("Low Knowledge" [LK] group; $n = 156$) and "High Knowledge" [HK] participants ($n = 30$) with MC education. Most ($n = 122$) LK participants completed the questionnaire twice to assess test–retest reliability. Expert review showed good agreement (> 80%) on item clarity and relevancy and pre-testing indicated good content and face validity. The HK group scored significantly higher than LK participants across the questionnaire (43 ± 5 vs. 28 ± 10; $p < 0.001$; $d = 1.48$ [1.05, 1.90]) and all knowledge domains ($p < 0.05$). High item discrimination parameters were found for all domains, indicating effective discrimination between respondents with different knowledge levels. Test–retest reliability was *excellent* (intra-class correlation coefficient estimates from 0.93 [0.90, 0.95] to 0.98 [0.96, 0.99]), with all domains showing good-to-excellent reliability. Internal reliability (Cronbach's alpha) was considered acceptable (0.93 [0.92, 0.95]; $\alpha \geq 0.7$). This questionnaire delivers a valid and reliable tool to assess MC and HC knowledge amongst athletes and support staff and is recommended to guide and evaluate educational interventions to improve menstrual health literacy within sport.

1 | Introduction

Over recent years there has been increased research interest and motivation from athletes and sports coaches [1, 2] to better understand how the menstrual cycle (MC) may impact exercise performance. It is well known that many athletes experience disordered menstruation [3, 4] and most menstruating athletes perceive their MC to influence training and

performance [5, 6], though MC impacts are highly variable from person to person [7]. Indeed, studies investigating the influence of the MC on objective performance metrics have produced variable and often contradictory results [6], perhaps—at least in part—due to the significant variability in MC characteristics and experience. For instance, strength and aerobic performance appear to be most commonly impaired during the late luteal phase of the MC (i.e., in the days prior to menstruation), though many studies also report no MC phase-related differences in these performance metrics [6]. Athletes' perception of their performance may also vary across the MC, with a positive impact on physical performance reported by some athletes during ovulation when compared to the early follicular (menstruation) and late luteal phases [8]. Hormonal contraceptives (HCs) are viewed as an attractive option for many menstruating athletes not only to prevent pregnancy, but to manage adverse menstrual symptoms (e.g., dysmenorrhea, menorrhagia) and/or to manipulate their cycle to avoid menstruating at undesirable times [9, 10]. However, HCs may induce side effects depending on individual physiology and the form(s) and potency of synthetic hormones administered [11]; indeed, many athletes who use HCs report adverse effects including low mood, irregular/inconvenient bleeding, headaches, and pain [10, 12]. Moreover, HCs may be prescribed without consideration of the most appropriate combination and formulation for each individual user [13]. For athletes to make informed decisions surrounding their MC and HC use, and for performance support staff to effectively assist their athletes, a basic understanding of MC physiology and the available HC options (and their potential side effects) is paramount. Increasing awareness of MC and HC symptoms and strategies amongst athletes and performance support staff may contribute positively towards optimizing the health, training, and performance of athletes who menstruate.

Unfortunately, available evidence suggests that athletes [14, 15] and sports performance support staff [1, 15–16] have low levels of knowledge regarding the MC and HCs. For instance, a questionnaire that assessed elite Australian athletes' ($n = 189$) MC and oral contraceptive pill (OCP) knowledge found that only a small fraction of athletes (16%) could identify estrogen and progesterone as the primary female sex hormones that fluctuate across the MC [14]. Moreover, only 18% of respondents could identify amenorrhea as a condition of the absence of menstruation [14]; a concerning finding given the high prevalence of amenorrhea observed in elite athlete populations, which is often associated with Relative Energy Deficiency in Sport (REDs) [17, 18]. Athlete knowledge surrounding HCs also appears to be poor despite the high prevalence of HC use in this cohort (~50% [10, 12, 14]). The majority (71%) of Australian athletes previously surveyed [14] did not know that combined OCPs—the most common HC utilized amongst Australian athletes [10, 14] – contain two hormones, and an overwhelming majority (88%) did not know that there were different combined OCP options available (e.g., monophasic, biphasic, and triphasic preparations). Knowledge surrounding progesterone-only OCPs (i.e., the "mini pill") was also limited, with 82% of athletes unaware that the mini pill contains only one synthetic hormone [14]. Furthermore, less than half (41%) of these athletes understood that the use of OCPs decreased the production of endogenous female sex hormones [14]. A similar study in New Zealand elite basketball athletes and their performance support staff reported comparably low knowledge surrounding the MC and HCs [15].

Collectively, these findings suggest that athletes and performance support staff have a poor understanding of various aspects related to menstruation, such as knowledge of MC physiology, the types of active components used in HC medications and their physiological effects, and the scope of HC options available. Thus, it is possible that athletes and their performance team are not making the most appropriate decisions regarding menstrual health, factoring in individual health and performance needs. Moreover, the modification of training programs according to MC phase is becoming an increasingly popular topic [19], yet may be occurring in the absence of adequate MC knowledge. This emphasizes the need for evidence-based education if athletes that menstruate are to make informed decisions surrounding their training and MC and HC use, such as choosing an appropriate HC (if desired) or knowing to seek professional medical advice if their MC changes or stops. However, to our knowledge, no study has used a validated tool to assess MC and HC knowledge in athletes and performance support staff. Prior studies [14] are limited by their exclusive focus on OCPs, without consideration of other HC methods. While OCPs have typically been reported as the most popular HC method used by athletes [10, 12, 14], recent studies investigating HC prevalence in athlete populations [10, 20] indicate a shift towards long-acting reversible contraceptive (LARC) methods, such as subdermal implants and hormonal intrauterine devices (IUDs). Thus, it is important that knowledge surrounding LARC options is also captured. Other available MC or HC-related knowledge questionnaires have unknown validity and/or have been designed for populations with little relevance to sport and omit knowledge areas relevant for athletes and performance support staff [21–23].

This study aimed to develop and validate a questionnaire to assess MC and HC knowledge, including LARC options, amongst athletes who menstruate and sports performance support staff (e.g., coaches, physiotherapists, dieticians, sport scientists). While it should be noted that only those with a female reproductive system can experience menstruation, care has been taken throughout this manuscript and during the questionnaire design process to use language that is inclusive of all menstruating persons (including trans and gender-diverse individuals that menstruate) while retaining clarity and medical accuracy. Once assessed as both valid and reliable, this questionnaire can be confidently administered to athletes and performance support staff to identify gaps in knowledge surrounding the MC and HCs. This information can then be used to develop and assess targeted educational resources for athletes who menstruate and performance support staff regarding menstrual health.

2 | Materials and Methods

Ethical approval for this study was authorized by the University of Southern Queensland Human Research Ethics Committee (H22REA250). A three-phase approach informed by Boateng et al. [24] and Pai et al. [25] was broken down into six steps to guide questionnaire development and data analyses.

Step 1: Defining questionnaire categories: A literature review of relevant MC research, including published questionnaires investigating similar topics [14, 15, 21, 23, 26], was conducted to inform the questionnaire domains used to comprehensively assess athlete and performance support staff MC and HC knowledge. This led to the generation of four knowledge domains: (1) Normal MC Function, (2) MC Dysfunction, (3) OCPs, and (4) Other HCs.

Step 2: Development of question pool: Available literature and questionnaires [2, 14, 15, 21, 23, 26] were used to establish a pool of evidence-based knowledge questions under the four identified knowledge domains. An additional subset of questions was included to capture demographic information (e.g., age, date of birth) and sport-specific information (e.g., sport, competition level, time spent competing/working in sport). Questions contained a mix of open (free text), multiple choice questions (MCQs), and true/false (T/F) questions. All MCQs and T/F questions pertaining to knowledge allowed respondents to select "I don't know" to prevent guesses (which may not accurately reflect knowledge). Question items were reviewed by a sports physician (MD) with specific knowledge and experience pertaining to female reproductive physiology to ensure item accuracy.

Step 3: Expert focus group: A convenience sample of six participants who currently work with menstruating athletes (or compete) at a national or international level in their chosen sport participated in a 2-h online focus group to review the initial list of questionnaire items. The group comprised a talent advisor/coach, sports physiotherapist, a sports nutritionist and exercise physiologist, a sports scientist and MC researcher, a sports physician (and former elite female athlete), and a current elite female rower. Participants were provided with the draft questionnaire and gave written informed consent prior to participation. In the focus group, participants were asked to rate each question using a 4-point Likert scale according to two categories: Clarity ("Not Clear" [= 1] to "Clear" [= 4]) and Relevance ("Not Relevant" [= 1] to "Relevant" [= 4]), to determine whether questions were relevant and comprehensible for the target population. Item ratings were converted to percentages and an acceptability of > 80% determined acceptable content validity [25]. In-depth feedback and discussion regarding the potential rewording, removal, or adding of questions also occurred during the focus group.

Step 4: Face validity: A convenience sample of 19 participants, comprising menstruating athletes ($n = 12$) and performance support staff working with athletes who menstruate ($n = 7$) across a range of sports and competition levels (regional/state: $n = 8$; national: $n = 4$; international: $n = 7$), was recruited to pre-test the revised questionnaire. Athletes aged 15–42 years were included to ensure the questionnaire is suitable for younger athletes as well as adults. After providing written informed consent, participants completed the questionnaire and immediately performed a ~30-min semi-structured interview to discuss their understanding of what the questionnaire is measuring, their comprehension of questionnaire items, and any limitations/additional considerations. Interview questions included: "Are you unfamiliar with any words/terms used in the questionnaire?", "What do you think this part of the questionnaire is measuring?", "What do you think about the length of the questionnaire?", and lastly "Are there any knowledge areas relating to the MC or HC that you feel are missing from the questionnaire?". Participant feedback was then collated, reviewed, and used descriptively to make edits to questionnaire items as appropriate.

Step 5: Validity: The revised questionnaire was administered to two groups. The "Low Knowledge" (LK) group ($n = 156$) comprised 134 menstruating athletes and 22 performance support staff, including predominantly coaches, strength and conditioning coaches, and performance managers (Table 1) without specialized MC training/education. The second group comprised "High Knowledge" (HK) participants ($n = 30$) that currently work with athletes who menstruate and have received specialized training/education on the MC; that is, research academics with MC/HC expertise, sports physicians, physiotherapists, and other clinicians (Table 1). Participants were recruited via word of mouth, social media, and personal communication to coaches/high performance managers across various sports and provided written informed consent prior to questionnaire completion. A researcher administered the questionnaire in paper format which allowed for strict supervision and ensured responses reflected knowledge (i.e., by prohibiting online searches and ensuring participants completed their questionnaires without assistance). Both classical test theory (CTT) and item response theory (IRT) were undertaken to produce item discrimination and difficulty parameters, to assess questionnaire validity [24] (see Data Analysis section).

Step 6: Reliability: Most ($n = 122$) LK participants completed the questionnaire a second time under the same conditions, 1–2 weeks later. Questionnaire reliability was assessed via test–retest reliability and internal consistency analysis.

2.1 | Data Analysis

All analyses were undertaken in R (R Core Team) using the RStudio environment [27]. The total score of the LK and HK groups was compared for descriptive purposes, and group differences were analyzed using independent t-tests, with a statistical significance threshold of $\alpha = 0.05$, and Cohen's *d* effect size.

2.1.1 | Validation

Analysis of item discrimination and item difficulty in CTT was undertaken using the "ShinyItemAnalysis" package [28]. Corrected item-to-total correlation (i.e., item discrimination value) was calculated, and a correlation value of $r < 0.2$ was considered a threshold for possible removal of the question [29]. Item difficulty was calculated as the proportion of correct responses, with partially corrected responses considered incorrect for the purpose of analysis. A lower item difficulty value (i.e., closer to 0) indicated a more difficult question. Unidimensional analysis of response data was undertaken using IRT via the "mirt" package [30] and "ggmirt" [31] to produce plots. Data were coded as dichotomous and fit using a two-parameter logistic (2PL) model. Questions with a possibility of partial marks (Q7, Q8, and Q36) were recoded to a dichotomous format; a response was considered correct only if all correct options had been selected; otherwise the response was considered incorrect. Models were fit to the entire

TABLE 1 | Participant demographic information for the high (HK) and low (LK) knowledge groups.

	Low knowledge group		
	Athletes	**Support staff**	**High knowledge group**
n	134	22	30
Age (Mean ± SD; range)	21.9 ± 5.5 years; 15–43 years	35.4 ± 11.4 years; 20–60 years	35.7 ± 8.7 years; 23–63 years
Gender			
Man	—	11	4
Woman	134	10	26
Other/Left blank	—	1	—
Highest completed education			
Primary School	30	—	—
Secondary School	65	5	—
Diploma	4	3	—
Bachelor	25	8	7
Honors/Masters	10	6	14
PhD	—	—	9
HC status			
Yes	64	10	25
No	67	—	1
NA/left blank	3	12	4
Sport			
AFL	68	11	1
Athletics	1	—	1
Combat sports	1	1	1
Cross country running	2	—	7
Cycling	—	—	2
Endurance sports	—	—	2
European handball	1	—	—
Esports	—	—	1
Gymnastics	1	—	—
Hockey	1	—	—
Ice hockey/Ice skating	19	—	—
Netball	12	4	1
Rugby 7s	1	—	—
Rugby Union	—	—	1
Soccer	21	2	4
Swimming	2	—	1
Tennis	—	—	1
Triathlon	1	—	1
Water polo	1	—	1

(Continues)

TABLE 1 | (Continued)

	Low knowledge group		
	Athletes	**Support staff**	**High knowledge group**
Weightlifting	1	—	—
Multiple/no primary sport/ left blank	1	4	5
Level of competition			
Regional/State	84	8	5
National	35	7	10
International	13	6	11
Other/left blank	2	1	4
Role			
Academic (MC researcher)		—	6
Coach		11	1
Doctor (Sport physician)		—	3
Endocrinologist		—	1
Nutritionist/Dietician		—	2
Performance Manager		3	2
Personal Trainer		1	1
Physiotherapist		1	10
Sport Scientist		—	1
Strength & Conditioning Coach		6	2
Left blank		—	1
Years worked in high performance sport			
1–3		9	7
4–6		7	3
7–9		1	5
10+		4	5
NA/left blank		1	10

dataset and each of the four knowledge domains (1) Normal MC Function, (2) MC Dysfunction, (3) OCPs, and (4) Other HCs, as well as separately for the LK group.

Model outputs of interest were the discrimination (*a*) and difficulty (*b*) parameters for each question. The discrimination parameter (*a*) quantifies a question's ability to distinguish between respondents with varying levels of the latent trait (i.e., knowledge); a higher *a* value indicates the question is more effective at identifying respondents with different levels of knowledge. Questions with high discrimination parameters will show a larger difference in the proportion of correct responses between the LK and HK groups. The difficulty parameter (*b*) indicates the knowledge required to achieve a 50% probability of answering the question correctly, with higher *b* values requiring a higher level of knowledge (i.e., more difficult). Questions with high difficulty parameters are expected to be answered correctly primarily by the HK group, while those with low difficulty parameters should be easier for both groups. The HK group failed to converge using a 2PL model and so reverted to a Rasch model, which provided only item difficulty parameter estimates. For certain questions, the HK group provided exclusively correct responses and thus could not be modeled (e.g., Q3); these questions were removed from the analysis for this group.

2.1.2 | Reliability

Test–retest reliability of aggregated subcategory and total scores was assessed via intraclass correlations (ICC) with the "SimplyAgree" package [32] using absolute agreement, two-way, random-effects models ($ICC_{2,1}$) [33]. The criteria of Cicchetti [34]

were used to qualitatively interpret the reliability of ICC point estimates and 95% confidence interval (CI) bounds, with consideration that the CI bounds may span across more than one qualitative category. Additional reliability statistics were also calculated: (1) standard error of the measurement (SEM) and (2) minimum difference (MD).

$$\text{SEM} = \sqrt{\text{MSE}} \quad (1)$$

$$\text{MD} = z \times \text{SEM}\sqrt{2} \quad (2)$$

Where z = the z-score associated with a 95% CI (i.e., 1.96). All reliability data are presented as test statistic values and 95% CI, if relevant.

Internal consistency of the questionnaire was tested via the "psych" package [35] with Cronbach's α for the total questionnaire and the four knowledge domains, as well as for the LK group, with an $\alpha \geq 0.7$ considered satisfactory [36]. The effect of dropping each individual question on internal consistency was assessed by a comparison to the overall Cronbach's α, with an α value higher than the overall value considered possible evidence that the question should be removed.

3 | Results

The initial question pool contained 52 knowledge questions and 14–16 demographic/sport-related questions (note: demographic questions varied slightly between athlete and performance support staff versions of the questionnaire; however, all knowledge questions were identical across cohorts. See the final knowledge questionnaire in the Supporting Information). Fifteen questions fell under knowledge domain 1 (Normal MC Function), 14 questions fell under knowledge domain 2 (MC Dysfunction), five questions fell under knowledge domain 3 (OCPs), and 18 questions fell under knowledge domain 4 (Other HCs). There was very good agreement by the expert reviewers (Step 3) across domains 1–3, with a mean score of 3.85 for relevance and 3.69 for clarity on all knowledge domain 1, 2, and 3 questions. Only one question fell below the > 80% threshold for clarity (a T/F question: "It is normal to experience extreme pain that interferes with daily living prior to or during menstruation"; achieved 75% for clarity). As this question scored highly for relevance (95%), it was reworded following discussion with the expert reviewers and remained in the questionnaire. No other questions in knowledge domains 1 to 3 were removed following expert review, though small changes were made based on reviewer suggestions to reword/rephrase or reorder certain questions to improve comprehension and questionnaire flow, while maintaining question and domain themes.

Initially, knowledge domain 4 (Other HCs) contained 18 questions. While all questions scored highly for clarity (mean = 3.79), there was less agreement for item relevance (mean = 3.39). Specifically, eight questions pertaining to the makeup or administration of LARC HC options (contraceptive injections, vaginal rings, implants, and IUDs) scored below the > 80% threshold and were deemed by reviewers to be beyond the scope of knowledge that could reasonably be expected of athletes and performance support staff, unless they had personal experience using these medications. All other questions in this domain met the > 80% threshold (mean relevance score = 3.88). Thus, these eight questions only were removed, and two new questions were added to knowledge domain 4 which captured the key themes of these questions in a simplified manner. For instance, rather than asking individual questions about the specific hormones contained within individual LARC options, a broader question was added to determine whether respondents can distinguish between hormonal and non-HC options ("Which of the following are hormonal contraceptive options? You may select more than one answer"). Following the expert review process, knowledge domain 4 contained 12 questions.

The revised questionnaire comprising 46 knowledge questions was pilot tested with a convenience sample of 19 participants (Step 4), who were then asked about how they interpreted questions (i.e., what they thought the questions were measuring) and provided descriptive verbal feedback on the comprehension and relevancy of questionnaire items. The interview respondents' interpretation did not differ from what the questionnaire items were intended to measure, indicating valid responses. Suggestions were made to subtly improve the questionnaire, such as removing gendered language (girls, women) and replacing it with neutral terms (e.g., people who menstruate) to be inclusive of trans and gender-diverse people who menstruate, to re-order certain questions or response options, or to clarify what was meant by a particular term. For instance, one participant stated that the question "Name the distinct phases that occur within one typical menstrual cycle" required "more of an explanation about what the question is asking for" and suggested "one menstrual month" may be more easily understood than "one typical menstrual cycle". With consideration of this feedback and the potential for MC-length variability (i.e., not all MCs last one month), this comment and ensuing discussion prompted an addendum to the item "(i.e., from the first day of one period to the first day of the next period)" to enhance clarity.

3.1 | Knowledge Scores

Of the 46 knowledge questions, all but three questions were worth one point if answered correctly. Three questions had two-part answers and were therefore worth two points if answered correctly; thus, the highest overall knowledge score that could be achieved was 49, with maximum scores of 13, 18, 5, and 13 for knowledge domains (1) Normal MC Function, (2) MC Dysfunction, (3) OCPs, and (4) Other HCs, respectively (for questionnaire scoring instructions see Supporting Information: MC and hormonal contraception knowledge questionnaire user guide).

Participant demographic information for the LK and HK groups is presented in Table 1. The mean total knowledge score for the entire cohort ($n = 186$) was 31 ± 11 out of a possible 49, and the total score was significantly different between the LK (mean 28 ± 10) and HK groups (43 ± 5; $p < 0.001$; $d = 1.48$ [1.05, 1.90]; Figure 1). Similar between-group differences were found for each of the four knowledge domains (Table 2).

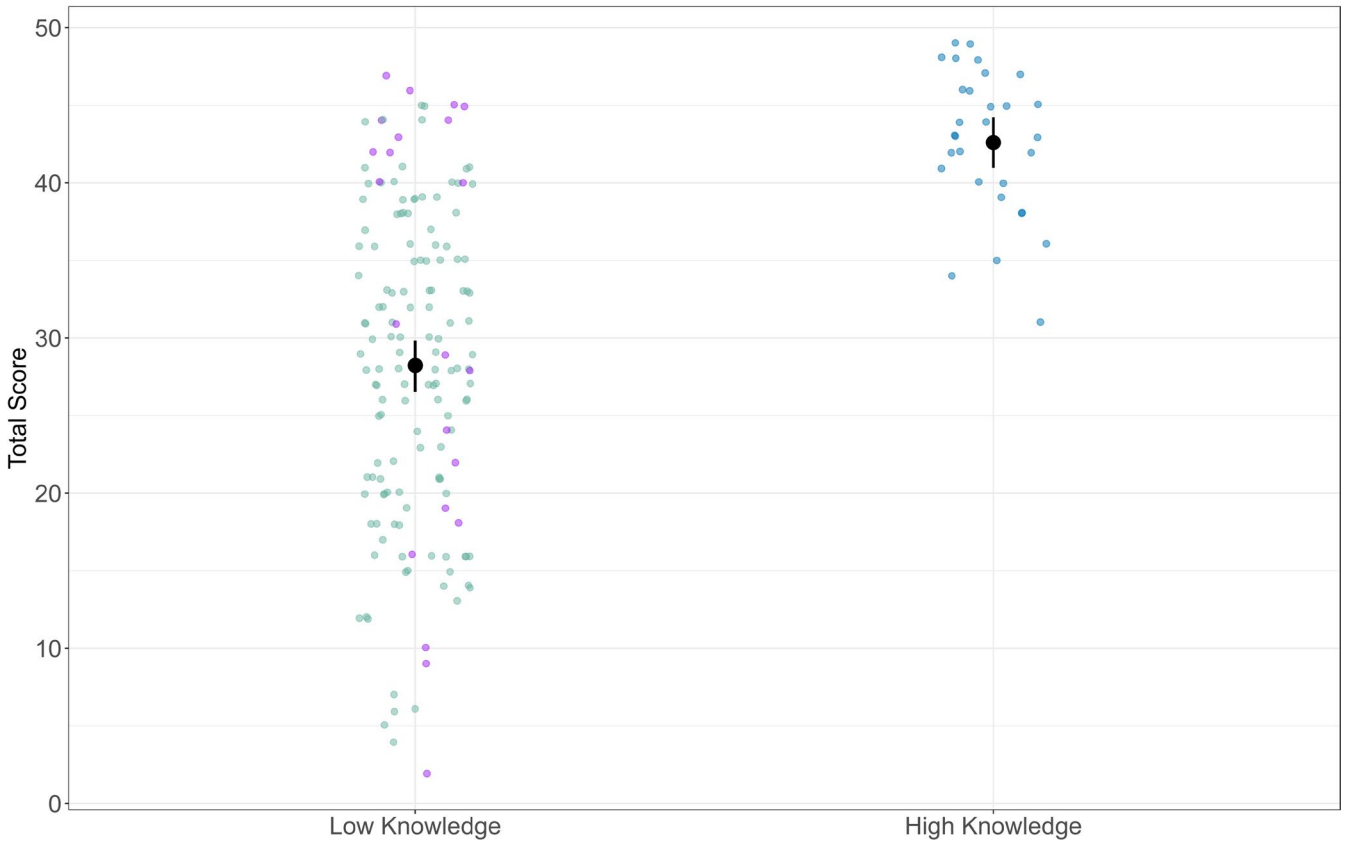

FIGURE 1 | Total knowledge score for the Low Knowledge and High Knowledge groups. Data presented as raw respondent total scores (colored points: Green = LK athletes; purple = LK performance support staff; blue = HK group), group means indicated with a solid black point, and black vertical lines indicate 95% confidence interval.

TABLE 2 | Summarized score data for the total questionnaire and the four knowledge domains, split by group.

	Total cohort ($n = 186$)	Low knowledge group ($n = 156$)	High knowledge group ($n = 30$)
Total questionnaire	31 ± 11	28 ± 10	43 ± 5*
Knowledge domains			
(1) Normal MC Function	8 ± 3	7 ± 3	11 ± 2*
(2) MC Dysfunction	13 ± 5	12 ± 5	17 ± 2*
(3) OCPs	2 ± 2	2 ± 2	4 ± 1*
(4) Other HCs	8 ± 4	7 ± 4	10 ± 2*

Note: Data presented as mean ± standard deviation of score.
*Statistically significant group differences within the same category.

3.2 | Validity

Item analysis of the total cohort using CTT found that the most discriminating knowledge domains were domains (2) MC Dysfunction ($r = 0.50$) and (4) Other HCs ($r = 0.56$), with the latter also having the highest discrimination for the LK group ($r = 0.56$; Table 3). This is supported by the IRT analysis (Table 4), where the Other HCs domain (4) was the most discriminating (discrimination median $a = 1.94$), particularly the questions regarding IUDs. For example, the three most discriminating items from the IRT analysis were the following binary T/F questions: Q43 "An IUD or implant must be inserted and removed by a medical professional" ($a = 5.10$), Q41 "An IUD cannot be removed early, even if someone changes their mind" ($a = 2.59$), and Q40 "An IUD can only be used in people who have previously given birth" ($a = 2.58$). The high discrimination parameter suggests that these questions are particularly effective at distinguishing between respondents with different levels of knowledge based on their responses.

The Normal MC Function domain (1) was found to have the lowest overall item discrimination using CTT ($r = 0.35$; Table 3). Two questions in this domain, Q4 and Q11, were identified as having a low item discrimination value using CTT item analysis

TABLE 3 | Item difficulty and discrimination from CTT for the questionnaire knowledge questions.

	Total cohort ($n = 186$)		Low knowledge group ($n = 156$)		High knowledge group ($n = 30$)	
Knowledge domain	**Item discrimination**	**Item difficulty**	**Item discrimination**	**Item difficulty**	**Item discrimination[a]**	**Item difficulty**
(1) Normal MC Function	0.35	0.66	0.31	0.61	0.14	0.88
Q1. At what age do most people begin to menstruate (i.e., get their first period)? (MCQ)	0.44	0.84	0.42	0.81	0.31	0.97
Q2. At what age do most people stop regularly menstruating (i.e., go through menopause)? (MCQ)	0.33	0.48	0.25	0.42	0.12*	0.80
Q3. For someone with a regular menstrual cycle, the length of one complete menstrual cycle (i.e., the number of days from the first day of one period to the first day of the next period) is: (MCQ)	0.35	0.85	0.31	0.82	—	1.00
Q4. What is the typical duration of menstruation (i.e., one period)? (MCQ)	0.14*	0.88	0.17*	0.88	—	0.90
Q5. The normal amount of menstrual fluid (blood) to lose during menstruation (i.e., one period) is: (MCQ)	0.30	0.48	0.28	0.45	0.10*	0.67
Q6. How many days before starting menstruation (i.e., the first day of a period) does ovulation typically occur? (MCQ)	0.44	0.43	0.35	0.35	0.13*	0.87
Q7. Name the female sex hormones produced by the ovaries that fluctuate throughout the menstrual cycle: (free text)	0.58	0.60	0.54	0.53	—	0.97
Q8. Name the distinct phases that occur within one typical menstrual cycle (i.e., from the first day of one period to the first day of the next period): (free text)	0.48	0.35	0.37	0.24	0.04*	0.90
Q9. Changes in hormone levels during the menstrual cycle prepare the body for a possible pregnancy (T/F)	0.35	0.81	0.30	0.78	—	1.00
Q10. Menstruation (a period) is the internal uterus lining being released through the vagina (T/F)	0.30	0.87	0.25	0.85	—	1.00
Q11. It is normal for menstrual cycles to be irregular for a few years after menstruation starts (T/F)	0.11*	0.64	0.13*	0.64	0.13*	0.63
(2) MC Dysfunction	0.50	0.71	0.48	0.67	0.31	0.92
Q12. It is considered healthy for athletes to experience absent menstruation (i.e., “lose their period”) during periods of hard training (T/F)	0.63	0.61	0.60	0.55	0.43	0.93

(Continues)

TABLE 3 | (Continued)

Knowledge domain	Total cohort ($n=186$)		Low knowledge group ($n=156$)		High knowledge group ($n=30$)	
	Item discrimination	Item difficulty	Item discrimination	Item difficulty	Item discrimination[a]	Item difficulty
Q13. Persistent absence of menstruation (i.e., "missing periods") can increase the risk of poor bone health (T/F)	0.60	0.53	0.55	0.46	0.27	0.93
Q14. Debilitating pain that interferes with day-to-day activities prior to or during menstruation is a feature of a healthy menstrual cycle (T/F)	0.54	0.74	0.50	0.69	—	1.00
Q15. Some people experience a range of physical and emotional symptoms in the 1–2 weeks before menstruation (e.g., fatigue, breast tenderness, food cravings, irritability). This phenomenon is known as: (MCQ)	0.42	0.76	0.39	0.73	0.57	0.90
Q16. If someone has infrequent menstruation, excess male hormone (androgen) levels and follicles on the ovaries, they may be diagnosed with: (MCQ)	0.51	0.56	0.49	0.51	0.15*	0.83
Q17. What is amenorrhea? (MCQ)	0.53	0.41	0.44	0.31	0.61	0.93
Q18. Which of the following statements regarding irregular/absent menstruation is most correct? (MCQ)	0.46	0.78	0.42	0.74	—	1.00
Q19. If someone has tissue similar to the lining of the uterus growing outside of the uterus, they may be diagnosed with:	0.45	0.63	0.41	0.59	0.36	0.87
Q20. If someone has extreme, abnormal mood shifts (e.g., sadness, anxiety) that interferes with day-to-day activities in the lead up to menstruation, they may be diagnosed with: (MCQ)	0.57	0.62	0.52	0.56	0.61	0.93
The next 9 questions relate to the following statement: True or false—the following factors can be associated with irregular/absent menstruation (i.e., "missing periods"):						
Q21. Insufficient energy intake (e.g., "under-fuelling") (T/F)	0.55	0.83	0.53	0.79	—	1.00
Q22. Low body weight/low body fat percentage (T/F)	0.63	0.69	0.61	0.64	0.07*	0.97
Q23. Significant changes in body weight (T/F)	0.45	0.70	0.47	0.68	0.25	0.80
Q24. Very high training loads (T/F)	0.61	0.82	0.60	0.79	—	1.00
Q25. Trauma/mental distress (T/F)	0.46	0.77	0.46	0.74	0.14*	0.90
Q26. Certain illnesses (T/F)	0.47	0.74	0.49	0.72	0.32	0.83
Q27. Certain menstrual disorders (T/F)	0.52	0.84	0.52	0.81	—	0.97

(Continues)

TABLE 3 | (Continued)

Knowledge domain	Total cohort ($n = 186$)		Low knowledge group ($n = 156$)		High knowledge group ($n = 30$)	
	Item discrimination	Item difficulty	Item discrimination	Item difficulty	Item discrimination[a]	Item difficulty
Q28. Pregnancy (T/F)	0.25	0.96	0.28	0.96	0.18*	0.97
Q29. Certain medications (T/F)	0.31	0.84	0.37	0.85	0.10*	0.83
(3) OCPs	0.46	0.46	0.35	0.38	0.19	0.87
Q30. What happens to the female sex hormones produced by the ovaries when someone uses hormonal contraception (e.g., "the pill")? (MCQ)	0.28	0.55	0.16*	0.49	0.27	0.87
Q31. Which of the following is not a way in which hormonal contraceptives like "the pill" work to prevent pregnancy? (MCQ)	0.42	0.46	0.32	0.38	0.13*	0.87
Q32. One type of oral contraception is called the combined pill. This form of contraception contains which hormones? (MCQ)	0.57	0.46	0.47	0.36	0.09*	0.97
Q33. Another type of oral contraception is called the mini pill. This form of contraception contains which hormone? (MCQ)	0.56	0.37	0.49	0.29	0.26	0.77
Q34. What may happen when the inactive oral contraceptive pills (i.e., the placebo "sugar pills") are skipped and the active, hormone-containing pills are continuously taken in their place? (MCQ)	0.46	0.47	0.34	0.38	0.20	0.90
(4) Other HCs	0.56	0.61	0.56	0.58	0.39	0.80
Q35. Which of the following statements about hormonal contraception is not true? (MCQ)	0.47	0.66	0.45	0.59	—	1.00
Q36. Which of the following are hormonal contraceptive options? You may select more than one answer: (MCQ)	0.60	0.74	0.59	0.69	0.41	0.97
Q37. An IUD can prevent pregnancy for 3–10 years (T/F)	0.55	0.54	0.55	0.51	0.45	0.70
Q38. An IUD is inserted into the uterus (T/F)	0.58	0.64	0.56	0.59	0.50	0.90
Q39. An IUD cannot be removed early, even if someone changes their mind (T/F)	0.59	0.51	0.58	0.46	0.52	0.77
Q40. An IUD can only be used in people who have previously given birth (T/F)	0.62	0.70	0.62	0.67	0.38	0.90
Q41. An implant can prevent pregnancy for at least 3 years (T/F)	0.59	0.59	0.63	0.58	0.49	0.63

(Continues)

TABLE 3 | (Continued)

Knowledge domain	Total cohort ($n = 186$)		Low knowledge group ($n = 156$)		High knowledge group ($n = 30$)	
	Item discrimination	Item difficulty	Item discrimination	Item difficulty	Item discrimination[a]	Item difficulty
Q42. An implant is inserted under the skin in the upper arm (T/F)	0.57	0.70	0.58	0.67	0.11*	0.90
Q43. An IUD or implant must be inserted and removed by a medical professional (T/F)	0.69	0.83	0.72	0.81	0.34	0.93
Q44. IUDs and implants are more effective at preventing pregnancy than oral contraceptive pills as they do not require daily administration (T/F)	0.45	0.50	0.51	0.51	0.37	0.43
Q45. IUDs and implants affect fertility in the long term (i.e., after removal) (T/F)	0.49	0.36	0.46	0.29	0.45	0.70
Q46. IUDs (e.g., Mirena) and implants (e.g., Implanon NXT) are hormonal forms of contraception (T/F)	0.48	0.59	0.48	0.56	0.41	0.97

Note: Discrimination values are the corrected item-to-total correlation, and item difficulty values are the proportion of correct responses for that question. The threshold of minimum item discrimination is $r = 0.2$ (indicated with *), while a lower item difficult represents a more difficult item.

[a]Small sample size of the high knowledge group resulted in unstable item discrimination values, and thus should be considered with caution.

($r = 0.14$ and 0.11, respectively; both < 0.2), with both questions also remaining below threshold for the LK group ($r = 0.17$ and 0.13). The item discrimination values of the HK group were unstable, likely due to the small sample size, and thus are not considered further. The median IRT 2PL item discrimination parameter (a) was also lowest in the Normal MC Function subcategory (median $a = 1.41$; Table 4) suggesting that this domain had the lowest ability to discriminate between respondents of different knowledge. Like the CTT item analysis, the IRT analysis found that Q4 and Q11 in this domain had relatively small a parameters (0.36 and 0.24, respectively), indicating that these questions were less effective at distinguishing between varying knowledge levels.

The difficulty of questions varied between domains, with the two HC-related domains (OCPs and Other HCs) found to have the most difficult questions on average according to the item analysis in both CTT and IRT. The domain difference in difficulty between the LK and HK groups demonstrated that the HK group found the questions considerably easier, as shown by the range in difficulty values from the item analyses using CTT (LK: 0.38–0.67; HK: 0.80–0.92; a higher value represents a high proportion of correct respondents). Notably, many of the questions were correctly answered by all respondents in the HK group.

3.3 | Reliability

The test–retest reliability of the total questionnaire was high, with ICC estimates ranging from 0.93 (0.90, 0.95) to 0.99 (0.97, 0.99; see Table 5), and qualitatively judged to have *excellent* reliability when compared against the guidelines of Cicchetti [34]. All knowledge domains also had good-to-excellent test–retest reliability, with the lowest ICC values reported by athletes for the OCPs domain 0.73 (0.64, 0.80; *good-to-excellent*).

The overall internal reliability of the questionnaire, as measured via Cronbach's α, was 0.93 (0.92, 0.95), and considered acceptable ($\alpha \geq 0.7$). This was also found for each of the four knowledge domains: (1) Normal MC Function = 0.72 (0.63, 0.76); (2) MC Dysfunction = 0.88 (0.85, 0.90); (3) OCPs = 0.70 (0.63, 0.76); and (4) Other HCs = 0.87 (0.84, 0.89). However, it should be noted that the lower CI bounds for knowledge domain (1) Normal MC Function, and knowledge domain (3) OCPs, were below the acceptable threshold (both $\alpha = 0.63$). Marginal improvements in internal consistency were found if Q11 and Q30 were dropped from the questionnaire.

4 | Discussion

Previous studies assessing MC and HC knowledge in athletes and/or performance support staff utilized questionnaires with unknown validity (content, and construct) and reliability (test–retest and internal consistency) [14, 15]. The questionnaire developed in the present study assesses knowledge across four key domains that are central to understanding menstrual health in these cohorts: (1) Normal MC Function, (2) MC Dysfunction, (3) OCPs, and (4) Other HCs. This demonstrably valid and reliable questionnaire may be used in applied or research settings to measure athlete, coach, and other performance support staff

TABLE 4 | Estimates of menstrual function subcategory item parameters (discrimination and difficulty) using ITT analysis.

	Entire cohort		Low knowledge group		High knowledge group
Knowledge domain	**Discrimination (a)**	**Difficulty (b)**	**Discrimination (a)**	**Difficulty (b)**	**Difficulty (b)**
(1) Normal MC Function					
Q1. At what age do most people begin to menstruate (i.e., get their first period)? (MCQ)	2.13	−1.28	3.91	−0.99	−3.78
Q2. At what age do most people stop regularly menstruating (i.e., go through menopause)? (MCQ)	0.81	0.12	0.57	0.63	−1.66
Q3. For someone with a regular menstrual cycle, the length of one complete menstrual cycle (i.e., the number of days from the first day of one period to the first day of the next period) is: (MCQ)	1.41	−1.63	1.31	−1.51	—
Q4. What is the typical duration of menstruation (i.e., one period)? (MCQ)	0.36	−5.71	0.56	−3.75	−2.55
Q5. The normal amount of menstrual fluid (blood) to lose during menstruation (i.e., one period) is: (MCQ)	0.71	0.1	0.67	0.34	−0.85
Q6. How many days before starting menstruation (i.e., the first day of a period) does ovulation typically occur? (MCQ)	1.65	0.25	0.95	0.79	−2.20
Q7. Name the female sex hormones produced by the ovaries that fluctuate throughout the menstrual cycle: (free text)	2.94	0.6	2.1	1.16	−2.55
Q8. Name the distinct phases that occur within one typical menstrual cycle (i.e., from the first day of one period to the first day of the next period): (free text)	10.92	0.78	8.17	1.27	−1.66
Q9. Changes in hormone levels during the menstrual cycle prepare the body for a possible pregnancy (T/F)	1.69	−1.27	1.24	−1.29	—
Q10. Menstruation (a period) is the internal uterus lining being released through the vagina (T/F)	1.35	−1.84	0.87	−2.24	—
Q11. It is normal for menstrual cycles to be irregular for a few years after menstruation starts (T/F)	0.24	−2.47	0.28	−2.1	−0.68
Mean ± SD	2.20 ± 3.00	−1.12 ± 1.88	1.88 ± 2.32	−0.70 ± 1.65	−1.99 ± 1.01
Median	1.41	−1.27	0.95	−0.99	−1.93
(2) MC Dysfunction					
Q12. It is considered healthy for athletes to experience absent menstruation (i.e., “lose their period”) during periods of hard training (T/F)	2.97	−0.33	2.46	−0.15	−3.03

(Continues)

TABLE 4 | (Continued)

Knowledge domain	Entire cohort		Low knowledge group		High knowledge group
	Discrimination (a)	Difficulty (b)	Discrimination (a)	Difficulty (b)	Difficulty (b)
Q13. Persistent absence of menstruation (i.e., "missing periods") can increase the risk of poor bone health (T/F)	2.56	−0.1	2.17	0.14	−3.03
Q14. Debilitating pain that interferes with day-to-day activities prior to or during menstruation is a feature of a healthy menstrual cycle (T/F)	1.94	−0.83	1.6	−0.69	—
Q15. Some people experience a range of physical and emotional symptoms in the 1–2 weeks before menstruation (e.g., fatigue, breast tenderness, food cravings, irritability). This phenomenon is known as: (MCQ)	1.29	−1.14	1.12	−1.1	−2.55
Q16. If someone has infrequent menstruation, excess male hormone (androgen) levels and follicles on the ovaries, they may be diagnosed with: (MCQ)	1.66	−0.21	1.51	−0.02	−1.91
Q17. What is amenorrhea? (MCQ)	2.09	0.27	1.53	0.72	−3.03
Q18. Which of the following statements regarding irregular/absent menstruation is most correct? (MCQ)	1.58	−1.15	1.29	−1.07	—
Q19. If someone has tissue similar to the lining of the uterus growing outside of the uterus, they may be diagnosed with:	1.43	−0.52	1.21	−0.38	−2.20
Q20. If someone has extreme, abnormal mood shifts (e.g., sadness, anxiety) that interferes with day-to-day activities in the lead up to menstruation, they may be diagnosed with: (MCQ)	2.13	−0.38	1.72	−0.2	−3.03
Q21. Insufficient energy intake (e.g., "under-fuelling") (T/F)	2.20	−1.18	2.00	−1.06	—
Q22. Low body weight/low body fat percentage (T/F)	2.86	−0.57	2.71	−0.41	−3.78
Q23. Significant changes in body weight (T/F)	1.35	−0.82	1.57	−0.67	−1.66
Q24. Very high training loads (T/F)	3.04	−1.03	2.73	−0.91	—
Q25. Trauma/mental distress (T/F)	1.43	−1.13	1.53	−0.96	−2.55
Q26. Certain illnesses (T/F)	1.42	−1	1.67	−0.83	−1.91
Q27. Certain menstrual disorders (T/F)	1.94	−1.3	2.06	−1.14	−3.78
Q28. Pregnancy (T/F)	1.26	−3.01	1.43	−2.75	−3.78
Q29. Certain medications (T/F)	0.91	−2.14	1.25	−1.72	−2.62
Mean ± SD	1.89 ± 0.64	−0.92 ± 0.76	1.75 ± 0.50	−0.37 ± 0.76	−2.73 ± 0.74

(Continues)

TABLE 4 | (Continued)

Knowledge domain	Entire cohort		Low knowledge group		High knowledge group
	Discrimination (a)	Difficulty (b)	Discrimination (a)	Difficulty (b)	Difficulty (b)
Median	1.80	−0.92	1.59	−0.76	−2.79
(3) OCPs					
Q30. What happens to the female sex hormones produced by the ovaries when someone uses hormonal contraception (e.g., "the pill")? (MCQ)	0.75	−0.33	0.42	0.06	−2.20
Q31. Which of the following is not a way in which hormonal contraceptives like "the pill" work to prevent pregnancy? (MCQ)	1.27	0.15	0.88	0.62	−2.20
Q32. One type of oral contraception is called the combined pill. This form of contraception contains which hormones? (MCQ)	3.05	0.11	2.46	0.44	−3.78
Q33. Another type of oral contraception is called the mini pill. This form of contraception contains which hormone? (MCQ)	2.75	0.38	2.62	0.64	−1.43
Q34. What may happen when the inactive oral contraceptive pills (i.e., the placebo "sugar pills") are skipped and the active, hormone-containing pills are continuously taken in their place? (MCQ)	1.88	0.1	1.42	0.45	−2.55
Mean ± SD	1.94 ± 0.97	0.08 ± 0.26	1.56 ± 0.96	0.44 ± 0.23	−2.43 ± 0.86
Median	1.88	0.11	1.42	0.45	−2.20
(4) Other HCs					
Q35. Which of the following statements about hormonal contraception is not true? (MCQ)	1.34	−0.61	1.19	−0.36	—
Q36. Which of the following are hormonal contraceptive options? You may select more than one answer: (MCQ)	2	−0.8	1.77	−0.66	−0.68
Q37. An IUD can prevent pregnancy for 3–10 years (T/F)	1.88	−0.08	1.84	0.02	−1.03
Q38. An IUD is inserted into the uterus (T/F)	1.92	−0.43	1.73	−0.27	−2.55
Q39. An IUD cannot be removed early, even if someone changes their mind (T/F)	2.59	0.04	2.43	0.19	−1.43
Q40. An IUD can only be used in people who have previously given birth (T/F)	2.58	−0.59	2.48	−0.47	−2.55
Q41. An implant can prevent pregnancy for at least 3 years (T/F)	2.29	−0.22	2.63	−0.17	−0.68
Q42. An implant is inserted under the skin in the upper arm (T/F)	1.84	−0.69	1.92	−0.53	−2.55

(Continues)

TABLE 4 | (Continued)

Knowledge domain	Entire cohort		Low knowledge group		High knowledge group
	Discrimination (a)	Difficulty (b)	Discrimination (a)	Difficulty (b)	Difficulty (b)
Q43. An IUD or implant must be inserted and removed by a medical professional (T/F)	5.10	−1.0	9.89	−0.88	−3.03
Q44. IUDs and implants are more effective at preventing pregnancy than oral contraceptive pills as they do not require daily administration (T/F)	1.35	0.03	1.7	0	0.31
Q45. IUDs and implants affect fertility in the long term (i.e., after removal) (T/F)	1.96	0.5	1.88	0.75	−1.03
Q46. IUDs (e.g., Mirena) and implants (e.g., Implanon NXT) are hormonal forms of contraception (T/F)	1.37	−0.33	1.37	−0.2	−1.43
Mean ± SD	2.19 ± 1.01	−0.35 ± 0.42	2.57 ± 2.35	−0.22 ± 0.43	−1.51 ± 1.04
Median	1.94	−0.38	1.86	−0.24	−1.43

Note: Data presented as parameters (discrimination, *a*, and difficulty, *b*) from a two-parameter logistic model.

knowledge pertaining to the MC and HCs. For instance, the questionnaire can be used as a pre-education assessment to determine baseline MC and HC-related knowledge; information that can subsequently be used to create and deliver targeted education in areas where knowledge is found to be lacking. Moreover, the questionnaire tool can be used evaluatively following education delivery, allowing for the comparison in MC and HC knowledge pre- and post-education intervention. Importantly, respondents aged 15+ across different competition levels (regional/state to international) were included throughout the validity and reliability testing process, ensuring that the tool can be confidently administered to athletes and performance support staff at various stages of their competitive careers.

Prior questionnaires measuring MC and/or HC knowledge have either not been validated and/or have been designed for populations other than athletes/performance support staff [17, 18, 24–26, 29, 32]. Further, many existing questionnaires omit relevant knowledge areas for this audience (e.g., LARC HC options) or have a narrow focus (e.g., emergency contraception only, REDs) and thus, do not provide a complete picture of MC and HC knowledge. Without a comprehensive understanding of athlete and performance support staff knowledge surrounding menstrual health, our ability to provide, and assess, the effectiveness of targeted education to improve menstrual health literacy within sport may be compromised. The questionnaire developed in this study to assess general MC and HCs knowledge has high face and content validity according to our participant cohort of athletes and performance support staff. An expert panel reviewed the questionnaire to ensure important knowledge domains and questionnaire items were captured in the tool, resulting in modifications to improve questionnaire comprehension and the reduction of items deemed less relevant or too difficult for the target audience. The face validity interview process further refined question wording to ensure items were inclusive and could be easily interpreted by younger athletes aged 15+. For example, in some instances younger athletes preferred a definition/clarifying statement (often in more colloquial language) to be added to a question to ensure they were interpreting it correctly (e.g., "It is considered healthy for athletes to experience absent menstruation (i.e., '*lose their period*') during periods of hard training"). These steps are important in reducing respondent burden and improving the quality of responses obtained [24]. While the final questionnaire covers four knowledge domains and comprises 46 knowledge questions (in addition to basic demographic and sport-specific questions), the logical flow of questionnaire domains/items and type of questions utilized (predominantly MCQs and T/F) allow the questionnaire to be completed in ~15 min by most respondents, ensuring it can be practically administered in research and applied settings.

Participants in the HK group had a strong foundation of MC physiology knowledge due to their education, clinical training/experience, and/or research expertise in the field. Construct validity testing confirmed the discriminating capacity of the questionnaire tool, with HK participants scoring significantly higher than the LK group overall and across each of the four knowledge domains. Indeed, several questions were answered correctly by all HK respondents. Certain knowledge domains were more discriminating than others in both CTT and IRT analyses; specifically, the Other HCs domain's IUD-related

TABLE 5 | Intraclass correlation coefficients and qualitative reliability evaluation of test–retest agreement for the knowledge questionnaire.

Test	ICC	95% CI	Qualitative ICC[a]	SEM	MD
Total questionnaire					
Total sample	0.95	0.93, 0.96	Excellent	2.56	7.10
Athletes	0.93	0.90, 0.95	Excellent	2.68	7.42
Performance support staff	0.99	0.97, 0.99	Excellent	1.72	4.77
(1) Normal MC Function domain					
Total sample	0.88	0.84, 0.91	Excellent	0.98	2.72
Athletes	0.86	0.81, 0.90	Excellent	0.97	2.69
Performance support staff	0.92	0.83, 0.97	Excellent	1.01	2.80
(2) MC Dysfunction domain					
Total sample	0.89	0.85, 0.92	Excellent	1.58	4.38
Athletes	0.86	0.82, 0.90	Excellent	1.66	4.60
Performance support staff	0.97	0.93, 0.99	Excellent	1.07	2.97
(3) OCPs					
Total sample	0.79	0.73, 0.84	Good-to-excellent	0.68	1.89
Athletes	0.73	0.64, 0.80	Good-to-excellent	0.70	1.93
Performance support staff	0.91	0.82, 0.96	Excellent	0.60	1.66
(4) HCs					
Total sample	0.89	0.86, 0.92	Excellent	1.27	3.52
Athletes	0.88	0.84, 0.91	Excellent	1.34	3.71
Performance support staff	0.96	0.92, 0.98	Excellent	0.79	2.19

Note: Data presented as reliability statistic (95% confidence interval). ICC values are calculated using two-way random-effects absolute agreement models ($ICC_{2,1}$) [33].
Abbreviations: ICC, intraclass correlation coefficient; MD, minimum difference; SEM, standard error of measurement.
[a]Interpretation of ICC values is from the guidelines recommended by Cicchetti [34].

questions demonstrated the strongest ability to discriminate between HK and LK respondents. It is perhaps unsurprising that LARC knowledge was low in this cohort given their typically low prevalence of use amongst Australian athletes [9, 14], with evidence suggesting that Australia generally has had a slow uptake of LARC options [37]. However, McNamara et al. [10] more recently reported ~a third of Australian elite female athletes that utilized a HC in their study to use a hormonal IUD, potentially indicating a preference shift. Nevertheless, the theory that LARC knowledge is low in athletes due to their low prevalence of use and/or recent uptake may be somewhat refuted by the fact that OCP knowledge is also poor, despite OCPs typically being the most popular HC amongst athlete populations [9, 10, 12, 14]. This finding supports prior studies (albeit using tools that were not validated) reporting low OCP knowledge amongst athletes and performance support staff [14, 15] and highlights the need for targeted educational strategies to improve MC and HC-related knowledge in this cohort. Promisingly, however, athletes and performance support staff exhibited relatively higher levels of knowledge overall in the present study, with even "Low Knowledge" participants answering on average 57% of questions correctly compared to 36%–40% correct responses reported in prior athlete MC and HC knowledge surveys [14, 15]. This finding may reflect an increase in awareness and education surrounding the MC and HCs within sport over recent years; even so, the findings strongly suggest a need for further improvements in menstrual health literacy amongst Australian athletes and performance support staff.

Certain questionnaire items (e.g., Q4 and Q11) showed limited ability to discriminate between respondents of different knowledge levels and were considered for removal from the questionnaire. However, these questions scored 100% for relevance by all members of the expert panel and were similarly well received by face validity interviewees in terms of item relevancy and clarity. Moreover, these questions cover knowledge that the authors deem important in understanding normal MC function; for instance, Q4 investigates respondents' understanding of the typical length of menstruation. As prolonged menstrual bleeding (7+ days) may be indicative of MC dysfunction [38], responses to this question may provide important descriptive information to help guide MC education interventions. The overall questionnaire tool (as well as each of the four individual knowledge domains) is able to meaningfully discriminate between participants of high and low knowledge. Furthermore, these questions do not reflect a substantial participant burden in terms of completion time given their short description and question format (MCQ or T/F), and removal of these items increased internal consistency of the Normal MC Function domain only marginally (from $\alpha = 0.698–0.703$ [Q4] or 0.718 [Q11]). Thus, the

decision was made to leave these items in the questionnaire tool, to provide relevant and important information.

Internal reliability of the overall questionnaire and each of the knowledge domains was analyzed using Cronbach's α and found to be acceptable ($\alpha \geq 0.7$), indicating that items are closely related [39], although the lower CI bounds for two domains were below the acceptable threshold. This was possibly due to select questions (e.g., Q11 and Q30), which were considered for removal from the questionnaire based on internal reliability testing findings. However, consideration was again given to item relevance (100% relevance agreement for all three items based upon expert review), participant burden (low), and the descriptive information that could be gleaned from these questions and used to prompt further discussion around the MC in a high-performance environment. The tool exhibited *excellent* test–retest reliability [34] with the inclusion of these items, with a 1-point difference in mean knowledge score between attempts 1 (28) and 2 (29) and negligible differences across the four knowledge domains between attempts. Therefore, these items were retained in the final questionnaire.

While the developed questionnaire reflects a valid and reliable tool to measure MC and HC knowledge amongst athletes and performance support staff, there are limitations that must be acknowledged. Firstly, the questionnaire was developed with Australian athletes and support staff only, the majority of whom (> 80%) identified as Caucasian/White, and was administered in English. While athletes' MC experience, prevalence of HC use, and attitudes surrounding menstruation appear to be generally similar across regions such as Australia and Europe, there may be cultural and societal differences in how the MC (and therefore HC use) is viewed amongst First Nations Australians or athletes from different geographical regions. For instance, athletes and performance support staff from regions such as Sub-Saharan Africa are known to differ in their attitudes towards menstruation and prevalence of HC use [40]. Given the current cohort was geographically narrow (Australian) and culturally homogenous (> 80% white/Caucasian), the questionnaire may need to undergo additional refinement and testing, including translation into languages other than English, before it can be confidently administered internationally or to diverse groups within Australia in a way that is culturally relevant and appropriate. The questionnaire was also designed to be relevant to athletes of menstruating age (and support staff working with these athletes), so it is likely not relevant or applicable to athletes at other life stages (e.g., postmenopausal Masters athletes). It is also worth noting that while effort was taken to ensure the language used in the questionnaire was inclusive of trans and non-binary athletes who menstruate without compromising item clarity, the current participant cohort comprised cisgendered female athletes which precluded commentary on whether the questionnaire was inclusive and affirming for those with diverse gender expressions from those with lived experience. Thus, feedback should be sought from trans and non-binary athletes who menstruate to ensure their comfortability with the questionnaire topics and wording prior to administration. In addition, while many types of performance support staff were included throughout the questionnaire development and testing process (e.g., coaches, physicians, physiotherapists, dieticians, sport scientists, high- performance managers, and more), participant response numbers precluded comparison of knowledge between individual roles, which could be useful information when creating targeted educational interventions to improve menstrual health literacy within sport. Likewise, athletes and performance support staff from a range of competition levels (regional/state to international) were included in the testing process; as there may be a disparity in the type and level of MC education delivered to athletes of different competition levels, comparison of these cohorts would be a useful avenue for future research. It should also be noted that, while athletes aged 15+ were included in the questionnaire development process, menarche (i.e., the onset of menstruation) on average occurs at age ~12 (and can occur even earlier [41]). Thus, future research should explore options to assess MC knowledge in athletes aged younger than 15 so that age-appropriate education can be delivered to younger athletes who may already be menstruating. Indeed, this may be a particularly important avenue for future research given the known decrease in organized sports participation that occurs as girls move through adolescence [42], with evidence to suggest that menstruation may be a deterrence to sport participation amongst this cohort [43].

An additional limitation is that the questionnaire comprises predominantly MCQs and T/F questions, with select items requiring free text (short answer) responses. These types of responses may limit a deep level of understanding. However, the strength of this approach is that it allows the tool to obtain an overview of knowledge across four key knowledge domains (namely: (1) Normal MC Function, (2) MC Dysfunction, (3) OCPs, and (4) Other HCs) while only taking respondents approximately 15 min to complete; information that can then be used to foster more in-depth and nuanced conversations. Finally, as the primary aim of this study was to establish questionnaire validity and reliability, no formal scoring cut-offs or benchmarks have been proposed. However, respondents could reasonably compare their scores against the "High Knowledge" and "Low Knowledge" group scores presented in this manuscript (with consideration of their own level of education) to get an understanding of where their knowledge level is situated compared to their peers. Moreover, the questionnaire can be confidently used to: (1) assess MC and HC baseline knowledge level (pre-education), (2) identify knowledge gaps to inform targeted education opportunities, and (3) assess the efficacy of education delivery through the comparison of pre-education and post-education knowledge scores. Future research should explore the development of benchmark categories to facilitate enhanced practical administration of the questionnaire across varied sporting contexts.

The valid and reliable MC and HC knowledge survey can be administered to athletes (aged 15+) and performance support staff to assess their menstrual health literacy; information that can be used to develop, implement, and assess targeted MC and HC education interventions. By improving knowledge, athletes will be afforded the ability to make more informed decisions about their MC and use (or non-use) of HCs, and performance support staff will be better positioned to assist their athletes. For example, it is hoped that with improved MC/HC literacy, athletes will recognize abnormal MC signs and symptoms earlier and thus, seek professional advice more promptly. It is hoped that through increasing awareness of the MC and HCs within sport, athletes and their performance support staff will be able to make personalized adjustments (where necessary) to optimize athlete health, wellbeing, and performance.

4.1 | Perspective

Previous studies assessing MC and HC knowledge in athletes and performance support staff utilized custom questionnaires with unknown validity (content, and construct) and reliability (test–retest and internal consistency). This study developed and validated a questionnaire to assess MC and HC knowledge amongst athletes and performance support staff. The valid and reliable MC and HC knowledge questionnaire can be confidently administered to athletes (aged 15+) and performance support staff to assess their menstrual health literacy; information that can be used to develop, implement, and assess targeted MC and HC education interventions within sport.

Author Contributions

Study conception and design was led by Brianna Larsen with assistance from all authors. Material preparation and data collection were performed by Brianna Larsen and Erica Greet. Participant recruitment was facilitated by Brianna Larsen, Erica Greet, Stephen P. Bird, Karlee Quinn, and Alice McNamara. Data analyses were performed by John O. Osborne, Brianna Larsen, and assistance was provided by Erica Greet. The first draft of the manuscript was written by Brianna Larsen with significant contributions from John O. Osborne, and all authors commented on drafts of the manuscript. All authors read and approved the final manuscript.

Ethics Statement

Ethical approval for this study was authorized by the University of Southern Queensland Human Research Ethics Committee (H22REA250).

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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Supporting Information

Additional supporting information can be found online in the Supporting Information section. **Appendix S1.** Knowledge survey. **Appendix S2.** Menstrual cycle and hormonal contraception knowledge questionnaire user guide.