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**Understanding Experience, Knowledge and Perceived Challenges Related to
Bra Fit for Sports Participation: A Scoping Review**

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Abstract

The breasts are reported as the fourth largest barrier to participation in physical activity (PA). This scoping review provides a comprehensive understanding of experiences, knowledge and challenges relating to bra fit and sports participation. The search strategy was adopted by the Preferred Reporting Items for Scoping Reviews (PRISMA-ScR) guidelines and multiple databases were searched. All research was in English and within the last 20 years. Exclusion criteria excluded reviews, male participants and the inability to locate or access full-text articles. The JBI critical appraisal tool assessed methodological quality. Twenty-three studies were included. Key themes from the studies are breast motion during PA, sports bra design, perceived barriers to participation in PA and education/knowledge of breast support and bra fit. Increasing breast support reduces breast movement during PA yet breast motion and bra fit are still the most common breast concerns for females. This is likely influenced by poor breast knowledge, leading to poor breast support choices. Future research should explore to what extent breast motion, knowledge and bra fit influences sport participation, and this research should include a more diverse range of adult ages, cup sizes, ethnicities and PA levels to provide a wider understanding.

Key words: bra fit; breast support; sports participation; women's health; barriers

Introduction

Sixty percent of women and 45% of girls achieve the recommended physical activity government guidelines in England (Women In Sport, "Stats Pack for Media.", 2021). Consequently, obesity rates are rising, and it is forecast that the prevalence of obesity for women in England will increase from 4 to 8% by 2035 (Keaver et al., 2020). Similarly, breast size amongst white British and white American females has been shown to be increasing over time as a potential consequence of the obesity epidemic (Brown et al., 2016). Increasing participation in physical activity has a plethora of health benefits, including but not limited to reduced risk of diabetes, stroke, heart disease, obesity and premature death (Warburton et al., 2006; Keaver et al., 2020). However, several barriers may prohibit physical activity participation including a lack of self-confidence, low self-esteem, menstrual cycle stage, absence of motivation, lack of facilities and breast-related factors (Moreno & Johnston, 2014; Burnett et al., 2015).

Women and girls demonstrate a lack of knowledge in breast health and bra fit and previously, the breast has been reported as the fourth largest barrier to participation in physical activity (Burnett et al., 2015; Scurr et al., 2016; Brown et al., 2018). In a cohort of 249 women, 17% reported barriers related to bra fit, including *"I can't find the right sports bra"* and *"I am embarrassed by excessive breast movement"* (Burnett et al., 2015). In addition, for most girls (85%), the breasts were the first physical change in puberty and a challenging time for maintaining confidence and positivity towards body image (Scurr et al., 2015). Brown et al. (2018) detected that in 2089 girls, 87% reported at least one concern with their breasts, and one of the most common (44%) concerns was *"breast bounce whilst exercising"* (Brown et al., 2018).

The breast is composed largely of adipose tissue; whilst Cooper's ligaments are present within the breast tissue, their ability to provide structure and support during physical activity is unknown (Bowels et al., 2008). Breast movement during physical activity is not uncommon, and it is evident that larger-breasted women experience greater breast movement due to more breast mass acting as a greater force (Brown et al., 2012, 2015; McGhee et al., 2013; Burnett et al., 2015). Excessive breast movement can increase embarrassment, reduce willingness to exercise, decrease self-confidence, and lower self-esteem (Moreno & Johnston, 2014; Burnett et al., 2015; Scurr et al., 2015). Whilst movement as little as 2cm can induce breast pain (McGhee et al., 2007), breast movement of up to 19cm vertical plane and 4cm in the medial-lateral and anterior-posterior planes have previously been recorded during physical activity (Mason et al., 1999; McGhee et al., 2007; Scurr et al., 2011). Therefore, correct breast support is required for women to minimise exercise-induced breast pain and prevent breast sag (ptosis) (Page & Steele, 1999; Coltman et al., 2017).

In a previous global study of 1,659 women globally, 32% reported more breast pain when participating in physical activity (Scurr et al., 2014). Yet, 75 to 100% of women wear an ill-fitting bra during sporting and non-sporting activities (McGhee et al., 2010; Coltman et al., 2018). The sports bra market is saturated with many different types of bras, which may become overwhelming (Scurr et al., 2016). There are two main types of bras recommended during physical activity: compression and encapsulation style (Page et al., 1999). Compression bras compress both breasts to the chest wall to minimise movement (Page et al., 1999). Encapsulation bras are cupped and support each breast individually and have been previously recommended for larger-breasted women (Mason et al., 1999; Page et al., 1999). Bra-fitting services are useful to help optimise breast support, limiting breast movement and embarrassment to exercise (Bowels et al., 2012). However, of 104 Australian women, 75%

reported never using a bra fitting service (McGhee et al., 2010; Burbage et al., 2021). Although reasons as to why were not discussed. Nevertheless, implementing a correctly fitted sports bra has previously relieved 85% of women's breast pain symptoms during physical activity (Hadi, 2000). Therefore, correct bra fit is essential for breast health during participation in physical activity (Page & Steele, 1999; Coltman et al., 2017). However, this is an ongoing challenge continuously highlighted in previous research (McGhee et al., 2010; Bowels et al., 2012; Coltman et al., 2019). If this challenge could be addressed, the breasts and poor bra fit as barriers to participation in sport may be removed and knock-on effects would be multifaceted and advantageous in terms of physical and mental health benefits.

Poor breast health awareness, limited utilisation of professional bra fitting services and the vast array of sports bras available may all contribute to inadequate sports bra fit for women (Burnett et al., 2015; Scurr et al., 2016; Brown et al., 2018), although the extent of these factors, and other contributing factors remain under-researched. Therefore, this scoping review aims to provide a comprehensive understanding of experiences, knowledge and perceived challenges relating to bra fit and sports participation. The objectives will determine three key outcomes:

1. To examine present research on experiences, knowledge and perceived challenges relating to bra fit and sports participation.
2. To establish whether agreement exists in reporting the breast to be a barrier for sports participation due to larger breast size, lack of knowledge, bra related factors and breast pain.
3. To highlight knowledge gaps in the present evidence base on experiences, knowledge and perceived challenges relating to bra fit and sports participation that may help inform future research in the topic area to overcome breast/bra-related barriers to physical activity or sports participation.

Methods

Design and Search Strategy

The search strategy was built based on the Preferred Reporting Items for Scoping Reviews (PRISMA-ScR) guidelines, directed by the Arksey and O'Malley (2005) framework for scoping reviews. The research questions were identified, and the relevant studies were reviewed based on the inclusion and exclusion criteria. This method allowed for a thorough search of the research to better understand females' experiences, knowledge, and perceived challenges relating to bra fit and sports participation.

Eligibility Criteria

Research that met the inclusion and exclusion criteria was considered for review. Studies were included if they discussed breast size or breast movement, barriers to physical activity in women, females, or adolescent girls regardless of pregnancy, breastfeeding and childbirth. All research was written in English, regardless of country of origin, and within the last 20 years (2002-2022). Exclusion criteria excluded reviews, articles tested on animals, males and an inability to locate or access full-text articles.

Data Selection, Collection and Extraction

Figure 1 presents the PRISMA-ScR (Arksey and O'Malley, 2005) schematic for the full process of article review. Sources searched included electronic databases and reference lists from key journal articles. The databases included Scopus, Sport Discus, ProQuest central, PubMed, Science Direct, MEDLINE (via OVID) and CINAHL Complete. The database search was carried out on the 23rd of March 2022. Keywords included "women", "*female*", "*girls*", "*adolescent*", "*breast size*", "*breast fit*", "*breast support*", "*breast health*", "*knowledge*", "*experience*", "*awareness*", "*education*", "*bra fit*", "*physical activity*", "*sports participation*".

The keyword "cancer" was excluded from the search given that breast cancer patients will face alternative and additional barriers and knowledge for sports participation and breast health (Brunet et al., 2013; Smith et al., 2017). Boolean operators were used to add further personalisation as follows: (women OR girls OR female OR adolescent) AND ("breast support" OR "bra fit" OR "breast size" OR "bra size" OR "breast pain" OR "breast health") AND (knowledge OR education OR barrier* OR decision* OR puberty) AND (physical activity OR sports participation OR exercise). At least one of the keywords from each AND operator in title, abstract or keywords was required.

Titles and abstracts were screened by two reviewers, and the remaining studies were reviewed for full-text screening by a single reviewer. If the title or abstract did not reveal enough information to determine appropriateness for inclusion, the full article was retrieved for full-text review. References were exported to Mendeley Desktop reference management software (version 2.68.0) for screening, and all duplicates were removed. A thematic synthesis approach (Thomas & Harden, 2008) was conducted to identify the main themes within the research.

Assessment of methodological quality was conducted following the Joanna Briggs Institutes (JBI) guidance using JBI critical appraisal tools (The Joanna Briggs Institute (JBI). Critical appraisal tools for use in JBI systematic reviews. 2020). These critical appraisal tools include nine items for assessing cross-sectional studies and ten for assessing qualitative studies. Items required a yes, no, unclear or not applicable response and more 'yes' responses represented higher quality. Due to limited studies available, no studies were excluded based on methodological quality however, quality was accounted for in the interpretation of the results.

Results

From the initial search, 199 articles were identified through databases and 11 articles through reference lists (Figure 1). Following title and abstract screening, 177 studies were not considered appropriate for full study screening. A total of 27 studies were screened and 4 studies were removed. The remaining 23 studies were included in this scoping review.

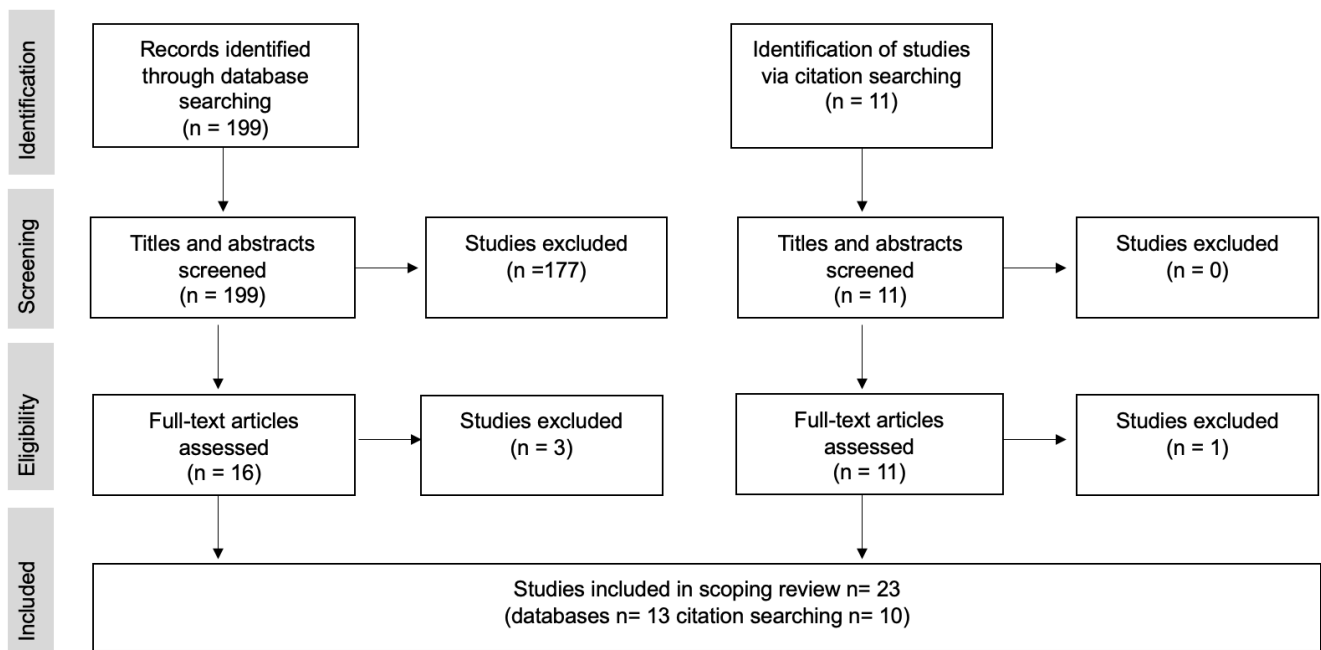


Figure 1: PRISMA schematic for included articles

Study Characteristics

The main themes and focus of the studies were breast motion during physical activity for sports bra design, perceived barriers to participation in physical activity and education/knowledge of breast support and bra fit. Ten studies used quantitative methods to measure breast motion and breast support (McGhee et al., 2007; Scurr et al., 2009; 2010; 2011; 2015; Mills et al., 2015a; Risius et al., 2015; Mills et al., 2015b; Risius et al., 2017) and breast knowledge (McGhee et al., 2010). The remaining 13 studies used qualitative methods to measure perceived barriers and knowledge of breast support and bra fit (Brown et al., 2014; Burnett et al., 2015; Scurr et

al., 2016; Burbage et al., 2017; Smith et al., 2018; Brown et al., 2018; Coltman et al., 2019; Brisbane et al., 2019; Omrani et al., 2020; Brisbane et al., 2020; Brown et al., 2021; Rizzone et al., 2021). An overview of the studies are presented in Table 2.

The years of publication were between 2007-2021 and breast-related studies increased each year. Most of the research was located in the United Kingdom (n=15), whilst six studies were in Australia and two in the United States. The populations of the studies included both adolescent girls (n=3), athletes (n=6) and the general female population (n=14). Cup size across the studies ranged from AA to J. Of the nine quantitative cross-sectional studies, six solely investigated women with a D cup.

Critical appraisal

Table 1 presents the results from the critical appraisal. The cross-sectional studies had an overall score between 6 to 8/8, the qualitative studies all presented a score of 8/8 and the randomised-controlled study had a score of 9/13. This suggests the majority of the research articles included in this scoping review contain most of the prerequisites stipulated on the JBI critical appraisal tools.

Table 1: Critical appraisal results

First author et al. (year)	1	2	3	4	5	6	7	8	9	10	11	12	13	Overall Score
Cross-sectional studies														
McGhee et al. (2007)	Y	Y	Y	Y	N	N	Y	Y						6/8
Scurr et al. (2009)	Y	Y	Y	Y	Y	Y	Y	Y						8/8
Scurr et al. (2010)	Y	Y	Y	Y	Y	Y	Y	Y						8/8
Scurr et al. (2011)	Y	Y	Y	Y	N	N	Y	Y						6/8
Mills et al. (2015a)	Y	Y	Y	Y	Y	N	Y	Y						7/8
Risius et al. (2015)	Y	Y	Y	Y	Y	Y	Y	Y						8/8
White et al. (2015)	Y	Y	Y	Y	Y	N	Y	Y						7/8

Mills et al. (2015b)	Y	Y	Y	Y	Y	N	Y	Y					7/8
Risius et al. (2017)	Y	Y	Y	Y	N	N	Y	Y					6/8
Qualitative studies													
Bowels et al. (2008)	Y	Y	Y	Y	Y	N	N	Y	Y	Y	Y		8/10
Brown et al. (2014)	Y	Y	Y	Y	Y	N	N	Y	Y	Y	Y		8/10
Burnett et al. (2015)	Y	Y	Y	Y	Y	N	N	Y	Y	Y	Y		8/10
Scurr et al. (2016)	Y	Y	Y	Y	Y	N	N	Y	Y	Y	Y		8/10
Burbage et al. (2017)													8/10
Smith et al. (2018)	Y	Y	Y	Y	Y	N	N	Y	Y	Y	Y		8/10
Brown et al. (2018)	Y	Y	Y	Y	Y	N	N	Y	Y	Y	Y		8/10
Coltman et al. (2019)	Y	Y	Y	Y	Y	N	N	Y	Y	Y	Y		8/10
Brisbine et al. (2019)													8/10
Omrani et al. (2020)	Y	Y	Y	Y	Y	N	N	Y	Y	Y	Y		8/10
Brisbine et al. (2020)	Y	Y	Y	Y	Y	N	N	Y	Y	Y	Y		8/10
Brown et al. (2021)	Y	Y	Y	Y	Y	N	N	Y	Y	Y	Y		8/10
Rizzone et al. (2021)	Y	Y	Y	Y	Y	N	N	Y	Y	Y	Y		8/10
Randomised controlled trials													
McGhee et al. (2010)	Y	N	Y	N	N	N	Y	Y	Y	Y	Y	Y	9/13

Y = yes meets the criteria. N = no does not meet the criteria.

Table 2: Studies included within the review

Article	N	Participant characteristics	Cup size average (range)	Key findings
Cross-sectional studies				
McGhee et al. (2007)	16	Healthy women (32 years range 19–43)	C+ (C+)	Breast discomfort decreased significantly in deep water running vs treadmill running.
Scurr et al. (2009)	15	Healthy women (24 ± 4.8 years)	34D (26D-36D)	Breast displacement did not change significantly across a gait cycle. 56% of breast movement was vertical (p<0.05).
Scurr et al. (2010)	15	Healthy women (25.1 ± 4.8 years)	D (D)	Significant mediolateral and anteroposterior correlations with breast comfort were reported. Breast comfort was most closely correlated with breast velocity and displacement but a low correlation with breast acceleration.
Scurr et al. (2011)	21	Healthy women (25.1 ± 4.8 years)	D (D)	Breast support was effective in reducing the amplitude of breast displacement during walking and running but the direction was unaffected.
Mills et al. (2015a)	6	Healthy women (29 ± 7 years)	(34F-34HH)	Sports bra significantly reduced breast displacement. The swimsuit did not provide any extra breast support for larger-breasted women.
Risius et al. (2015)	16	Healthy women (22 ± 2 years)	32D (32D)	Jumping; greater vertical breast displacement (.09 m), less mediolateral breast displacement (.05 m), agility tasks produced the highest multiplanar breast velocities and acceleration (p>0.05).
White et al. (2015)	11	Recreational runners (26 ± 7 years)	(32D-34E)	The high support bra reduced breast kinematics and decreased breast pain (P< 0.05). Female runners with larger breasts should wear a high support bra to reduce breast pain.
Mills et al. (2015b)	10	Healthy women (22 ± 2 years)	32D (32D)	No significant change in breast displacement between L/R breast. 70% had greatest superiorinferior displacement of the left breast in the no bra condition, 90% in the everyday bra and 60% in the sports bra compared to the right breast (p>0.05).

Risius et al. (2017)	10	Healthy women (27 ± 6 years)	34D (34D)	Of the 62 variables measured, 22 kinematic and subjective variables were affected by changes in breast support. Willingness to exercise, time lag and superio-inferior breast velocity were most affected by breast support.
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Qualitative studies

Bowles et al. (2008)	413	Healthy women (20-35 years)	(32A- 42DD)	41% currently wore an encapsulating sports bra for PA. Women with large breasts were more than twice as likely to wear a sports bra as their smaller-breasted counterparts.
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Brown et al. (2014)	1397	Runners (18-74 years)	34B (AA-HH)	Sports bra use and perceived importance was high, but lower in moderate than vigorous activity and smaller-breasted women. 75% reported bra fit issues, common issues were chaffing and shoulder straps digging in, and more prevalent in larger-breasted women. Use of professional bra fitting was low, and perceived knowledge of breast health was poor.
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Burnett et al. (2015)	249	Healthy women (18-65 years)	(A-GG)	52% rated their breast knowledge as 'average'. Breast pain was reported in 41% of women. PA was the most common factor for causing breast pain. The breast was a barrier to PA for 17% of respondents.
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Scurr et al. (2016)	2089	School girls (11-18 years)	(A- >DD)	46% reported that their breasts affected participation in PA, more prevalent in girls aged 13-14 years (51%) and in larger-breasted girls (63%). >50% reported never wearing a sports bra during sports.
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Burbage et al. (2017)	1324	Horse riders (18-24 years)	34B (28AA-44J)	40% reported breast pain, significantly related to cup size (P<0.001), increasing linearly. At least one bra issue was reported by 59% of participants; larger-breasted participants reported experiencing all bra issues more frequently than smaller-breasted participants (P< 0.001).
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Smith et al. (2018)	194	Collegiate athletes (19.3 years)	Did not state	47.9% reported a breast injury during their career, <10% reported injury to health personnel. 97.8% were not wearing any protective breast/chest equipment in addition to normal bra/support. ~18.2% indicated that their participation/performance competitions was affected by mild/moderate pain.
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Mills, Risius & Scurr (2015)	10	Healthy women (22 ± 2 years)	32D (32D)	No significant change in breast displacement between L/R breast. 70% had greatest superioinferior displacement of the left breast in the no bra condition, 90% in the everyday bra and 60% in the sports bra compared to the right breast (p>0.05).
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Brown et al. (2018)	2089	School girls (11-18 years)	(A- >DD)	26% reported negative feelings about their breasts and 87% reported ≥ 1 breast concern. 50% wanted to know more about breast sag and breast pain. A need for breast education and delivery preferences was identified.
Coltman et al. (2019)	355	Healthy women (42.3 \pm 18 years)	Did not state	Women with large breasts participated significantly less PA, specifically less vigorous-intensity PA and perceived their breasts to affect their PA compared to women with smaller breasts.
Brisbine et al. (2019)	504	Elite athletes (25.7 \pm 9.5 years)	(8A-20G)	36% reported experiencing breast injuries and 21% perceived their breast injury to negatively affect performance. Contact breast injuries were significantly more when athletes were involved in contact/combat sports or with larger-breasted athletes. <10% reported their injury to a coach/medical professional and 50% used prevention strategies.
Omrani et al. (2020)	787	adolescent girls (13.2 \pm 0.8 years)	Did not state	Intervention group improved breast knowledge, attitudes to breasts & engagement with positive breast habits, compared to control (p<0.01). Intervention made them “feel less embarrassed” about their breasts & wanted to do more exercise & change their bra purchasing/wearing habits.
Brisbine et al. (2020)	540	Elite athletes (25.67 years)	32/34B (30A-42G)	63% reported breast pain associated with the menstrual cycle, 33% reported that this pain worsened during activity. 44% reported exercise-induced breast pain during training or competition.
Brown et al. (2021)	3147	Physically active women (18-29 years)	34B	<i>‘I can’t find the right sports bra’</i> was the most frequent breast barrier to exercise (25.4%). 75% of women wore a sports bra during exercise.
Rizzone et al. (2021)	438	Healthy women and girls (22 \pm 12.2 years)	(AA-G)	27.4% reported lack of breast support prevented them from being active or exercising. Age (p = 0.03), breast size (p < 0.0001), and household income (p = 0.01) were associated with greater frequency of PA being limited by lack of breast support
Randomised controlled trials				
McGhee et al. (2010)	115	School girls (14-18 years)	B	Experimental group improved bra knowledge by 19% more than control group. 39% more of the experimental group passed the Bra Fit Assessment test and 30% more passed the Level of Breast Support test than the control group.

Discussion

This scoping review aimed to produce a comprehensive overview of females' experience, knowledge, and perceived challenges related to bra fit for sports participation. To the author's knowledge, this is the first scoping review to do so. Evidence from the literature suggests three directions. The first is a focus on breast movement during physical activity under different breast support conditions, the second is surveys to determine perceived challenges and barriers to physical activity and the third is knowledge and education of breast support and bra fit. Figure 2 below denotes the themes in breast-related barriers to sports participation.

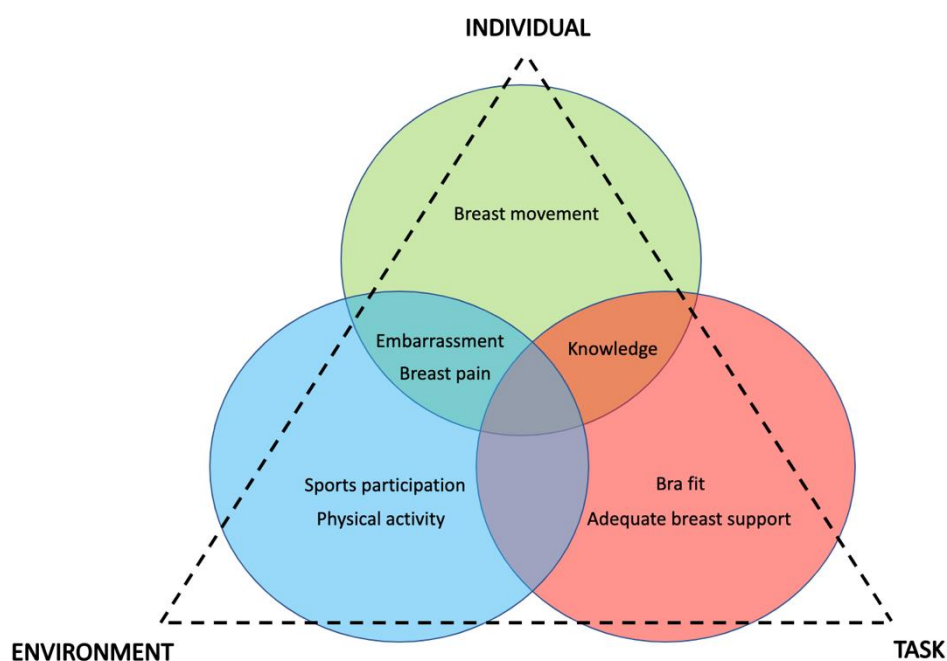


Figure 2: Newell's model of constraints to show the themes in breast-related barriers to sports participation

In determining whether larger breast size and excessive breast movement influence sports participation decisions, the research supports the notion that breast movement is a concern during physical activity (Burnett et al., 2015; Scurr et al., 2016; Brown et al., 2018). Breast motion was however reduced when breast support level increased, such as when wearing an appropriately fitted bra for the desired activity (McGhee et al., 2007; Scurr et al., 2009; 2010;

2011; 2015; Mills et al., 2015a; Risius et al., 2015; Mills et al., 2015b; Risius et al., 2017). Results were consistent across various activities, including walking, running, jumping, and swimming. Scurr et al. (2009) detected that 56% of breast motion was vertical during a treadmill run with fifteen bare-breasted women with D-cup breast size. This was one of the first studies of its kind and signified the requirement of adequate breast support to limit breast motion during physical activity (Scurr et al., 2009). Unsurprisingly, during a treadmill run in three breast support conditions (everyday bra, compression bra and encapsulation bra), vertical breast displacement was significantly reduced ($p < 0.001$) as breast support increased, respectively (Scurr et al., 2011). Parallel findings were reported by Scurr et al. (2015), Mills et al. (2015), Risius et al. (2015) and White et al. (2015); an increase in breast motion was present during high-intensity activities such as jumping, running and agility tasks compared to lower intensity activities such as walking.

The magnitude of breast motion differs between breast sizes and how this directly links to sports participation is not yet well researched. Larger-breasted women have a heavier breast mass and thus require greater support than smaller-breasted women (Coltman et al., 2019). It may be postulated that increased breast size may be another contributor to greater breast motion during sports participation (Burnett et al., 2015). Most quantitative studies within the literature investigated larger-breasted women, with a D cup breast size, whilst cup sizes can exceed an H cup. Existing research is therefore not reflective of all women and leaves a clear gap in understanding the true impact of increasing breast size on breast motion. In addition, how the magnitude of breast motion and differing breast support directly links to sports participation is not well documented. Risius et al. (2017) was the first quantitative study to determine perceived barriers with differing breast support during physical activity. The authors observed a significant increase in breast or bra comfort, willingness to exercise, and a significant reduction

in embarrassment during high support conditions for physical activity (Risius et al., 2017). However, this was a small-scale study of 10 women and thus, further research with a larger population is required to highlight the relationship between breast support and sports participation.

With respect to the second outcome, qualitative studies were appraised to understand the current stance on the experience, knowledge and perceived challenges relating to bra fit and sports participation. In surveys with 2089 adolescent girls, at least one breast concern was reported in 73% and 87% of girls, respectively. Where "*breast bounce whilst exercising*" was the first (44%) and second (37%) most common concern (Scurr et al., 2016; Brown et al., 2018). Education interventions have been a successful method for improving knowledge of the breast in adolescent girls (McGhee et al., 2010; Omrani et al., 2020). In this study, the experimental group received an educational booklet on breast support and bra fit (McGhee et al., 2010). Four months after receiving the booklet, the experimental group's bra knowledge was 19% greater than the control group (McGhee et al., 2010). Additionally, a 50-minute breast education class for adolescent girls significantly improved breast knowledge, attitudes to breasts and engagement with positive breast habits, compared to participants that did not receive the class ($p < 0.01$) (Omrani et al., 2020). The impact of the class was to reduce embarrassment, increase willingness to do more exercise, and change bra purchasing/wearing habits. It is evident from the above literature that girls lack the knowledge of breast health and adequate breast support and providing education to adolescent girls may be an effective method to improve knowledge. Whilst breast knowledge has also been researched in 249 women, where 52% of women rated their breast knowledge as "average", 25% rated "below average" and 24% rated "above average" (Burnett et al., 2015). Most women have an "average" knowledge of breast health and bra fit, which may contribute to poor breast support choices

and consequently greater breast movement and pain during physical activity. In turn, providing education to adolescent girls may contribute to reducing the gender gap in dropout rates of sports participation at puberty and potentially throughout adulthood.

It has been shown in a study on 1397 female runners at the London marathon, that women who regularly participate in physical activity do not have a much greater understanding of the importance of adequate breast support (Brown et al., 2014). Fifty-eight percent of the runners rated their knowledge of breast health and bra fit as average and only 6% rated their knowledge as excellent. In addition, Brown (2014) detected that 97% of the marathon runners reported wearing a sports bra during exercise, much greater than the general population (41%) (Bowels et al., 2008). This difference may be expected as marathon runners complete more hours of higher-intensity activity, which is more likely to cause excessive breast motion (Bowels et al., 2008). Therefore, although a greater number of marathon runners wear a sports bra during physical activity, their knowledge of breast health and bra fit is similar to that of the general population. Highlighting that irrespective of whether women participate in physical activity or not, breast knowledge is poor. Addressing this gap in knowledge may contribute to a reduction in the perceived challenges associated with the breast and participation in physical activity.

All the studies investigating breast motion used brand new, unworn bras and did not consider that they will be worn after multiple washes over a length of time. This potentially influences the functional properties of the bra, and it has been previously recognised that after 25 washes a sports bra support is reduced by ~20% (Wakefield-Scurr et al., 2022). There is evidence that the breast is a barrier to sports participation for women and girls due to excessive breast motion, poor bra fit and knowledge of the breast (Burnett et al., 2015; Scurr et al., 2016; Risius et al., 2017; Brown et al., 2018). However, how much this limits participation, and the associated

social barriers remain unknown. The majority of studies focussed on white Caucasian women however, due to this limitation, it is unclear whether ethnicity is a barrier.

Limitations, Strengths and Implications

A key strength of this scoping review was the use of a broad search strategy, a 20-year date restriction, the use of multiple databases and a grey literature search, which captured a wide range of results. Additionally, although not required for a scoping review, the addition of a critical appraisal highlighted the high quality of research within the field. Only studies written in the English language were included, indicating a bias, and a limitation of the study as a result of not knowing what barriers were presented in the research of other languages.

Conclusion

To conclude, increasing breast support does reduce breast movement during activities such as running, walking and swimming (McGhee et al., 2007; Scurr et al., 2009; 2010; 2011; 2015; Mills et al., 2015a; Risius et al., 2015; Mills et al., 2015b; Risius et al., 2017). Whilst breast motion and bra fit are the most common breast concerns for women and girls, the magnitude of breast motion and how this influences participation in sport requires further investigation. Breast knowledge is poor in both girls and women, irrespective of activity level and participation in sports, leading to poor breast support choices (Bowels et al., 2008; McGhee et al., 2010; Omrani et al., 2020). Educational interventions are an effective way of improving breast knowledge and reducing breast concerns. The overall quality of the studies is considered high. However, future research requires a greater national coverage of all adult ages, cup sizes, ethnicities and physical activity levels to bridge the current evidence gaps around the influence of the breast on physical activity participation decisions. Therefore, evidence-based solutions can be determined with an aim to increase sports participation amongst girls and women.

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Declaration of interest statement

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper

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