Changes in Physical Activity and Breast-Related Factors During and After Pregnancy in Women in Sport and Physical Activity Journal, Volume 33: Issue 1

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Key points

- Bra size, breast pain during physical activity, sports bras and breastfeeding may contribute to changing PA habits during and after pregnancy.
- Suitable breast support must be developed for pregnant and post-partum women.

Abstract

Several barriers likely contribute to physical activity (PA) changes that occur during pregnancy and the post-partum period, but the contribution of bra size, breast pain during PA, sports bras and breastfeeding is currently unknown. This study aimed to 1) investigate how PA, self-reported bra size and breast pain during PA change during and after pregnancy and 2) investigate the influence of sports bras and breastfeeding on PA in women who classed themselves as physically active pre-pregnancy. Three-hundred and twenty-three women who were pregnant (n=97), had given birth within the last 12 months (n=192) or were breastfeeding (n=34) at the time of data collection completed an online questionnaire and 13 of these women participated in focus groups. Fourteen percent less pregnant and 10% less post-partum participants were physically active whilst pregnant. In the post-partum period, 85% of participants were physically active. Forty-five percent of post-partum participants reduced their PA impact level compared to pre-pregnancy. Self-reported UK bra size increased on average by one underband and two cup sizes from before to during and after pregnancy. The incidence of breast pain during PA was highest for pregnant participants and

those who had or were breastfeeding. Focus groups showed that the lack of suitable sports bras and/or breastfeeding led to a decline in or change to the type of PA. These findings highlight the need for maternity/nursing sports bras which adapt to the female body, provide support, minimise breast pain during PA and help minimise the logistical challenges of breastfeeding and PA.

Introduction

Regular physical activity (PA) during and after pregnancy provides numerous benefits including reducing the risk of excessive gestational weight gain and post-partum depression (DiPietro et al., 2019; Okyay & Ucar, 2018). Reflecting on these benefits, current guidelines state that pregnant and post-partum women (without contraindications) should participate in at least 150 minutes of moderate-intensity aerobic PA per week (World Health Organisation, 2020). Despite these recommendations, PA levels often decline during pregnancy and remain below pre-pregnancy levels in the post-partum period. Pereira et al. (2007) identified a decline of 2.7 hours per week in average self-reported PA during pregnancy and 1.4 hours per week at six months post-partum. Walking, swimming and yoga are reported to become more popular during pregnancy (Weallens et al., 2003), whilst following pregnancy women often do not return to vigorous PA (Pereira et al., 2007; Treuth et al., 2005). For example, James et al. (2022) found that 25% of women (883 post-partum women within two years of giving birth who ran at least once per week pre-pregnancy), did not return to running post-partum mainly due to experiencing post-partum pain/symptoms. These changing PA habits are attributed to the barriers pregnant and post-partum women face towards PA, including fatigue, nausea, lack of time and/or access to suitable facilities (Atkinson et al., 2020; Harrison et al., 2018; Salingheh et al., 2016; Snyder et al., 2020). However, changes in bra size and breast pain during PA and the potential impact of sports bras and breastfeeding on

pregnant and post-partum women's PA is not yet known despite the importance of being physically active during this time.

The breasts and rib cage undergo numerous changes during pregnancy which likely lead to changes in bra fit (Alex et al., 2020; Gordon, 2015; Irvine, 2022). Only Morris (2011) has reported bra size changes from before to after pregnancy with an increase of 1.38 underband sizes and one cup size identified. Morris (2011) recruited only eight participants and since breast growth is individualised (Geddes, 2007), it would be beneficial to gather further data on bra size changes from before to after pregnancy and from before to during pregnancy as this has not yet been reported. The breasts have previously been reported as the fourth biggest barrier to PA (Burnett et al., 2015) and women with larger breasts are reported to participate in less vigorous PA (Coltman et al., 2019). Therefore, further data on bra size changes during and after pregnancy, alongside PA habit data, may provide a useful insight into whether changing bra size contributes to changes in PA habits.

Research in the general population has also identified breast pain during PA as a barrier to PA (Burnett et al., 2015) and that breast pain during PA increases with increasing breast size (Brown et al., 2016; Scurr et al., 2014). With a greater breast mass there is a greater net force which results in greater breast movement and thus, breast pain during PA (McGhee et al., 2013). Additionally, breast sensitivity also increases and tissue-remodelling occurs during pregnancy and breastfeeding (Jindal et al., 2014; Robinson & Short, 1977). However, there is currently no research on breast pain during PA of pregnant and post-partum women, therefore exactly how breast pain during PA changes during and after pregnancy is currently unknown.

In the general population finding the right size sports bra has been reported as the biggest breast-related barrier to PA (Brown et al., 2021). Access to and suitability of sports

bras also appears to be a barrier to PA for pregnant and post-partum women as research identified that only 15% of maternity/nursing sports bra purchasers find exactly what they want (Reeves et al., 2024). Unfortunately, the potential influence of sports bras on pregnant and post-partum women's PA is currently unknown and therefore is an important area of research which may assist in highlighting the need for suitable maternity/nursing sports bras (Reeves et al., 2024).

Exclusive breastfeeding is beneficial for a mother and baby and is recommended for the first six months post-birth (World Health Organisation, 2023). However, breastfeeding may also act as a barrier to PA (Edie et al., 2021), with over 50% of mothers reporting that the method of feeding their child influences their PA (Morris, 2011; Reeves et al., 2024). Despite these findings, exactly how and why breastfeeding is a barrier to PA is currently unknown. Therefore, this is a key area of research to assist in understanding how these challenges can be minimised which may help to encourage pregnant and post-partum women to be physically active (Burnett et al., 2015).

PA habit changes during and after pregnancy are often attributed to a multitude of barriers faced by pregnant and post-partum women. Previous research has identified various breast-related factors that impact PA for women in the general population. However, changes in bra size and breast pain during PA and the potential impact of sports bras and breastfeeding on pregnant and post-partum women's PA is not yet known. Therefore, this study aimed to 1) investigate how PA, bra size and breast pain during PA change during and after pregnancy and 2) investigate the influence of sports bras and breastfeeding on PA in women who classed themselves as physically active pre-pregnancy.

Methodology

Research design

A sequential explanatory mixed methods design utilising an online questionnaire followed by in-person focus groups was undertaken (Schoonenboom & Johnson, 2017; Thashakkori & Teddlie, 2003). Nottingham Trent University Non-Invasive Ethics Committee provided ethical approval (application reference: 1624509).

Participants

Questionnaire participants were recruited through targeted word-of-mouth, social media and email (e.g., mother and baby groups). Adult females, living in the UK, who were pregnant (n=97) or had given birth within the last 12 months (n=192) or were still breastfeeding (n=34) at the time of data collection (January and February 2023) were asked to complete the questionnaire. The post-partum period is defined as up to six months after giving birth, however participants who had given birth within the last 12 months or were still breastfeeding were included in the current study because changes that occur during pregnancy often exist up to a year after giving birth (James et al., 2022). Additionally, research suggests that the post-partum period should include up to one-year post-birth and previous studies have utilised similar inclusion criteria (Gordon et al., 2013; Morris et al., 2017; Mottola, 2002; Snyder et al., 2020).

Focus groups utilised the same criteria as the questionnaire. To recruit participants, the lead researcher (KR) attended mother and baby classes in Nottinghamshire and Derbyshire. Anybody interested in participating in the focus groups was asked to complete the online questionnaire in which additional questions had been added to allow organisation of the focus groups. Therefore, the questionnaire data also includes the focus group participants responses. During May and June 2023, thirteen participants provided written informed consent and participated in focus groups.

Questionnaire design

The questionnaire included 26 closed questions, plus sub-questions, and covered four topics: pregnancy/post-partum stage, demographics, PA habits, bra sizing and fit. Demographic questions asked participants their age and average total household income. PA habit questions included binary questions on whether participants were physically active and if participants experienced breast pain during PA. Participants were informed that PA referred to all movement including during leisure time, getting to and from places or as part of work as stated by the World Health Organisation (2020). Participants were also asked what level of impact of PA they participated in with participants able to select all relevant PA impact levels with the options being low, medium or high. The following activities were put together from the National Health Service (2024) and the World Health Organisation (2020) and listed as a guide for participants per PA impact level: low- walking, yoga, Pilates and hiking; medium- circuit training, volleyball, cycling and tennis; high- running, boxing, basketball, football and aerobics. Pregnant participants were asked these questions relating to pre-pregnancy and the time of data collection (i.e., whilst they were pregnant). Post-partum participants were asked these questions relating to pre-pregnancy, during their pregnancy and the time of data collection (i.e., post-partum). Post-partum participants were also asked how long after giving birth they return to PA. Bra sizing and fit questions asked participants what their UK bra size was pre-pregnancy and their current UK bra size (during pregnancy for pregnant participants and during the post-partum period for post-partum participants). Participants were also asked whether they had been professionally bra fitted for each size reported.

Questionnaire data analysis

Of the 338 fully completed questionnaire responses, 15 were removed as participants did not identify themselves as being physically active pre-pregnancy. The remaining 323 responses were analysed using Microsoft Excel and descriptive statistics were calculated. Change in self-reported UK bra size from before to during pregnancy and before pregnancy to post-

partum was calculated per participant for bra underband and cup size individually. IBM SPSS Statistics (Version 28, IBM, USA) was used for statistical analysis with a significance threshold of $p < 0.05$. Mann Whitney U tests assessed whether focus group participants were representative of questionnaire participants. Rank-biserial effect sizes were calculated and interpreted as 0.1-0.3 small effect size, 0.3-0.5 medium effect size and >0.5 large effect size (Cureton, 1956). McNemar's test assessed significant differences in the proportion of pregnant participants from before to during pregnancy and the proportion of post-partum participants before to during pregnancy and from before pregnancy to the post-partum period. This was completed for the following variables: physically active and non-physically active, knew and did not know bra size, had and had not been professionally bra fitted and did and did not experience breast pain during PA. Cohen's g effect sizes were calculated and interpreted as 0.05-0.15 small effect size, 0.15-0.25 medium effect size and >0.25 large effect size (Cohen, 1988). Wilcoxon signed rank test was used to assess significant changes in pregnant participants self-reported UK bra underband and cup size from before to during pregnancy and post-partum participants self-reported UK bra underband and cup size from before to after pregnancy. Rank-biserial effect sizes were calculated and interpreted as above (Cureton, 1956). Chi-square test of independence was used to examine the association between breastfeeding and breast pain during PA.

Focus group design

Focus groups were conducted face-to-face. Questionnaire data were used to develop an interview guide with two questions relevant to this manuscript: how much do you think the decrease in PA is related to sports bras? and how do you manage breastfeeding your child around PA?. A flexible approach was taken beyond the interview guide such that the participants drove the conversation but the necessary topics were discussed. Four focus

groups were conducted, three of which recruited three participants and one recruited four participants.

Focus group analysis

An inductive approach to thematic analysis was taken, based upon grounded theory, to analyse responses using QSR-NVIVO (Version 12; QSR International, Australia) (Patton, 2014). The six-phase thematic analysis model was followed (Braun & Clarke, 2006). Further details are presented by Reeves et al. (2024).

Results

Demographics

Table 1 presents the demographic characteristics of the 323 questionnaire participants and 13 focus group participants. Sixty-nine percent of participants were post-partum and 80% had or planned to breastfeed their child. Questionnaire and focus group participants had similar average household incomes ($U = 1676.500$, $p = 0.265$, $d = -0.003$, extremely small). However, there were more post-partum questionnaire participants ($U = 1443.000$, $p = 0.033$) and questionnaire participants were older ($U = 1096.500$, $p = 0.001$) compared to focus group participants, but the extremely small effect sizes ($d = -0.01$) demonstrate this result was not practically significant.

(Place Table 1 here)

Questionnaire

Physical activity. Eighty-six percent of pregnant participants identified themselves as physically active at the time of data collection. There was a significant increase in the number of non-physically active pregnant participants from before to during pregnancy ($p<0.001$, $g = 0.5$, large effect size), specifically 14 participants changed from active to inactive. Ninety

percent of post-partum participants identified themselves as physically active whilst pregnant, this declined to 85% of participants at the time of data collection. There was also a significant increase in the number of non-physically active post-partum participants from before to during pregnancy ($p<0.001$, $g = 0.5$, large effect size) and before to after pregnancy ($p<0.00.1$, $g = 0.5$, large effect size). Specifically, 23 participants changing from active to inactive whilst pregnant and 34 participants changing from active pre-pregnancy to inactive post-pregnancy.

Twenty-six percent of post-partum participants returned to PA less than six weeks after birth, 45% returned six to 12 weeks after birth, 25% returned 12-24 weeks after birth and five percent returned more than 24 weeks after giving birth.

Figure 1a shows PA impact levels before and during pregnancy for participants who were pregnant at the time of data collection. Low impact PA increased by 47% from before to during pregnancy, whilst medium and high impact PA both decreased (-62% and -80%, respectively). More participants who were in their third trimester engaged in low impact PA (34 participants) compared to the first (11 participants) and second trimester (30 participants). Figure 1b shows post-partum participants PA from before, during and after pregnancy. The greatest decrease was for high impact PA from before to during pregnancy (-67%), whilst the greatest increase was for high impact PA from during to after pregnancy (41%). Low impact PA was the only PA undertaken by participants who were up to six weeks post-birth.

(Place Figures 1a and 1b here)

Of the post-partum participants, 41% had the same PA impact level before and after pregnancy; whilst 45% reduced their PA impact level post-pregnancy and eight percent incorporated low impact PA alongside medium and/or high impact. Only six percent of post-partum participants increased their PA impact level following pregnancy.

For breastfeeding and non-breastfeeding participants, low impact PA was the most popular (62% and 58%, respectively) compared to medium (24% and 27%, respectively) and high impact (14% and 15%, respectively). Of the 31 post-partum participants who did not consider themselves to be physically active, 87% had or were breastfeeding their child, compared to 13% who were not breastfeeding, with no statistically significant difference between these groups ($p = 0.153$).

Bra size. Bra size data were only gathered from participants that reported their bra size. Five pregnant participants (5%) did not know their pre-pregnancy bra size compared to 27 (28%) participants who did not know their current bra size whilst pregnant. Four post-partum participants (2%) did not know their pre-pregnancy bra size compared to 44 (20%) that did not know their current bra size. There was a significant increase in the number of participants that did not know their bra size from before to during pregnancy ($p<0.001$, $g=0.4$, large effect size). There was also a significant increase in the number of post-partum participants that did not know their bra size from before pregnancy to the post-partum period ($p<0.001$, $g=0,5$, large effect size). One participant selected 'prefer not to answer' for before pregnant and whilst post-partum.

All participants pre-pregnancy self-reported UK bra sizes are displayed in Table 2a. Table 2a also contains all pregnant and post-partum participants self-reported UK bra sizes for the time of data collection (pregnancy for pregnant participants and post-partum for post-partum participants) and shows how the distribution of these size changes. Mode self-reported UK bra size was 32B pre-pregnancy, 34D during pregnancy and 36C post-partum. Fifty-three percent of participants had a pre-pregnancy self-reported UK bra size of ≥D cup, compared to 81% during pregnancy and 70% during the post-partum period. Mode self-reported UK bra size of breastfeeding post-partum participants was 36C, compared to 34DD and 36C of non-breastfeeding post-partum participants, as shown in Table 2b.

(Place Table 2a and 2b here)

The change in pregnant participants self-reported UK bra size from before to during pregnancy is shown in Table 3a. Participants in the third trimester of pregnancy experienced the greatest change in self-reported UK bra size compared to participants who were in the first and second trimesters of pregnancy. There was a statistically significant increase in pregnant participants self-reported UK bra underband ($p<0.001$, $r=0.8$, large effect size) and cup size ($p<0.001$, $r=0.7$, large effect size) from before to during pregnancy. Table 3b shows the change in post-partum participants self-reported UK bra size from before pregnancy to the post-partum period. Participants who were six to 12 months post-partum experienced the greatest change in self-reported UK bra size compared to the participants at other post-partum stages. There was also a statistically significant change in post-partum participants self-reported UK bra underband ($p<0.001$, $r=0.6$, large effect size) and cup size ($p<0.001$, $r=0.6$, large effect size) from before pregnancy to the post-partum period. Post-partum participants data were also split into breastfeeding and non-breastfeeding (Table 3b) which shows breastfeeding participants experienced a median increase of two cup sizes compared to one cup size for non-breastfeeding participants.

(Place Table 3a and 3b here)

Bra fitting. Seventy percent of pregnant participants reported being professionally bra fitted for their self-reported pre-pregnancy bra size compared to only 33% of pregnant participants for their current self-reported bra size. There was a significant increase in the number of pregnant participants that had not been professionally bra fitted for their self-reported size from before to during pregnancy ($p<0.001$, $g=0.5$, large effect size). For post-partum participants, 60% reported being professionally bra fitted for their self-reported pre-pregnancy bra size, which decreased to 36% of post-partum participants for their current size.

Thus, there was a significant increase in the number of post-partum participants that had not been professionally bra fitted for their self-reported size from before pregnancy to the post-partum period ($p<0.001$, $g=0.4$, large effect size).

Breast pain during PA. There was a significant increase in the number of pregnant participants that experienced breast pain during PA from before to during pregnancy ($p<0.001$, $g=-0.4$, large effect size) with the number of pregnant participants experiencing breast pain during PA whilst pregnant more than double compared to pre-pregnancy (16% vs 38%). There was also a significant increase in the number of post-partum participants that experienced breast pain during PA from before to during pregnancy ($p<0.001$, $g=-0.5$, large effect size) and before to after pregnancy ($p<0.001$, $g=-0.4$, large effect size) but this increase was not significant from during pregnancy to the post-partum period ($p=0.178$, $g=0.09$, small effect size). Only 11% of post-partum participants experienced breast pain during PA pre-pregnancy compared to 37% during pregnancy and 31% in the post-partum period. Of the participants that had or were breastfeeding their child, 29% experienced breast pain during PA, compared to three percent of non-breastfeeding participants. A chi-squared test of association between breastfeeding and breast pain during PA revealed no significant association ($X^2(1)=0.191$, $p=0.662$).

Focus groups

Sports bras. Five out of the 13 focus group participants explained how sports bras impacted their PA during and/or after their pregnancy. Participant five shared, "*the bra issue is a massive issue I really really struggle with it to the point where it puts me off doing stuff*" and then also went on to say, "*my activity did decrease partly because of the bra.*" Participant six was also in agreement stating, *"the sports bra was one reason [pause] probably after pregnancy as well as before.*" Meanwhile, participant 11 explained how as her pregnancy

progressed and her breast size increased, running became uncomfortable and so this "*led to a change in the type of exercise*" she participated in.

Breastfeeding. Nine of the 13 focus group participants felt that breastfeeding had impacted their PA. Participants one, two and three explained how breastfeeding had stopped their PA. Other participants explained how they did less PA than they wanted due to breastfeeding often due to the worry of leaving their child, with participant nine explaining "*I probably do less than I would want to mainly because it just makes me nervous…there's no kind of back up basically if I'm not there.*" Participant eight also shared, "*I would have liked to have got back into exercise…unfortunately he wouldn't take a bottle…so it's difficult to leave him*." The logistics of breastfeeding and PA were also problematic with five participants explaining the challenges they faced. Participant 11 explained, "*a lot of planning and preparation has to go into it so it can hinder your ability to go on to participate.*" Furthermore, participant four explained, "*I wear a sports bra, but I make sure she's fed before I put it on…it's just a nightmare, I'd have to take the whole bra off."*

Discussion

This study aimed to 1) investigate how PA, bra size and breast pain during PA change during and after pregnancy and 2) investigate the influence of sports bras and breastfeeding on PA in women who classed themselves as physically active pre-pregnancy. The number of women who identified themselves as physically active declined during and after pregnancy alongside sustained reductions in medium and high impact PA. Self-reported UK bra size increased on average by one underband and two cup sizes from before to during pregnancy and before pregnancy to the post-partum period. The proportion of participants who reported experiencing breast pain during PA more than doubled during pregnancy and the post-partum period, compared to pre-pregnancy. Focus groups identified that five of the 13 participants

felt sports bras impacted their PA during and/or after pregnancy, whilst nine participants felt breastfeeding impacted their PA and five participants spoke of the logistical challenges of breastfeeding and PA.

Fewer women identified themselves as physically active whilst pregnant and following pregnancy (including up to 12 months following pregnancy or women who were still breastfeeding after this time) compared to pre-pregnancy, supporting previous research that pregnancy often leads to a decline in PA levels (James et al., 2022; Pereira et al., 2007). As previously identified (James et al., 2020; Pereira et al., 2007; Treuth et al., 2005; Weallens et al., 2003) the type of PA women participated in also changed during and after pregnancy. For example, 60% of pregnant women decreased in their PA impact level (i.e., from high to medium or low or medium to low impact) from before to during pregnancy and this was also the case for 45% of post-partum from pre-pregnancy to post-partum. The questionnaire did not ask participants why they changed their PA habits but is the first to identify how increasing bra size and breast pain during PA may contribute to these changing PA habits. Furthermore, focus groups showed for the first time how some participants felt that lack of suitable sports bras and/or breastfeeding led to a change or decline in their PA.

A median increase in self-reported UK bra size of one underband and two cups from before to during pregnancy and before pregnancy to the post-partum period was identified. These changes in breast size likely occur due to elevated hormone levels which are present during pregnancy and the post-partum period (Alex et al., 2020). The rib cage also expands and becomes more barrel-shaped (LoMauro & Aliverti, 2022) which likely explains the increasing underband size identified. Breast development and differentiation are only complete once full-term pregnancy is reached for the first time and physiological and biomechanical changes may persist up to two years after pregnancy (Alex et al., 2020; James et al., 2022) which likely also explains why these changes in self-reported bra size were

found. The greatest breast development is reported to occur before the 22nd week of pregnancy (second trimester), but the ductal system will continue to expand into the third trimester where it dilates and fills with colostrum (Alex et al., 2020; Geddes, 2007). Therefore, this may explain why the greatest increase in self-reported UK bra size, from before to during pregnancy, was identified in women in the third trimester of pregnancy. Increases in self-reported bra size, from before pregnancy to the post-partum period, were also identified which is likely because physiological and biomechanical changes may persist up to two years after pregnancy (Alex et al., 2020; James et al., 2022).

The increases in self-reported UK bra size identified in this study may have contributed to the changes in PA habits. Previous research reports that women with larger breasts participate in less vigorous PA (Coltman et al., 2019). The current study identified that 81% of pregnant and 70% of post-partum participants could be considered larger busted (≥D cup) (Brown et al., 2021) and decreases in high impact PA were identified from before to during pregnancy and before pregnancy to the post-partum period. The current findings also suggest that increasing bra size may lead to a preference for low impact PA, as low impact PA increased across pregnancy trimesters as did the increases in self-reported UK bra size. However, it is important to note that PA guidelines advise women to not begin high impact PA, such as running, until around 12 weeks post-birth (Schulz et al., 2023). Therefore, PA guidelines, alongside other factors, such as increasing abdomen size, lack of time and tiredness (Edie et al., 2021; Evenson et al., 2009; Harrison et al., 2018; Subramanian et al., 2022) will also have influenced these changes in PA for pregnant and post-partum women, but changes in bra size may have also been a contributing factor. The breasts have previously been ranked as the fourth biggest barrier to PA for women in the general population (Burnett et al., 2015) and 66% of pregnant and post-partum women have reported that the availability and/or cost of maternity/nursing sports bras was a barrier to PA (Reeves et al., 2024). Taken

together, these findings imply that the breasts, including increase breast size and availability and/or cost of sports bras, may also be a barrier to PA for pregnant and post-partum women.

Breast pain is a barrier to PA (Burnett et al., 2015) and increased breast size is suggested to lead to greater breast pain during PA (Brown et al., 2016; Scurr et al., 2014). The current study found the proportion of participants that experienced breast pain during PA was greatest during pregnancy, during which there was a median increase of two cup sizes in self-reported UK bra size. The incidence of breast pain during PA was also higher in women who had or were breastfeeding their child, compared to non-breastfeeding, and these breastfeeding women also reported a greater increase in self-reported bra cup size than non-breastfeeding women (two cups vs one cup, respectively). Therefore, these increases in breast pain during PA could be related to the increasing self-reported bra size as with increased bra size, there is greater breast mass and thus greater net force, which likely results in greater breast movement and breast pain during PA (McGhee et al., 2013). It is important to note that the increased breast pain during PA may also be due to increased breast sensitivity and tissue-remodelling which occur during pregnancy and breastfeeding (Jindal et al., 2014; Robinson & Short, 1977). Sports bras are the most important factor in mitigating breast pain during PA (Burnett et al., 2015), therefore increasing breast pain during PA highlights the importance of suitable breast support for pregnant and post-partum women.

Over 60% of women reported being professionally bra fitted for their self-reported pre-pregnancy bra size but this almost halved for the self-reported bra size data during (33%) and after pregnancy (36%). McGhee and Steele (2010) reported that 78% of women previously used professional bra fitting services, yet over 90% stated they usually purchased bras without using professional bra fitting criteria. The current study did not ask for reasons which prevented participants from getting professionally bra fitted, yet there are likely to be a multitude. Wood et al. (2008) suggested that larger breasted women are less likely to seek

professional bra fitting due to fear of embarrassment. As self-reported bra size was found to increase from before to during and after pregnancy, women's embarrassment of being professionally bra fitted may have also increased with this increasing self-reported bra size. It is also important to note that although a large proportion of participants had not been professionally bra fitted these participants may still have reported their correct bra size.

Over a quarter of pregnant women and almost a fifth of post-partum women did not know their current bra size. The continual breast and rib cage changes that occur during pregnancy and breastfeeding (Alex et al., 2020; Geddes, 2007; Gordon, 2015) consequently lead to changes in bra fit (Irvine, 2022), and thus likely contribute to pregnant and post-partum women not knowing their bra size. Educational programmes have previously been found to lead to significant improvements in bra knowledge, fit and level of breast support within the general population (McGhee et al., 2010). Therefore, it would be useful to have information about the importance of breast support and how a bra should fit correctly which is specifically tailored to the unique needs of pregnant and post-partum women. This information would therefore assist pregnant and post-partum women in finding the correct bra size, without the need for professional bra fitting services which they may not utilise due to various factors such as increasing breast size (Wood et al., 2008), and thus improve breast health and knowledge of this population.

The focus groups highlighted the influence sports bras had on pregnant and post-partum women's PA. Five of the 13 of focus group participants explained how not having a suitable sports bra meant they decreased their PA and/or changed to lower impact with one participant explaining how she was put off PA due to the struggle she faces with sports bras. Previous research identified being unable to find the right size sports bra as the biggest breast-related barrier to PA for women in the general population (Brown et al., 2021) and Reeves et al., (2024) reported that only 15% of maternity/nursing sports bra purchasers found

exactly what they wanted. Taken together with the current findings, it appears sports bras are also a barrier to PA for pregnant and post-partum women; highlighting the need for suitable breast support for this population.

Finally, the current study supports Edie et al. (2021) that breastfeeding may be a barrier to PA as 87% of women who had or were breastfeeding their child(ren) were not physically active compared to only 13% of non-breastfeeding women. The influence of breastfeeding on PA was further highlighted during focus groups. Out of the 11 focus group participants that had or were breastfeeding their child, nine felt that breastfeeding had influenced their PA. Some participants had completely stopped PA whilst others explained how they participated in less PA whilst breastfeeding. A common reason was worrying about their child needing to be fed particularly as some participants explained their child would not take a bottle. Five participants also explained how the logistics of breastfeeding and PA presented difficulties. Breastfeeding prior to PA may improve comfort (Morris, 2011) but as identified in the focus groups, this is not always possible. These findings not only show how breastfeeding acts as a barrier to PA, but also the importance of nursing sports bras which in turn could help ease the logistical challenges faced by these women towards being physically active.

Strengths and Limitations

This study collected novel data on pregnant and post-partum women's PA habits, self-reported bra size, breast pain during PA and the impact of sports bras and breastfeeding on PA and highlighted areas requiring further research. A mixed methods approach was utilised to collect qualitative and quantitative data, with over 300 questionnaire responses included. Focus group participants were representative of questionnaire respondent's total household income which was beneficial as previous research suggests people in a higher socio-economic position participate in more PA (Gidlow et al., 2006).

The limitations of this study should also be considered. All participants were physically active pre-pregnancy; as the aim of the study was to determine the impact of pregnancy and following giving birth on PA habits, therefore the results may differ for non-physically active women. No questions on birth method were asked which could have been useful when looking at post-partum participants PA as this likely would have impacted what PA they participated in. PA data were self-reported and previous research suggests self-reported PA data is often under or over-estimated (Prince et al., 2008). Bra size data were also self-reported and over 80% of women are reported to wear the wrong size bra (Wood et al., 2008) and there is no standard bra sizing (Bowles et al., 2008) which likely would have influenced the current data. Furthermore, a number of factors can influence bra size including respiratory rate and physical characteristics with inaccuracy of the traditional sizing method reported to increase with increasing underband size (Chen et al., 2010; McGhee & Steele, 2006; White & Scurr, 2012). However, as the goal was to collect data from a wide range of pregnant and post-partum women, utilising an online questionnaire was the most appropriate method despite the reliance of self-reported data. The data collected on breast pain during PA only utilised a single binary question and therefore lacks information of the intensity, location and duration of this breast pain. The focus groups also had a relatively low number of participants, particularly compared to the questionnaire, and therefore the findings may not fully represent the views of pregnant and most-partum women. Despite these considerations, these data provide an initial indication of PA changes and how breast-related factors may contribute to these changes during and after pregnancy and highlight the need for further research in this area.

Conclusions

Despite the benefits of PA during and after pregnancy, PA habits changed with almost two fifths of post-partum participants reducing their PA impact level from before to after

pregnancy. This study is the first to identify an average increase in self-reported UK bra size of one underband and two cup sizes from before to during and before to after pregnancy and suggests how this increase in bra size could contribute to changing PA habits. The study is also the first to identify increased breast pain during PA of pregnant and post-partum women and suggests that pregnancy and breastfeeding may be associated with an increase in the incidence of breast pain during PA due to increasing breast size. Focus groups showed how the lack of suitable sports bras and the challenges of breastfeeding can negatively influence pregnant and post-partum women's PA. Together these findings highlight the need for pregnant and post-partum women to have access to suitable breast support which adapts to their ever-changing body, provides adequate support to minimise breast pain during PA and in turn helps to reduce the logistical challenges of breastfeeding and PA faced by these women.

References

Alex, A., Bhandary, E., & McGuire, K. P. (2020). Anatomy and physiology of the breast during pregnancy and lactation. *Diseases of the Breast during Pregnancy and Lactation,* 3-7. https://doi.org/10.1007/978-3-030-41596-9_1

Atkinson, L., De Vivo, M., Hayes, L., Hesketh, K. R., Mills, H., Newham, J. J., Olander, E. K., & Smith, D. M. (2020). Encouraging physical activity during and after pregnancy in the COVID-19 era, and beyond. *International Journal of Environmental Research and Public Health, 17*(19), 7304. https://doi.org/10.3390/ijerph17197304

Bowles, K. A., Steele, J. R., & Munro, B. (2008). What are the breast support choices of Australian women during physical activity?. *British Journal of Sports Medicine, 42*(8), 670-673. https://doi.org/10.1136/bjsm.2008.046219

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology, 3*(2), 77-101. https://doi.org/10.1191/1478088706qp063oa

Brown, N., Burbage, J., & Wakefield-Scurr, J. (2021). Sports bra use, preferences and fit issues among exercising females in the US, the UK and China. *Journal of Fashion Marketing and Management: An International Journal*, *25*(3), 511-527. https://doi.org/10.1108/JFMM-05-2020-0084

Brown, N., Burnett, E., & Scurr, J. (2016). Is breast pain greater in active females compared to the general population in the UK?. *The breast journal, 22*(2), 194-201. https://doi.org/10.1111/tbj.12547

Burnett, E., White, J., & Scurr, J. (2015). The influence of the breast on physical activity participation in females. *Journal of Physical Activity and Health, 12*(4), 588-594. https://doi.org/10.1123/jpah.2013-0236

Chen, C., LaBat, K., & Bye, E. (2010). Physical characteristics related to bra fit. *Ergonomics, 53*(4), 514–524. https://doi.org/10.1080/00140130903490684

Cohen , J. 1988 . Statistical power analysis for the behavioural sciences , Hillsdale, NJ : Lawrence Erlbaum .

Coltman, C. E., Steele, J. R., & McGhee, D. E. (2019). Does breast size affect how women participate in physical activity? *Journal of Science and Medicine in Sport, 22*(3), 324-329. https://doi.org/10.1016/j.jsams.2018.09.226

Cureton, E. E. (1956). Rank-Biserial Correlation. *Psychometrika*, *21*(3), 287–290. https://doi:10.1007/BF02289138

DiPietro, L., Evenson, K. R., Bloodgood, B., Sprow, K., Troiano, R. P., Piercy, K. L., ... & Powell, K. E. (2019). Benefits of physical activity during pregnancy and postpartum: an umbrella review. Medicine and science in sports and exercise, 51(6), 1292-1302. https://doi.org/10.1249/MSS.0000000000001941

Duncombe, D., Wertheim, E. H., Skouteris, H., Paxton, S. J., & Kelly, L. (2009). Factors related to exercise over the course of pregnancy including women's beliefs about the safety of exercise during pregnancy. *Midwifery, 25*(4), 430-438. https://doi.org/10.1016/j.midw.2007.03.002

Edie, R., Lacewell, A., Streisel, C., Wheeler, L., George, E., Wrigley, J., Pietrosimone, L., & Figuers, C. (2021). Barriers to exercise in postpartum women: A mixed-methods systematic review. *The Journal of Women's & Pelvic Health Physical Therapy, 45*(2), 83-92. https://doi.org/10.1097/JWH.0000000000000201

Evenson, K. R., Aytur, S. A., & Borodulin, K. (2009). Physical activity beliefs, barriers, and enablers among postpartum women. *Journal of Women's Health, 18*(12), 1925–1934. https://doi.org/10.1089/jwh.2008.1309

Geddes, D. T. (2007). Inside the lactating breast: The latest anatomy research. *Journal of Midwifery & Women's Health, 52*(6), 556-563. https://doi.org/10.1016/j.jmwh.2007.05.004

Gidlow, C., Johnston, L. H., Crone, D., Ellis, N., & James, D. (2006). A systematic review of the relationship between socio-economic position and physical activity. *Health Education Journal*, 65(4), 338–367.

Gordon, L. A. (2015). *The development of design requirements for breastfeeding apparel: A user-oriented product development approach* (Doctoral dissertation).

Harrison, A. L., Taylor, N. F., Shields, N., & Frawley, H. C. (2018). Attitudes, barriers and enablers to physical activity in pregnant women: A systematic review. *Journal of Physiotherapy, 64*(1), 24-32. https://doi.org/10.1016/j.jphys.2017.11.012

Irvine, H. M. (2022, Choosing the right sports bra for pregnancy and breastfeeding. Runner's World, 57 https://www.runnersworld.com/gear/a39702113/sports-bras-for-pregnancy-breastfeeding/

James, M. L., Moore, I. S., Donnelly, G. M., Brockwell, E., Perkins, J., & Coltman, C. E. (2022). Running during pregnancy and postpartum, part A: Why do women stop running during pregnancy and not return to running in the postpartum period? *The Journal of Women's & Pelvic Health Physical Therapy, 46*(3), 111-123. https://doi.org/10.1097/JWH.0000000000000228

Jindal, S., Gao, D., Bell, P., Albrektsen, G., Edgerton, S. M., Ambrosone, C. B., Thor, A. D., Borges, V. F., & Schedin, P. (2014). Postpartum breast involution reveals regression of secretory lobules mediated by tissue-remodeling. *Breast Cancer Research, 16*, 1–14.

Kent, J. C. (2007). How breastfeeding works. *Journal of Midwifery & Women's Health, 52*(6), 564–570. https://doi.org/10.1016/j.jmwh.2007.04.007

LoMauro, A., & Aliverti, A. (2022). Respiratory physiology in pregnancy and assessment of pulmonary function. Best Practice & Research Clinical Obstetrics & Gynaecology, 85, 3-16. https://doi.org/10.1016/j.bpobgyn.2022.05.007

McGhee, D. E., & Steele, J. R. (2006). How do respiratory state and measurement method affect bra size calculations? *British Journal of Sports Medicine, 40*(12), 970–974. https://doi.org/10.1136/bjsm.2005.025171

McGhee, D. E., & Steele, J. R. (2010). Optimising breast support in female patients through correct bra fit. A cross-sectional study. *Journal of Science and Medicine in Sport, 13*(6), 568-572. https://doi.org/10.1016/j.jsams.2010.03.003

McGhee, D. E., Steele, J. R., & Munro, B. J. (2010). Education improves bra knowledge and fit, and level of breast support in adolescent female athletes: A cluster-randomised trial. *Journal of Physiotherapy, 56*(1), 19-24. https://doi.org/10.1016/S1836-9553(10)70050-3

McGhee, D. E., Steele, J. R., Zealey, W. J., & Takacs, G. J. (2013). Bra–breast forces generated in women with large breasts while standing and during treadmill running: Implications for sports bra design. *Applied ergonomics, 44*(1), 112-118. https://doi.org/10.1016/j.apergo.2012.05.006

Morris, K. D. (2011). *Collaborative product development: Examining the development of a nursing sports bra* (Doctoral dissertation).

National Health Service (2024, May 22). *Physical activity guidelines for adults aged 19 to 64.* Physical activity guidelines for adults aged 19 to 64 - NHS (www.nhs.uk)

Okyay, E. K., & Ucar, T. (2018). The effect of physical activity level at postpartum period on quality of life and depression level. *Medicine Science International Medical Journal, 7*, 587–593. https://doi.org10.5455/medscience.2018.07.8822

Patton, M. Q. (2014). *Qualitative research & evaluation methods: Integrating theory and practice*. Sage publications.

Pereira, M. A., Rifas-Shiman, S. L., Kleinman, K. P., Rich-Edwards, J. W., Peterson, K. E., & Gillman, M. W. (2007). Predictors of change in physical activity during and after pregnancy. *American Journal of Preventive Medicine, 32*(4), 312–319. https://doi.org/10.1016/j.amepre.2006.12.017

Prince, S. A., Adamo, K. B., Hamel, M. E., Hardt, J., Gorber, S. C., & Tremblay, M. (2008). A comparison of direct versus self-report measures for assessing physical activity in adults: A systematic review. *International Journal of Behavioural Nutrition and Physical Activity, 5*, 1–24. https://doi.org/10.1186/1479-5868-5-56

Reeves, K., James, R., Mears, A., & Griggs, K. (2024) Assessing current maternity/nursing sports bras and providing recommendations for future product development. *Research journal of textile and apparel*. https://doi.org/10.1108/RJTA-12-2023-0138

Robinson, J. E., & Short, R. V. (1977). Changes in breast sensitivity at puberty, during the menstrual cycle, and at parturition. *British Medical Journal, 1*(6070), 1188–1191.

Saligheh, M., McNamara, B., & Rooney, R. (2016). Perceived barriers and enablers of physical activity in postpartum women: A qualitative approach. *BMC Pregnancy and Childbirth, 16*, 1-8. https://doi.org/10.1186/s12884-016-0908-x

Schoonenboom, J., & Johnson, R. B. (2017). How to construct a mixed methods research design. *Cologne Journal of Sociology and Social Psychology, 69*(2), 107-131. https://doi.org/10.1007/s11577-017-0454-1

Schulz, J. M., Marmura, H., Hewitt, C. M., Parkinson, L. J., & Thornton, J. S. (2023). Navigating the ‘new normal’: what guidelines exist for postpartum return to physical

activity and sport? A scoping review. *British Journal of Sports Medicine*, *57*(24), 1573-1578. https://doi.org/10.1136/bjsports-2023-107166

Scurr, J., Hedger, W., Morris, P., & Brown, N. (2014). The prevalence, severity, and impact of breast pain in the general population. *The Breast Journal, 20*(5), 508-513. https://doi.org/10.1111/tbj.12305

Snyder, K., Pelster, A. K., & Dinkel, D. (2020). Healthy eating and physical activity among breastfeeding women: The role of misinformation. *BMC Pregnancy and Childbirth, 20*(1), 1-7. https://doi.org/10.1186/s12884-020-03153-x

Subramanian, M. K., Van der Graaf, P., Hayes, L., Dawson, R., Sachdeva, K., & Azevedo, L. (2022). Barriers and facilitators for physical activity in pregnancy and post-partum? findings from a qualitative study to inform the design of an intervention for active women. *Obstetrics and Gynecology Research, 5*(4), 280–287. https://doi.org/10.26502/ogr0102

Thashakkori, A., & Teddlie, C. (2003). *Handbook of mixed methods in social and behavioural research*. Thousand Oaks: Sage Publications.

Treuth, M. S., Butte, N. F., & Puyau, M. (2005). Pregnancy-related changes in physical activity, fitness, and strength. *Medicine and Science in Sports and Exercise, 37*(5), 832–837. https://doi.org/10.1249/01.mss.0000161749.38453.02

Weallens, E., Clark, A., Maclntyre, P., & Gaudoin, M. (2003). A survey of exercise patterns in primigravidae at a scottish NHS trust: More consistent support and advice required for women and their families. *Health Education Journal, 62*(3), 234–245. https://doi.org/10.1177/001789690306200305

White, J., & Scurr, J. (2012). Evaluation of professional bra fitting criteria for bra selection and fitting in the UK. *Ergonomics, 55*(6), 704–711. https://doi.org/10.1080/00140139.2011.647096

Wood, K., Cameron, M., & Fitzgerald, K. (2008). Breast size, bra fit and thoracic pain in young women: A correlational study. *Chiropractic & Osteopathy, 16*(1), 1-7. https://doi.org/10.1186/1746-1340-16-1

World Health Organisation (2020). *WHO guidelines on physical activity and sedentary behaviour.* Geneva: World Health Organisation.

World Health Organisation (2023, December 20). *Infant and young child feeding.* World Health Organisation. Infant and young child feeding (who.int)