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Breast Impact Discomfort Reduced with Customised Breast Protection for Amateur Female Soccer and Rugby League Players in New Zealand

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BACKGROUND: The aims of this study were to survey amateur female domestic soccer and rugby league players on their sports bra use, to compare prior use of sports bra to wearing a custom fitted sports bra with polymer inserts over a competition season in New Zealand, and to compare breast injuries with different sports bra utilization over a competition season.
METHODS: Players were invited to participate in a baseline survey of sports bra use. Players who completed the survey were provided with the opportunity to wear a sports protection bra and inserts and to complete post-match surveys reporting any breast injuries. The study duration was one competition season in 2023.
RESULTS: 93 players (41 soccer open, 29 soccer U16, 23 league) completed the baseline survey. Of these 79 players (32 soccer open, 24 soccer U16, 23 league) utilised the sports breast protector during the season. There were 25 breast injuries over the study resulting in a pooled breast injury incidence of 41.3 (95% CI: 26.7 to 61.1) per 1,000 match-hrs. Eight of 25 injuries (32%) occurred to players wearing the sports protection bra (i.e., 5/79 =10% sports breast protector players; 9/14 = 64% other players; 14/93 = 15% all players). Of the 34 participants who reported a previous breast injury, there were 2.6 ±1.4 breast injuries per player in the previous year and, more than a third (37.5%) reported either wearing a padded bra or did not use strategies to prevent breast injuries.
CONCLUSION: It is important that players, coaches, and team medical support associated with female sports are educated on the injury risk to breasts in training and competition enabling these players to be encouraged to report and seek treatment if necessary.

INTRODUCTION

There has been an exponential rise of females participating in traditionally male-dominated sports over the past few years.[1] To enable the growth of female sports participation, the current sports science and player well-being strategies are often underpinned by evidence derived from male sports participants.[2] While this approach is based around good practices, it does fail to consider the uniqueness of the female in regards to the psychological, biomechanical and anatomical characteristics.[3] One aspect of this is this approach are breast injuries. Consisting of adipose fibroglandular tissue attached via a continuous irregular fibrous ring to the chest wall, the breast is a highly malleable structure prominently positioned to be vulnerable to impacts from hard or fast-moving objects during sports participation.[4,5] Although the breast skin and tissues provide some protection for the corpus mamma (the delicate

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functional elements of the breast) they do not provide adequate support against high-energy shear or compressive forces that may occur from participation in contact sports.[4] Although there is an increase in female participation in contact sports, the absence of a consensus around breast injury classifications, lack of breast injury surveillance processes and, as a result of these aspects, limited breast injury data being available has resulted in inadequate awareness of this injury and the associated health related breast injury issues.[6, 7]

Most sports injury surveillance systems provide narrow injury definition (Orchard Sports Injury and Illness Classification System (OSIICS); Sport Medicine Diagnostic Coding System (SMDCS)) having a limited scope for breast pain and injury reporting.[8-11] The absence of a tailored injury surveillance system specific for female athletes may lead to a failure to optimise strategies to mitigate against future injuries such as breast contact injuries.[3, 12] It was not until 2021 that the term "breast" appeared in these coding systems highlighting how these injuries have remained largely undocumented with a paucity of data available.[3] In addition, breast protection knowledge and use is reportedly low which can result in poor bra choices, poorly and inappropriately fitting bras resulting in breast pain, potential tissue damage and mechanical changes in performance.[13,14]

To provide protection to the breast, the "Jog Bra" was first developed in 1977 by sewing two male athlete support structures together for female runners.[15] With further developments, the sports bra market now accounts for approximately 25% of the total bra market.[16] However, these were designed to be supportive from running with movement of the breast and not for impacts that can occur in sports such as soccer and rugby league. Contact breast injuries are associated with swelling, tenderness, pain, haematomas, ecchymosis with/without a mass, fat necrosis and scar tissue.[17, 18] Fat necrosis and scar tissue can mimic breast carcinoma, and these can pose difficulties to breast screening in later life.[17] Although the incidence of breast injuries remain unreported, it has been reported that retrospectively 26% to 62% of participants experience one or more breast injuries with 18% to 48% of these injuries having an negative impact on their sports performance.[19-21]

Appropriate breast support has been reported to reduce breast pain, improve participation and improve performance.[22-24] Studies have identified that reduced breast motion has altered muscle activation, ground reaction forces and gait kinematics and could positively affect technique and performance.[24-27] However, there is a paucity of data pertaining to the use of a contact sports bra designed to reduce the effects of direct impacts during match participation. In addition, there are no identified studies reporting on sports bra use and breast injuries in amateur female soccer and rugby league participants in New Zealand. As such, this study undertook to survey club based female soccer and regional rugby league players in regard to sports bra use and comfort, effects and impacts on sporting performance, history of breast injuries, preventative strategies for the prevention of these injuries and the reporting of breast injuries. In addition, players were offered to wear a customed fitted sports bra with polymer inserts and to report after each match the comfort, frequency and number of impacts, any discomfort that occurred and the perceived effects on performance from this over a competition season, and to compare breast injuries with different sports bra use.

The aims of the study were to: 1) Survey amateur female domestic soccer and rugby league players on their sports bra use, 2) Compare prior use of sports bra to wearing a custom fitted sports bra with polymer inserts over a competition season in New Zealand; and 3) Compare breast injuries with different sports bra utilization over a competition season.

METHODS

Participants

The Health and Disability Ethics Committee deemed this study to be out of scope (HDEC: 2023 OOS 15447) and ethics was not required to be completed. However, all players were asked to provide consent prior to completing the online survey and players under the age of 16 yr. were required to gain parental consent prior to being given the survey link. Players were included in the study if they were registered for the soccer club or regional rugby league team, consented to participate in the study and wore a bra during sports match participation. Any player that did not consent to participate was not provided with the survey link, offered a sports breast protector or asked to report on any breast injuries that occurred during match participation via a survey link. Only player age was recorded, and no data pertaining to breast size, height, body mass questions were included in the questionnaire.

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Baseline Retrospective Survey

All players were invited to participate in the baseline survey that used a modified version from a previous study.[28] The survey consisted of 36 questions with Likert scale responses for most of the questions that focused on previous use of sports-bras and injuries that occurred from match and training participation. An example of these are "*Have you ever had a breast injury at training or competition (options include yes and no)*", and "*What strategies do you personally use to prevent breast injury during training or competition" (options including "wear padded sports bra", "wear protective bra with hard cups", "strap breasts to chest", "modify movements to limit breast motion", "limit activities that might cause breast injury", "protect breasts with hands when playing" and "do not use any strategies")* (Supplementary Table 1).

Definitions

There are no consensus-based definitions for a breast injury that have been published, therefore the following was utilised for the purpose of this study "*Any impact or contact to the breast or breasts that results in discomfort, and / or pain with or without time loss from training or competition participation.*" The definition of mastalgia for the purpose of this study was "*Any tenderness, tightness, pain or discomfort in the breast tissue that occurs always or around the time of their period (aka cyclic mastalgia) and this is worsened by breast movement during training or competition activities."*

Breast Protector In Season Use

All players who completed the baseline survey were provided the opportunity to wear a fitted protective bra and inserts (QP Sports prototype rugby/soccer breast protector [https://qpsport.com/products/coolguard-super]). Players were custom fitted with their own specific protective bra and insert by a trained bra fitting female. The fitting was based on individual measurements of the under bust and around bust sizes to develop the correct top and insert size (https://www.youtube.com/watch?v=GyoRAIew1PA&t=2s). The breast protector was provided for the use of this research and no researcher has any link or association with the product utilised.

The sports protective bra consists of a sports bra made from moisture wicking Tactel / Lycra® for "cool 'n' dry" comfort and performance. A "double panel" pocket is formed over each breast to firmly hold the ergonomically shaped patent pending polymer inserts in position. Inserts are easily removed or fitted while the sport protective bra is being worn into a self-contained pouch over each breast and the inserts don't touch the wearer's body. The inserts have been tested by Sheffield-Hallam University in the UK, identifying that the inserts can reduce up to 75% of impact forces to the breast from relevant ball/ player contact when compared with over-the-counter store sports bras. QP Sport has received regulation approval for World Karate, World Fencing and by the Amateur International Boxing Association (AIBA) for protection for women in boxing and has passed European CE certification for use as a Martial Arts women's chest protector (EN 13277, EU 2016/425). The participants were able to select their appropriately sized Tactel / Lycra® top (sizes S to XL) and inserts (sizes XXS to XL) for their own breasts enabling a customised breast protection to be worn.

Post-Match Prospective Surveys

Following competition matches, all players enrolled in the study were encouraged to complete an online seven question post-match survey irrespective of whether they wore the sports protective bra or another form of breast protection, and to report on the use of breast protection, any injuries that occurred, any breast pain they incurred from sport participation, perceived effects on performance following an injury. The feedback was in the form of seven semi-structured questions and open answers through an online format (Supplementary Table 2).

Statistical Analysis

All data collected were entered into a Microsoft Excel spreadsheet and analysed with Statistical Package for Social Sciences for Windows (SPSS; V29.0.2.0). Match breast injury incidence was calculated as the number of injuries per 1,000 match-hrs, ((Σ injuries/Σ exposure hrs)x1,000) with 95% confidence intervals (CI's).[29] Injury incidence from the included sports groups were combined in a pooled analysis to provide an overall breast injury incidence.[30, 31] A one-sample chi-squared (χ^2) test was used for analysis by subgroups for the survey questions. Data are reported as means with 95% confidence intervals (CI) or number and percentage.[32] Significance level was set at $p < 0.05$.

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RESULTS

Participants

A total of 93 (mean age 26.3 ±5.6 yr.) female members of a domestic soccer club and a regional female rugby league team were invited to participate in the research. The majority (n=70; 75.3%) of the female participants were from the soccer club and consisted of the U16 (n=29 [31.2%]; mean age 14.8 ±0.8 yr.) and women's open (n=41 [44.1%]; mean age 26.4 ±10.0 yr.) teams competing in the district round-robin format over the 2023 competition season. The representative female rugby league team (n=23 [24.7%]; mean age 26.0 ±5.4 yr.) competed nationally in a six-team round-robin competition in 2023.

Baseline Retrospective Survey

Ninety-three players completed the survey. Of the 34 participants retrospectively reporting having had a previous breast injury (36.6% of total players), with a mean of 2.6 ±1.4 breast injuries per player in the previous year (Table 1). This varied from 2.3 ±1.0 for open soccer age soccer players to 4.8 ±1.6 for the U16 yr. soccer players. A third of participants (36.6%; $\chi^2_{(1)}$=6.7; p = 0.0095) reported they had retrospectively incurred a breast injury from sports participation which was significant compared with those reporting no breast injury. Of 34 players retrospectively reporting on their most severe previous breast injury, the significant causes were a direct blow from another player (75.0%) when compared with a blow from sporting equipment (10%; $\chi^2_{(1)}$=19.9; p < 0.0001), contact with surface (12.5%; $\chi^2_{(1)}$=17.9; p < 0.0001) and contact from a sports bra/uniform (2.5%; $\chi^2_{(1)}$=27.1; p < 0.0001). More (85.3%) participants did not consult anyone about their breast injury compared with those that did.

Of 34 players that retrospectively reported a breast injury, there were significantly more (37.5%) that reported they wore a padded bra or did not use any strategies in order to prevent breast injuries when compared with those players that reported they employed modification of movements to limit breast motion (12.5%; $\chi^2_{(1)}$=6.0; p = 0.0143), and limited activities that might cause a breast injury (8.3%; $\chi^2_{(1)}$=8.9; p =0.0028) (Table 2). There were significantly more injuries as a result of direct blows from another player (43.7%) than a blow from sporting equipment (23.9%; $\chi^2_{(1)}$=4.1; p = 0.0433), contact with the playing surface (18.3%; $\chi^2_{(1)}$=7.4; p=0.0067) and contact from sports bra / unforms (14.1%; $\chi^2_{(1)}$=10.8; p = 0.0010). As a result of these retrospective breast injuries, significantly more (33.3%) participants reported that the breast injuries did not affect their performance when compared with players that reported being hesitant to dive or tackle (14.3%; $\chi^2_{(1)}$=4.8; p = 0.0285), distracted by pain (9.5%; $\chi^2_{(1)}$=8.3; p=0.0039) or less likely to dive or tackle (4.8%; $\chi^2_{(1)}$=13.5; p = 0.0002).

Injuries Comparing Bra Use

Eight of 25 injuries (32%) occurred to players wearing the sports protective bra (i.e., five of 79 =10% sports breast protector players; nine of 14 = 64% other players; 14 of 93 = 15% all players). There were significantly more injuries reported (n=10) to the soccer open players who wore their own bras than those that wore the sports protective bra (n=2; $\chi^2_{(1)}$=5.3; p = 0.0209). There were significantly more injuries reported by players wearing their own bra (n=17 injuries for 14 players) than those who wore the sports protective bra (n=5 injuries for 79 players; $\chi^2_{(1)}$=66.6; p < 0.0001).

Use of Sports Bra

The player feedback of the participants that wore the sports protection bra is reported in Table 4. There were no negative feedback comments provided.

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Table 1. Baseline retrospective survey results for breast injury characteristics for activity, cause, type, and frequency for amateur female soccer and rugby league participants in New Zealand

	Soccer Open n=41	*Soccer U16 n=29*	*Rugby League n=23*	*Total n=93*
Player age				
mean ±SD	26.4 ±10.0[b]	14.8 ±0.8[ac]	26.0 ±5.4[b]	26.3 ±8.6
How many breast injuries have you had				
mean ±SD	2.3 ±1.0	4.8 ±1.6	2.4 ±1.3	2.6 ±1.4
Have you ever had a breast injury training / competition				
Yes, n (%)	14[e] (34.1)	9[e] (31.0)	11 (47.8)	34[e] (36.6)
No, n (%)	27[d] (65.9)	20[d] (69.0)	12 (52.2)	59[d] (63.4)
What was the cause of the most severe breast injury*				
Direct blow from another player, n (%)	11[h] (68.8)	4 (66.7)	15[h] (83.3)	30[ghi] (75.0)
Direct blow sporting equipment, n (%)	4 (25.0)	0 -	0 -	4[f] (10.0)
Direct contact with surface, n (%)	1[f] (6.3)	1 (16.7)	3[f] (16.7)	5[f] (12.5)
Contact from sports bra / uniform, n (%)	0 -	1 (16.7)	0 -	1[f] (2.5)
What was the breast injury type?**				
Bruise - week, n (%)	8[m] (53.3)	0 -	0 -	8[m] (26.7)
Bruise - few weeks, n (%)	6 (40.0)	5 (83.3)	6 (66.7)	17[lm] (56.7)
Cut/Abrasion - few weeks, n (%)	0 -	1 (16.7)	3 (33.3)	4[k] (13.3)
Winded, n (%)	1[j] (6.7)	0 -	0 -	1[jk] (3.3)
Approximately how frequently do you experience breast injuries?*				
Some matches, n (%)	3 (15.0)	3 (30.0)	5 (27.8)	11 (22.9)
Very few matches, n (%)	10 (50.0)	4 (40.0)	3 (16.7)	17 (35.4)
Almost no matches, n (%)	7 (35.0)	3 (30.0)	10 (55.6)	20 (41.7)
What was the breast injury cause?**				
Contact with player, n (%)	11[opq] (73.3)	4 (66.7)	3 (50.0)	18[opq] (66.7)
Contact with equipment, n (%)	2[n] (13.3)	1 (16.7)	0 -	3[n] (11.1)
Contact with the ground, n (%)	1[n] (6.7)	1 (16.7)	0 -	2[n] (7.4)
Unsure, n (%)	1[n] (6.7)	0 -	3 (50.0)	4[n] (14.8)
Did you report the breast injury?				
Yes, n (%)	1[e] (7.1)	4 (44.4)	0 -	5[e] (14.7)
No, n (%)	13[d] (92.9)	5 (55.6)	11 (100.0)	29[d] (85.3)
Whom did you report the injury to?**				
Parent, n (%)	1[u] (6.3)	3 (30.0)	0 -	4[u] (9.1)
Teammate, n (%)	1[u] (6.3)	0 -	0 -	1[u] (2.3)
Doctor, n (%)	1[u] (6.3)	2 (20.0)	0 -	3[u] (6.8)
Did not seek advice, n (%)	13[rst] (81.3)	5 (50.0)	18 (100.0)	36[rst] (81.8)
Did the most severe breast injury impact performance?*				
Yes, n (%)	6 (33.3)	4 (50.0)	0 -	10[e] (22.7)
No, n (%)	12 (66.7)	4 (50.0)	18 (100.0)	34[d] (77.3)

n=number; SD = Standard Deviation; % - Percentage; * = percentage based on number of responses received; ** = respondents can give multiple answers; Significant difference ($p<0.05$) than (a) = Soccer (open); (b) = Soccer (U16); (c) = Rugby League; (d) = Yes; (e) = No; (f) = Direct blow from another player; (g) = Direct blow sporting equipment; (h) = Direct contact with surface; (i) = Contact from sports bra / uniform; (j) = Bruise – week; (k) = Bruise - few weeks; (l) = Cut/Abrasion - Few weeks' (m) = Winded; (n) = Contact with Player; (o) = Contact with equipment; (p) = Contact with the ground; (q) = Unsure; (r) = Parent; (s) = Teammate; (t) = Doctor; (u) = Did not seek advice.

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Table 2. Baseline retrospective survey results for strategies to prevent, contribution to and effects of exercise-induced breast injuries for amateur female soccer and rugby league participants in New Zealand

	Soccer (open)	***Soccer U16***	***Rugby League***	***Total***
	n= 41	***n= 29***	***n= 23***	***n= 93***
What strategies do you utilise to prevent breast injury?**				
Wear padded bra, n (%)	5 (25.0)	3 (30.0)	10 (55.6)	18[bcde] (37.5)
Wear protective bra with hard cups, n (%)	0 -	0 -	0 -	0 -
Strap breasts to chest, n (%)	1[f] (5.0)	0 -	0 -	1[af] (2.1)
Modify movements limit breast motion, n (%)	4 (20.0)	2 (20.0)	0 -	6[af] (12.5)
Limit activities that might cause breast injury, n (%)	1[f] (5.0)	0 -	3 (16.7)	4[af] (8.3)
Protect breasts with hands when playing, n (%)	1[f] (5.0)	0 -	0 -	1[af] (2.1)
Do not use strategies to prevent breast injuries, n (%)	8[bde] (40.0)	5 (50.0)	5 (27.8)	18[bcde] (37.5)
Did any of these contributed to a breast injury for you*				
Direct blow from another player, n (%)	17[ij] (44.7)	4 (33.3)	10[h] (47.6)	31[hij] (43.7)
Direct blow sporting equipment, n (%)	12[i] (31.6)	3 (25.0)	2[gi] (9.5)	17[g] (23.9)
Direct contact with surface, n (%)	3[gh] (7.9)	1 (8.3)	9[h] (42.9)	13[g] (18.3)
Contact from sports bra / uniform, n (%)	6[g] (15.8)	4 (33.3)	0 -	10[g] (14.1)
Did the breast injury affect your playing performance*				
Yes, I am distracted by the pain, n (%)	1[p] (3.7)	1 (6.7)	4 (19.0)	6[p] (9.5)
Yes, I am less likely to dive or tackle, n (%)	3[p] (11.1)	0 -	0 -	3[nop] (4.8)
Yes, I am hesitant to dive or tackle, n (%)	4[p] (14.8)	2 (13.3)	3 (14.3)	9[p] (14.3)
Yes, I am unable to run comfortably, n (%)	3[p] (11.1)	5 (33.3)	5 (23.8)	13[l] (20.6)
Yes, I feel less confident, n (%)	3[p] (11.1)	5 (33.3)	3 (14.3)	11[l] (17.5)
No, breast injuries do not affect my performance, n (%)	13[klmno] (48.1)	2 (13.3)	6 (28.6)	21[klm] (33.3)

n=number; % - Percentage; * = percentage based on number of responses received; ** = respondents can give multiple answers; Significant difference (p<0.05) than (a) = Wear a padded bra; (b) = Strap breasts to chest; (c) = Modify movements limit breast motion; (d) = Limit activities that might cause breast injury; (e) = Protect breasts with hands when playing; (f) = Do not use strategies prevent breast injuries; (g) = Direct blow from another player; (h) = Direct blow sporting equipment; (i) = Direct contact with surface; (j) = Contact from sports bra / uniform

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Table 3. Post-match survey results for use of the Sports breast protector, any injury and exercise-induced breast injury, for amateur female soccer and rugby league participants in New Zealand

	Soccer Open n=41 (44.1%)	***Soccer U16 n=29 (31.2%)***	***Rugby League n= 23 (24.7%)***	***Total n=93 (100%)***
Responses				
n (%)	160 (100.0)	59 (100.0)	54 (100.0)	273 (100.0)
Exposure games; hrs				
n; hrs	17; 280.5	16; 264.0	4; 60.7	37; 605.2
Breast Injury Incidence				
Rate (95% CI)	42.8[bc] (24.3-75.3)	7.6[ac] (1.9-30.3)	181.3[ab] (100.4-327.2)	41.3 (27.9-61.1)
Number of players accepted sport protective bra				
N (%)	32 (78.0)	24 (82.8)	23 (100.0)	79 (84.9)
Used sport protective bra (survey responses)				
Yes: n (%)	131[e] (81.9)	40[e] (67.8)	36[e] (66.7)	207[e] (75.8)
No: n (%)	29[d] (18.1)	19[d] (32.2)	18[d] (33.3)	66[d] (24.2)
Any injury / discomfort (survey responses)				
Yes: n (%)	12[e] (7.5)	2[e] (3.4)	11[e] (20.4)	25[e] (9.2)
No: n (%)	148[d] (92.)5	57[d] (96.6)	43[d] (79.6)	248[d] (90.8)
Protection worn / Injuries recorded*				
Own bra: n (injury)	5 (10)[g]	2 (2)	2 (5)	9 (17)
Sport protective bra: n (injury)	2 (2)[f]	0-	3 (6)	5 (8)
If injury – how did this occur (survey responses)**				
Direct blow from another player: n (%)	7 (58.3)	0 -	4 (36.4)	11 (44.0)
Direct blow sporting equipment: n (%)	3 (25.0)	2 (100.0)	0 -	5 (20.0)
Direct contact with surface: n (%)	2 (16.7)	0 -	7 (63.6)	9 (36.0)
Did you feel that the breast injury affected your performance (survey responses)**				
Yes, I am distracted by the pain: n (%)	4 (33.3)	0 -	0 -	4[k] (16.0)
Yes, I am less likely to dive or tackle: n (%)	0 -	0 -	2 (18.2)	2[k] (8.0)
Yes, I feel less confident: n (%)	0 -	0 -	2 (18.2)	2[k] (8.0)
No, breast injuries do not affect my performance: n (%)	8 (66.7)	2 (100.0)	7 (63.6)	17[hij] (68.0)
Did you report the breast injury to anyone? (survey responses)**				
Did not report: n (%)	12 (100.0)	2 (100.0)	11 (100.0)	25 (100.0)
If not reported, what reason was this (survey responses)**				
Not important enough to tell: n (%)	7[m] (58.3)	2 (100)	4 (36.4)	13 (52.0)
Don't feel comfortable telling anyone: n (%)	1[l] (8.3)	0 -	4 (36.4)	5 (20.0)
No one to tell: n (%)	4 (33.3)	0 -	3 (27.3)	7 (28.0)

n=number; *= Number of players = number of players that reported and injury; % - Percentage; Significant difference (p<0.05) than (a) = Soccer Open; (b) = Soccer U16; (c) = Rugby League; (d) = Yes; (e) = No; (f) = own bra; (g) = Sports bra protector; (h) = Yes, I am distracted by the pain; (i) = Yes, I am less likely to dive or tackle; (j) = Yes, I feel less confident (k) = No, breast injuries do not affect my performance; (l) = Not important enough to tell; (m) = Don't feel comfortable telling anyone.

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Table 4. Perceptions of the Sports protective bra for amateur female soccer and rugby league participants in New Zealand

	Soccer Open* n (%)	Soccer U16* n (%)	Rugby League* n (%)	Total* n(%)
Feedback about Sports Protective Bra**				
Very comfortable to wear	6 (14.6)	8 (27.6)	4 (17.4)	18 (19.4)
Easy to put on and felt supported	8 (19.5)	5 (17.2)	2 (8.7)	15 (16.1)
No discomfort	6 (14.6)	5 (17.2)	3 (13.0)	14 (15.1)
Felt good	3 (7.3)	6 (20.7)	3 (13.0)	12 (12.9)
Love to wear them	7 (17.1)	0 -	5 (21.7)	12 (12.9)
Strange to wear initially	2 (4.9)	3 (10.3)	3 (13.0)	8 (8.6)
Worked well and supportive	4 (9.8)	2 (6.9)	0 -	6 (6.5)
Felt like a warrior	0 -	0 -	3 (13.0)	3 (3.2)
Good protection and great support	3 (7.3)	0 -	0 -	3 (3.2)
Fantastic to wear	2 (4.9)	0 -	0 -	2 (2.2)

% = percentage; * = percentage based on number of responses received; ** = respondents could give multiple answers

DISCUSSION

This study undertook to document the effects of breast pain on performance for a single club-based amateur female soccer and representative rugby league participants in New Zealand. The principal findings of this study for baseline retrospective survey data were the following:

(1) A third (36.6%) of players reported having had a previous breast injury;
(2) Of the 34 participants that reported a previous breast injury, there was an average of 2.6 ±1.4 breast injuries per player in the previous year;
(3) The most common cause for breast injuries was player-to-player contact;
(4) A third (33.3%) of players who reported a breast injury identified this did not affect their playing performance.

For the in-season prospective post-match survey data, the findings were the following:

(1) The pooled incidence of breast injuries was 41.3 (95% CI: 26.7 to 61.1) per 1,000 match-hrs; and
(2) Less than 10% of players (9.2%) reported a breast injury when wearing the sport protective bra.

Reporting of Breast Injuries

The finding that 37% of players retrospectively reported a breast injury was consistent with some but not all studies reporting on breast injuries in female sports participants.[17,19,33] However the reporting of these injuries has improved since the early studies.[33] In a recent systematic review, it was identified that the reporting rate for breast injuries varied between 0% and 42.9% of the participants. The reasons for this under-, or non-reporting included belief that the injury was not severe enough, non-recognition of the symptoms, and fear of judgement by coaches and/or teammates.[12] However, females were more likely to report their injury to an injury recorder of the same sex and within a supportive environment.[12] The results of the current study highlight the need to ask female sports participants directly and specifically about their experiences with breast injuries rather than letting them report these injuries on their own to team medical staff.[19] In addition, encouraging reporting can assist with early management of these injuries as two thirds (66.7%) of retrospectively reported breast injuries impacted on player performance.

Similar to other studies, the majority of these players did not report their breast injury for a variety of reasons, and this may be related to a general lack of awareness that these injuries do occur and what possible long-term consequences there are for female athletes.[12, 17, 19] For example, it has been reported that as a consequence of direct blunt breast trauma, females have been identified with fibrocystic breast tissue with some going on to develop fibroadenomas and small cystic lesions.[16, 34]

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Other studies have reported the development of haematomas that lead to palpable nodules that were diagnosed as lipid cysts or fat necrosis and this has been linked to chronic pain and anxiety from months to years following the injury.[35, 37] Therefore as one in three of our players reported sustaining a breast injury, it is important that players, coaches and team medical support associated with female sports are educated on the injury risk to the breast in training and competition enabling these players to be encouraged to report, and seek treatment if necessary.[19]

We have reported information for soccer open and rugby league players whose mean age was 26 years, plus for soccer U16 whose mean age was 15 years old. Given the age range, it is important to understand what the awareness of breast injuries and their consequences is for the pre-menarchal female athlete. Breast trauma can potentially lead to future issues due to injuries during development such as asymmetries.[38] This was a concern for the U16 cohort as they retrospectively reported an average of 4.8 injuries per person injured. Interestingly 31% of the U16 players retrospectively reported having had breast injuries, and this reduced to 3.4% of players prospectively reporting an injury whilst wearing the breast protection bra. Although this appears to be an interesting finding, what is not recorded is whether these players with the previous injury did so at club-based soccer or other sporting activities such as school soccer where the skill level may be different. Future studies may want to consider this aspect as part of the data background for the incidence of previous breast injuries.

This is the first study to prospectively report the incidence of breast injuries in two sporting activities. The finding that the rugby league participants reported a breast injury incidence of 181.3 per 1,000 match-hrs. was not unexpected given the nature of the game. Rugby league is a full contact sport requiring the opposition to physically stop the forward motion of a player with the ball. As a result, players undergo an average of 29 to 55 physical collisions (tackles and ball-carries) per game.[39] Consequently, this can result in direct contact around the breast or the player landing on the ground onto their breasts. However, the finding that the female soccer (open) had a breast injury incidence of 42.8 per 1,000 match hrs was unexpected and may be reflective of the physicality of the sport at this level of participation. Further studies are warranted to identify if this was unique to this cohort of female soccer players or whether the finding is reflective of the breast injuries that are occurring.

Cause of Breast Injuries

Nearly half of players (44%) retrospectively reported that player contact was the main cause of the previous breast injuries, and interestingly this was identical prospectively for when the players were wearing the sport protective bra. These results are the same as previous studies where player contact and contact with equipment was the most common causes for breast injuries.[17, 19]

The finding that a fifth (20%) of rugby league players prospectively reported breast injuries was expected as this is a full-body contact sport and these injuries are more common in contact sports when compared to non-contact sports.[40] This was similar with the results of our study where only 8% of open age and 3% of U16 female soccer players prospectively reported a breast injury. As there is an increase in female participation in contact sports such as rugby union, rugby league, and Australian Soccer league (AFL), then these players are at a higher risk of contact breast injuries.[41-43] Therefore, it is important that strategies for the prevention and management of breast injuries in these sports are developed and the education of players needs to be available at all levels of participation. This can be done with further research to identify the specific mechanisms (i.e. player-to-ground, player-to-ball, player-to-player) associated with each cause of 'traumatic' contact breast injury.[20] Understanding the exact mechanisms of injury in contact breast injuries is critical in the prevention of affecting performance and in the development of evidence-based prevention and management strategies.[44]

Performance Effects Due to Breast Injuries

Nearly a third (32%) of all players that prospectively reported a breast injury indicated that the injury had an effect on their performance. This was similar to other studies reporting on breast injuries where 18% to 32% of female players with a breast injury indicated that the pain had a negative impact on their performance.[17,28] Despite this finding, none of the players with a prospectively self-reported breast injury reported this to anyone that may have been able to assist in the management of these injuries. The unexpected finding from this study was that the players felt that these injuries were not important enough to tell anyone (52%) or that they didn't feel they had

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anyone they could tell (28%) despite all teams having a dedicated female medical support person and a registered health professional. This finding highlights the need to 'normalise' the discussion around breast injuries through education and awareness and for future research to try to understand why players chose to not report these injuries.

Protective Bras

The finding that less than 10% of current players prospectively reported a breast injury whilst wearing a sport protective bra with polymer inserts was unexpected but supported previous studies.[19, 28] Calls for the use of appropriately fitted high support bras that reduce excessive breast movement and provide impact reducing properties over the breast is warranted. In addition, no player reported any friction-related injuries with the customised sports bra which has been reported to be a concern with other bras worn in sporting activities.[19] The sport protective bra had a moisture wicking profile with "double panel" pockets formed over each breast for the ergonomically shaped patent pending polymer inserts, and despite the players participating in a variety of weather conditions, there were no reports of loss of inserts, skin integrity disruptions or friction-related injuries.

An observation of this study was how the open soccer players utilised their body more to control the ball than with heading the ball.[45] As heading in soccer is a unique skill and involves the deliberate redirection of the ball using the player's head.[46] On average, there are 1 to 4 headers per-player per-game in domestic amateur female soccer.[47] Although females partake in soccer under the same rules as male players, it has been reported that female players are less likely to be trained in heading technique than males.[48] In addition, it has been identified that heading in soccer for females can result in a fivefold greater volume of widespread microstructural white matter alteration when compared to males.[49] The open soccer players who wore the sport protective bra were seen to have a greater confidence after a few matches when putting their body forward in stopping the ball with their chest instead of trying to do a header for the ball. As a result, there was an observable reduction in female open soccer head injuries (17.8 per 1,000 match-hrs) over this competition season when compared with the previous year (23.6 per 1,000 match-hrs).[45] Further research is warranted to see if the use of the sport protective bra can assist with the reduction of heading in soccer and reducing the incidence of concussion.

Limitations

The results of this study were based on data collection from a series of survey's players completed at baseline and each week following competition matches. Firstly there are inherent limitations in subjective self-reported data such as previous injury recall.[50] This may be the same for the weekly survey's the players completed with those who had experienced a breast injury more likely to complete these surveys. Secondly, the findings of this survey were limited to amateur female rugby league and soccer players in a single district in New Zealand. As such the results should be interpreted with consideration that these may not be generalisable to all female sports participants. Only player age was recorded as part of this study. No other data such as breast size, height, body mass, player position was included in the data collection, and this can limit the generalization of the data reported. Despite these limitations, the study explored the behaviours and effects of a sport protective bra on the number of breast injuries in female amateur soccer and rugby league players. The results have identified that especially in contact sports, female players are at risk of traumatic contact breast injuries.

CONCLUSION

Despite the exponential rise in participation in female sports overt the past few years, there remains the risk of breast injuries, especially in contact sports participants. Nearly a third (32%) of all players that reported a breast injury indicated the injury had an effect on their performance. Almost half of the players (44%) reported that player contact was the main cause of previous breast injuries. The finding that the rugby league participants reported a breast injury incidence of 181.3 per 1,000 match-hrs. was not unexpected given the nature of the game. As one in three of these players reported sustaining a breast injury, it is important that players, coaches, and team medical support associated with female sports are educated on the injury risk to the breast in training and competition enabling these players to be encouraged to report and seek treatment if necessary.

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Conflict of Interest Statement

The authors declare no conflicts of interest with the contents of this study.

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