

**The Development and Psychometric Properties of a Survey to Assess Breast Knowledge
and Attitudes of Adolescent Girls**

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Abstract

Background: Breast education could alleviate breast concerns reported by adolescent girls.

Purpose: This article describes the development and psychometric properties of a survey to measure knowledge in multiple aspects related to breasts, attitudes to breasts and breast issues and the likelihood of engagement with positive breast habits among adolescent girls.

Methods: An 85-item, developmentally appropriate, breast survey was generated using previous research. Consultation with 13 breast experts and a focus group of 7 girls established face and content validity. Survey validity and reliability was established by item analysis with 148 girls, principal components analysis with 729 girls, confirmatory factor analysis with 921 girls, known groups validation with 15 breast experts and 18 girls, internal reliability (729 and 921 girls) and test-re test reliability (18 girls). **Results:** Results indicate that the final 39-item breast survey (10-subscales) is valid, reliable, and easy to administer.

Discussion: Each subscale within the survey addresses adolescent girls' specific breast concern which is consistent with the breast needs of adolescent girls. **Translation to Health**

Education Practice: This study offers researchers and health educators a survey that can be used to inform the design of breast education programs and determine the impact of such programs.

Keywords: Adolescents, survey development, breast survey, breasts, breast education

Background

Puberty is a challenging time for girls; breast development can be embarrassing and confusing, negatively impacting body image and self-esteem,¹ and affecting adolescent girls' sports participation.² There is very limited research on the impact of the breasts on adolescent girls' health and wellbeing . A large survey study with 2089 adolescent schoolgirls aged 11 to 18 years was recently conducted highlighting the importance of this topic for adolescent populations.^{2,3} The results were concerning; the majority of girls (87%) reported at least one breast concern.³ Furthermore, nearly half of the 2089 adolescent girls surveyed reported that their breasts had a negative effect on sport and exercise participation.²

One of the most prevalent breast concerns reported by 44% of girls was "how to check for breast cancer".³ Other studies have also highlighted that adolescent girls are concerned about breast cancer and how to reduce the risk of breast cancer, with many girls having misleading and incorrect information about breast cancer.^{4,5}. A major public health priority is focused on early breast cancer detection because of its significance in reducing mortality.^{6,7}. Breast education interventions on breast awareness (knowing how breasts look and feel normally and report any unusual changes to a suitable person) have been recommended as effective public health actions in prevention and control of breast cancer, especially among adolescents.^{8,9}

In the survey by Brown et al. (2018), breast pain and sagging breasts were also commonly reported breast concerns, reported by 41% and 29% of girls respectively.³ Both these issues are exacerbated by independent breast movement (breast bounce),^{10,11} which was one of the most common breast concerns reported by 44% of girls. The independent movement of the breast has also been reported to cause discomfort, embarrassment and reduce self-confidence.¹²⁻¹⁴ Breast pain is also a common health problem in adolescent girls population.¹⁵

Due to lack of knowledge and awareness, in adolescent girls breast pain stimulates anxiety and fears of breast cancer.¹⁶

Wearing the wrong size bra and finding a bra that fits were further breast concerns that were reported by 34% girls. It has been suggested that the independent breast movement and its associated negative health consequences (e.g. breast pain, breast sag, embarrassment) may be reduced by breast education and education on wearing an external support in the form of a well-fitted bra.^{10,17,18} However, the wide choice of brands, styles and sizes available may make the bra market a confusing place and the selection of appropriate, well-fitted bras difficult for adolescent girls.³

Research studies have confirmed that well designed sports bras are more effective in limiting the independent breast movement and associated breast pain and discomfort than standard fashion bras or crop tops.^{17,19,20} It is assumed that the reduction in these negative factors may help females to exercise in greater comfort, improve spots participation, and importantly enhance sporting performance.^{13,20} Nevertheless, studies have shown that adolescent girls were not aware of the importance of wearing an appropriate breast support.²¹ and only 10% always wear a sports bra during sport and exercise.² Breast education that promotes the benefits of appropriate breast support (e.g. a sports bra) and incorporates training on bra selection and fit is therefore needed.

A further concern reported by 36% of girls was boys view of their breasts, with a further 27% reporting embarrassment and 21% reporting lacking confidence because of their breasts.³ Breasts have been recognized as one of the changes that occupy “an inordinate amount of psychic space” for adolescent girls.²² Breast development has been associated with decreased body satisfaction and low self-esteem.^{22–24}

Adolescent girls were also concerned about breast size (reported by 35%), how breasts might look when you are 50 (reported by 35%), having one breast bigger than the other (reported by 34%), how quickly breasts grow (reported by 21%) and the age at which breasts start to grow (reported by 17%). Teaching adolescent girls about breasts sizes and shapes and how breasts change over time may improve body satisfaction and self-esteem in this population, empowering girls to accept and feel comfortable with the breast changes they undergo during puberty.³

The above problems are exacerbated by adolescent girls' low knowledge of breasts, breast health, bra fit, and appropriate breast support as shown in many literature.^{21,25-28} For example, Rogers et al. (2002) study results suggest many causes for concern because more than half of participants (n: 990, 11-14 years old girls) had misunderstanding and misconceptions about breasts and breast health and did not know about breast health and bra fitting.²¹ Other studies also supported their results by showing that half to two third of participating girls had very low knowledge about breasts and breast health.^{25,26,28} To improve adolescent girls' knowledge of breasts and address their breast concerns, breast education is needed. In the survey with 2089 schoolgirls (11 to 18 years), 87% of girls reported wanting to know more about their breasts and the majority reported that learning about breasts and breast health is important.^{3,29}

Adolescent girls are an important target group for breast education and promotion of positive breast habits (e.g. checking breasts)³ because lifetime habits and attitudes are often developed at this age.³⁰ It is during adolescence period that most future health-related lifestyles, behaviors, habits and attitudes are formed.³¹ Health and health attitudes and behaviors correspond strongly from adolescence into adult life, therefore, it is more likely that adults practice positive health behaviors when they are learnt about health related topics from an early age, particularly in adolescence.³²

The importance of health education for adolescents in key settings such as schools has been highlighted in many literature.³³⁻³⁵ It has been suggested that an effective health education intervention that increases health knowledge can also improve attitudes by outweighing the pros of adopting positive health habits the cons.^{30,35-37} Education on other sensitive topics (e.g. HIV/AIDS, cancer prevention) in school settings increases adolescents knowledge, and improves attitudes and healthy behavior.^{38,39} Previous studies have demonstrated that breast education interventions increase adolescent girls' knowledge and attitudes towards breasts.⁴⁰⁻⁴² Educating adolescent girls about breasts may alleviate the breast concerns identified by Brown et al. (2018) and improve adolescent girls' breast knowledge and attitude to breasts, thus promoting positive breast habits (e.g. checking breasts, checking if a bra fits, wearing a sports bra).^{3,40}

Brown et al. (2018)³ used the student voice, (thoughts, views and opinions of students regarding breast education⁴³), to provide practical guidance on breast education for adolescent schoolgirls and identified that the most appropriate age at which breast topics should be introduced is 11 years which is the average age of breast budding.⁴⁴ The authors also indicate that in order to address adolescent girls' breast concerns, a broad content should be included in breast education programs including, but not limited to; breast awareness, breast sag, breast pain, breast size and breast changes, breast surgery, appropriate breast support and bra fit.³ For effective breast education and promotion of positive breast habits Clark et al. (2000) and Horton (2011) recommend that programs should not only address the knowledge limitations of adolescents but also the attitude barriers to breasts (e.g. feeling negative and embarrassed about breasts).^{40,41} However, previous studies in the area of breast education have primarily focused only on knowledge, awareness and attitudes of breast self-examination and breast cancer in adolescent populations, not other aspects related to the breasts such as breast movement or attitudes to breast issues.^{40,41,45,46} Only a small body of

research has focused on other aspects related to the breasts such as breast movement, bra fit and appropriate breast support.^{21,42} However, the evaluation tools used in the above studies did not undergo a robust process of development and testing to ensure the validity and reliability of the tools, thus limiting the credibility of findings.^{47–54}

Various studies have developed valid and reliable tools to evaluate breast cancer knowledge and awareness in an adult population.^{55–58} However, due to differences in characteristics of this population and adolescent populations, the evaluation tools developed in these studies may not be appropriate for adolescents.^{59–61} As a transitional period between childhood and adulthood, adolescence involves rapid developmental changes in cognitive, social, physical and emotional development⁶². For example, adolescents have different cognitive abilities compared to adults; they are very context sensitive, literal, and liable to lose their motivation and get easily bored.^{63,64} It has also been shown that adolescents have poorer decision making and judgment skills compared to adults.^{65,66} Logical decision making ability increases with age, stabilizing around 21 years old. In addition, during early adolescence peer relationships take on a heightened importance, increasing the likelihood of adolescents changing their behavior or decisions in response to group norms and peer pressure.^{60,62,67} These developmental differences between adolescents and other age groups present a unique set of considerations when developing surveys for use with adolescents.⁶³ Furthermore, designing a suitable survey that targets young adolescents requires a balance between their characteristics (such as age, cognitive and decision ability), developmental stages and question characteristics (e.g. type of questions, question format and wording).^{61,68–70}

Methodological studies of adult populations have revealed that adults may experience problems with certain questions, and that question characteristics may affect data quality in surveys.^{70,71} Adults experience problems when information has to be retrieved from memory and when questions are very complex.⁷² With children as respondents, the same problems

may be magnified, and a slight error or ambiguity in the survey may have a large impact on data quality and be difficult to compensate. Furthermore, adolescents may experience specific problems when responding because they are still in the process of developing their psychological, emotional, cognitive and social skills^{62,65,73,74} and this affects how they respond to survey questions. Therefore, developing evaluation tools for use with adolescents involves special consideration and testing.⁶³ There is a need for a valid and reliable breast survey enabling rigorous evaluation of adolescent girls' knowledge and attitudes to breasts and breast issues. It is important to evaluate breast knowledge levels and attitudes to breasts in adolescent girls to inform the design of appropriate breast education programs to address their specific needs. The development of such a tool would also offer a means to determine the impact and success of breast education programs designed to address adolescent girls' breast concerns and improve their knowledge and attitudes towards their breasts.

Purpose

Given the absence of an appropriate tool to measure multiple aspects of breast knowledge and attitudes to breasts, the purpose of this study was to develop a developmentally appropriate self-report evaluation tool (survey) to measure breast knowledge, attitudes towards breasts and breast issues for use with adolescent girls aged ≥ 11 years. Methods will evaluate the face validity, content validity, construct validity, internal reliability and test-retest reliability of the survey.

Methods

Phase 1: Survey Development

Item generation

Adolescent breast concerns described above were used to generate a pool of 85 items related to breasts by a female breast expert. Of the initial 85 items, 64 were designed to measure multiple aspects of breast knowledge including breast size, breast composition, breast shape, breast bounce, breast pain, breast sag, bras, bra fit, and breast cancer awareness. The remaining 21 items were designed to assess adolescent girls' attitudes towards breasts and breast issues, hence evaluating the likelihood for girls to engage with positive breast habits. Consistent with recommendations for survey development for adolescents, items measuring breast knowledge had four possible responses 'completely false', 'sort of false', 'sort of true', and 'completely true'.^{59,69} A Likert scale format was also applied to items measuring attitudes towards breasts and breast issues, again with four possible responses; 'fully disagree', 'mainly disagree', 'mainly agree', 'fully agree'. Scores for both knowledge and attitudes items ranged from one (lowest) to four (highest), with negatively worded items reverse scored. The question characteristics including question type (e.g. open versus closed questions), question format (e.g. the use of dichotomous questions, multiple choice questions, or rating scales), question difficulty, wording (e.g. negative versus positive wording), length and response format (e.g. use of words versus numbers), the number of response options, the inclusion of a neutral mid-point, survey length, layout and question sequence were selected in accordance with recommendations for survey development for adolescents, which considers the developmental stage of adolescents.⁵⁹ Ensuring appropriate question characteristics for adolescents developmental stage has improved response quality in survey research with adolescents.^{59–61,69}

For the initial 85 items, readability tests determined that the survey was appropriate for reading levels of adolescents aged ≥11 years. SMOG test score was 7.0 that is suitable for adolescents 11-13 years.⁷⁵ Flesch Reading Ease test score was 71.8 and Flesch-Kincaid Grade test score was 6.2, these scores are considered suitable for adolescents aged 11-12 years.^{76–78}

Four demographic questions were included at the end of the survey to characterize participants. These asked for participants' date of birth, ethnic origin, school year and school type (single-sex, single-sex with boys at sixth form only and mixed school).

Ethical consideration

All participants who participated in validity and reliability assessment of the survey gave written informed consent by signing paper or electronic consent forms. Institutional ethical approval was granted, and in cases involving adolescent girls, permission from gate keepers (schools) and written informed parental consent were also obtained.

Breast experts and adolescent girls were recruited using a convenience sampling method. Breast experts who took part in the study were recruited from a Research Group in Breast Health based in the UK. Experts were White and had \geq one year experiences in the area of breast research (range 1-12 years). Adolescent girls were recruited from different schools for each stage of the study (characteristics are detailed in subsequent sections).

Face validity assessment

Face validity refers to the degree to which a survey appears (at face value) to measure what it claims to.⁷⁹ For the purpose of face validity assessment, the number of experts should be minimum of two.⁸⁰ A panel of three breast experts aged 36.0 ± 6.5 years reviewed the 85 item pool to ensure that the items appeared to adequately represent the variable or construct under investigation, thus verifying the face validity of the survey.^{79,81} The experts were informed that the breast survey included sections which contained a number of items that aimed to assess a specific aspect related to breasts and breast health. As recommended by Hardesty and Bearden (2004) the compete decision rule was used to decide which items to retain, whereby items were added, removed or amended until all experts reached a consensus

reported that the item was completely representative of the construct.⁸² Fifteen items were deemed unclear or irrelevant and were excluded and a further 23 items were amended. Following the face validity assessment, the survey contained 70 items (Figure 2).

Content validity assessment

Content validity refers to the extent to which items in a survey represent or reflect the content domain (i.e. the representativeness of the items).^{79,83,84} Content validity was assessed in two stages. Firstly, as recommended in the literature in content validity area,^{85–87} 10 female breast experts aged 33.7 ± 7.5 years provided feedback on the relevance and importance of individual survey items to ensure that the content of the survey assessed what it was supposed to.⁷⁹ An online questionnaire based on Lawshe method was created and used to quantify content validity.^{83,88,89} Similar to the face validity stage described above, the experts were provided with clear instruction on what each section of the survey aimed to assess regarding breasts and breast health. Each member of the panel responded to the following question for each of the items within the survey: is the knowledge (or attitude) measured by this item: ‘Essential’, ‘Useful but not essential’, or ‘Not necessary’. In addition, experts had an opportunity to provide written feedback on each item, which if provided, was reviewed to aid decision making for removal or amendments of the items. Lawshe reported a table of critical content validity ratios, (CVR_{critical}) which is the size of a calculated CVR necessary to exceed chance expectation for a specific number of panellists.⁸³ For a panel of 10 experts the CVR_{critical} minimum value should be 0.6 to retain an item.⁸⁹

CVR_{critical} values of the 70 items ranged from -0.6 to 1.0. In total, 32 items fell below the CVR_{critical} minimum threshold of 0.6. Twenty-two of these items were removed, however 10 were retained as written feedback provided by the panel indicated that these items were essential but needed rewording or minor amendments. Nine new items were also added based

on the written feedback. It was thought that these new items captured important aspects of breast knowledge of adolescent girls that were not previously covered. The results from content validity assessment were confirmed by three female breast experts aged 36.0 ± 6.5 years. Following the first stage of content validity assessment, the survey contained 57 items (Figure 2).

An important and necessary component of survey tool development is to assess whether participants understand the question and the response format, both consistently across participants and in the way anticipated by the researcher.^{90,91} Simply relying on pilot testing a survey is not sufficient to ensure the accuracy and quality of the instrument.^{92,93} Therefore, at the second stage of content validity assessment, adolescent girls aged 11 to 14 years were consulted to examine how the items and their response formats were understood and why a particular answer was given. This approach is referred to as “cognitive interviewing”, which is one of the most prominent methods for correcting and identifying issues with survey items, especially for survey improvements for young adolescents.^{61,90-95}

Cognitive interviewing is commonly conducted in a one-to-one interview. However, when refining study measures with adolescent girls a focus group approach is recommended over traditional one-on-one cognitive interviewing for various reasons.^{60,96} For example, Adolescent have a preference for group activities and the focus group method is considered more developmentally appropriate.⁹⁷ Moreover, early adolescents may find it considerably less intimidating to discuss sensitive topics in a group of peers than in one-to-one interactions with an adult.⁹⁸ Therefore, a focus group was conducted in a secondary school in the UK with seven adolescent girls aged 11 to 14 years from diverse ethnic backgrounds (42.8% Asian/Asian British, 28.5% White, 14.2% Black, and 14.2% Mixed/multiple ethnic groups).

During the focus group, participants were given a paper copy of the survey and instructed to read and answer the survey questions. Two most commonly used cognitive interviewing techniques, think-aloud and verbal probing, were used in the focus group discussion (duration 45 minutes).⁹¹⁻⁹⁴ Probes identified from the literature in the area of cognitive interviewing were discussed for each survey item and its response format.^{91,94} The audio recording from the focus group discussion was transcribed verbatim to maintain purity of the data⁹⁹ and subsequently analyzed using a thematic analysis approach known as framework method.^{100,101} Analysis of the focus group data established the survey content validity and achieved the goals of cognitive interviewing; all participants agreed and confirmed that they understood the survey items and response format, this was consistent with the way intended by the researcher.^{90,91}

Participants found the survey items and their response format to be clearly worded and easy to complete. There were some terms that the participants were less familiar with such as “breast bounce”, “breast sag”, “cup size”, and “milk ducts”. However, further discussion identified that this was due to low knowledge in this area rather than lack of clarity or issue with an item. This was confirmed by the participants with comments such as: “I think it’s [survey] actually quite good, but maybe the terms that some people are less familiar with for example, like sagging boobs and stuff like that, maybe you should ask the teacher to explain it to them”. Following further questions, participants confirmed that they were able to answer to the survey items, even though they were less familiar with some terms, one participant commented: “I think it’s [survey] fine how it is, most people understand it, like, you have a sense of what these words mean”, this was followed by murmured agreement from other participants. No survey items were removed following completion of the second stage of content validity assessment, although small amendments were made to three items following participants’ feedback (Figure 2).

Phase 2: Item Analysis

Item difficulty and discrimination assessment

The aim of this stage was to detect items that lacked clarity or that may not be appropriate for, or differentiate between, participants; this is a particularly useful analysis for items that assess knowledge.¹⁰² Evaluation of item difficulty and item discrimination are the two most common analysis methods that should be considered in item analysis.^{102,103} Item difficulty is the percentage of participants who have answered an item correctly.¹⁰³ A single item should not be highly endorsed,¹⁰⁴ therefore items assessing knowledge were removed if > 80% (very easy) or < 10% (very difficult) of participants answered an item correctly.^{103,105} Item difficulty was not calculated for items measuring attitudes towards breasts as there were no right or wrong answers for these items. Item discrimination is the ability of an item to differentiate between participants who do not well, and those who do.¹⁰² A cut-off > 0.14 was used for an item-total correlation to detect items with very low discrimination ability, hence informing a decision to remove them (this analysis applied to all items).¹⁰⁵

Adolescent girls aged 11 to 14 years from one secondary single-sex school in the UK were recruited to complete the 57-item breast survey. In total, 148 schoolgirls aged 12.8 ± 0.8 years (range 11 to 14 years) completed an online version of the breast survey. Of the participants, 82.4% were White, 6.8% were Mixed/multiple ethnic groups, 6.1% were Asian/Asian British, 1.4% were Black/African/Caribbean/Black British, and 3.4% did not report their ethnic group.

Following the item analysis, very easy items ($n = 4$), very difficult items ($n = 3$) and items with very low discrimination index (< 0.14 , $n = 8$) were removed (Figure 2). One item with a discrimination index of 0.103 was revised. An additional eight items were retained despite low discrimination indexes, as literature suggests items with very low (< 0.14) or low (0.14 to

0.19) discrimination indexes can be retained in circumstances where an item is considered particularly important in terms of content validity.¹⁰⁵ With a minimum of two experts recommended,⁸⁰ five female breast experts aged 38.6 ± 7.8 years reviewed the results of the item analysis and reported that some of the very easy and difficult items removed measured important aspects of breast knowledge. Therefore, four new items were generated and added to the survey to ensure knowledge in these areas were assessed.¹⁰⁵ Wording used in the new items was consistent with the remaining items to ensure that the level of difficulty was suitable for adolescent girls. Following the item analysis, the survey contained 46 items (Figure 2).

Phase 3: Construct Validity Assessment

Exploratory factor analysis

Construct validity concerns with how well the items in a survey measure and characterize the underlying construct.^{79,106} One way to assess construct validity is Exploratory Factor Analysis (EFA) which assesses how the current construct is working and whether a measure contains cohesive items, clear and distinct subscales.^{102,107,108} EFA is a heuristic method that can help researchers to reduce and refine a developing measure.^{102,107}

For the purpose of factor analysis of the breast survey, adolescent girls aged 11 to 14 years from three secondary schools (two single-sex and one mixed school) in the UK were recruited to complete the 46-item survey. In total, 729 schoolgirls aged 12.2 ± 0.9 years (range 11 to 14 years) completed the breast survey either online (87%) or on paper (13%). The items and format of the online survey were identical to the paper-based survey to maintain equivalency and increase reliability of the mixed-mode strategy.¹⁰⁹ Of the participants, 75.9% were White, 7.5% were Asian/Asian British, 5.8% were Mixed/multiple

ethnic groups, 1.6% were Black/African/Caribbean/Black British, 1.5% other ethnic background and 7.7% did not report their ethnic group.

Principal components analysis (PCA) with a Varimax orthogonal rotation was used as an extraction method for EFA on the 46-item breast survey as it is recommended for establishing preliminary solutions when no priori theory or model exists.^{107,108,110} Multiple retention approaches were used to decide how many factors to retain following PCA. First, Kaiser's criterion eigenvalues were examined and revealed that 16 components had eigenvalues > 1 and should be retained. Second, the scree plot was examined and the break point in the data (the “elbow” of the graph) indicated that 10 components should be retained.^{108,110} Parallel analysis, one of the most accurate factor retention methods which, also indicated that 10 components should be retained.^{111,112} As such, 10 components were retained. The interpretation of the factors was led by the factor loadings ≥ 0.3 ,^{107,108} items with weak loading < 0.3 were removed resulting in a 39-item survey. Three items had multiple factor loadings, after careful inspection these items were removed to create a simple structure solution because their content did not fit with any of the factors (36-item survey) (Table 1).^{103,108}

The 10-factor solution explained 47.45% of the total variance. Following a thorough investigation of the content of each factor, the factors were labelled as follows to reflect their theoretical and conceptual intent: 1) attitudes to breasts, 2) breast awareness, 3) breast anatomy and breast pain, 4) bra purchasing, 5) positive breast habits, 6) breast bounce and breast sag, 7) breast variation and correct bra fit, 8) incorrect bra fit 9) sports bras, and 10) breast cancer symptoms. Of those items removed in factor analysis, three were identified as important contributors to the content of the survey by four breast experts. As recommended by Pett et al. (2003)¹⁰⁸ these three items were retained. Following the factor analysis, the survey contained 39 items.

Table 1 near here

Confirmatory factor analysis

Four female breast experts aged 35.7 ± 5.3 years reviewed the results of exploratory factor analysis and agreed that the three items that were retained during the EFA would fit conceptually into one of the 10 factors identified in the exploratory PCA to make a more parsimonious solution. To test whether the hypothesized 10-factor model with 36-items provided a good fit to the data (model one), and whether adding the three items (39-items) to the relevant factors would change the fit indexes (model two), a confirmatory factor analysis (CFA) was conducted.^{113,114} CFA is best accomplished on a data set independent of the initial EFA,¹¹³ therefore, adolescent girls aged 11 to 14 years from four secondary single-sex schools in the UK were recruited to complete the 39-item breast survey. In total, 981 schoolgirls aged 13.2 ± 0.86 years (range 11 to 14 years) completed the breast survey either online (61%) or on paper (39%). Of the participants, 42.8% were Black/African/Caribbean/Black British, 21.5% were Asian/Asian British, 17.1% were White, 9.6% were Mixed/multiple ethnic groups, 3.4 other ethnic background and 5.6% did not report their ethnic groups. As recommended by Hooper, Coughlan, and Mullen (2008)¹¹⁵ and Kline (2005)¹¹⁴ the following fit indices were used to verify how well the 10-factor model fit the data: the Chi-Square to df ratio (χ^2/df) (values < 5 are indicative of an acceptable fit), the Goodness of Fit (GFI) (value ≥ 0.9 generally indicating acceptable model fit),¹¹⁶ the Root Mean Square Error of Approximation (RMSEA) (good model fit with values < 0.08), the Comparative Fit Index (CFI) (values ≥ 0.9 indicate good fit) and the Root Mean Square Residual (RMR) (a value of < 0.08 indicative of an acceptable fit).

Fit indices in model one was as follow: $\chi^2/df = 2.463$, GFI= 0.928, RMSEA= 0.039, CFI= 0.862, RMR= 0.035. Fit indices for model two was as follow: $\chi^2/df = 2.320$, GFI= 0.926,

RMSEA= 0.037, CFI= 0.862, RMR= 0.035. Both models demonstrated acceptable model fit, with no substantial differences between fit indices in model one and two. However, χ^2/df and RMSEA values were slightly better in model two. Thus, it was decided that model two was a better fit to the data, and the three additional items (considered important contributors to the survey content), were added to the most relevant factors for the purpose of analysis. The final survey comprised 39 items, with 10 factors (represented as subscales) as shown in Figure 1. It is worth noting that as recommended by Song et al. (2013), overall scores are composited for conceptually relevant subscales (Figure 1) using “meaningful grouping” approach; that is the nonstatistical combination of selected original subscales based on the interpretation of the subscales’ values or scores, guided by the science of the field, and consultation with four breast experts.¹¹⁷

Figure 1 near here

Known groups validation

Known groups validation is a method to investigate the construct validity of a survey.^{79,84} It is provided when a survey can discriminate between groups that theoretically are expected to be different, based on their test scores.^{79,84,106,118} Approximately 20 participants are recommended for test-re test reliability and known groups validation assessment.¹¹⁹ To assess known groups validation of the survey, 15 breast experts aged 33.0 ± 6.4 years (12 females and 3 males) and 18 adolescent girls aged 13.1 ± 1.1 (range 11 to 14 years) completed the 39-item breast survey online. All the breast experts were White. Of the 18 adolescent girls, 83.3% were White, 11.1% were Mixed/multiple ethnic groups, and 5.6% were Asian/Asian British. An independent-samples t-test revealed that experts mean overall breast knowledge score (3.83 ± 0.13) was significantly higher than schoolgirls mean breast knowledge score (3.23 ± 0.20), ($t_{(31)} = 9.804, p < 0.05, d = 3.42$).

Experts mean overall attitudes towards breasts and breast issues score (3.59 ± 0.25) was also significantly higher than schoolgirls mean attitude towards breasts and breast issues score (2.71 ± 0.56), ($t_{(25)} = 5.805$, $p < 0.05$, $d = 1.88$). In addition to comparing means for the overall breast knowledge and attitude scores, the experts and schoolgirls mean scores for all survey 10 subscales were also computed and compared using the independent-samples t-test. Experts mean scores were significantly higher than the schoolgirls on all subscales ($p < 0.05$). The above results confirmed that the breast survey met the criterion for construct validity.

Phase 4: Reliability Assessment

Internal reliability analysis

Internal reliability is concerned with the interrelatedness of a set of items and how well a test measures one concept.^{79,108,120} All items within a scale should correlate well with each other, and items are considered sufficiently reliable when the reliability values are ≥ 0.7 .^{47,103} Internal reliability is often assessed with Cronbach's alpha, however this test has been heavily criticized^{120–123} and it is suggested that there are better alternatives to Cronbach's alpha such as McDonald Omega and Greatest Lower Bound (GLB). The GLB has been recommended as the highest possible lower bound and the only one resulting in a realistic value.^{122,123} The remaining 39 items of the breast survey were analyzed for internal reliability with the data from 729 schoolgirls recruited for the exploratory factor analysis stage, as well as the data from 981 schoolgirls recruited for the confirmatory factor analysis stage. The entire survey produced a GLB of 0.812 and 0.834 respectively which is considered as acceptable^{122,124} and identified that the 39-item survey has sufficient internal reliability.

Test-retest reliability

Test-retest reliability evaluates the stability of a measure over time, which allows researchers to evaluate if similar results are generated under the same methodological conditions, but at different time intervals.^{84,102,125} The 18 adolescent girls who participated in the known groups validation stage completed the breast survey a second time (14 ± 2 days after the first completion) to allow assessment of test-retest reliability. The period of two weeks was considered long enough for the participants to have forgotten their responses, but not too long for a real change to occur in their knowledge or attitudes towards their breasts.^{48,108,126–128}

Published research often uses correlations (e.g. Pearson's correlation coefficients) for evaluating test-retest reliability.¹²⁹ Nevertheless, correlations are not an appropriate method for establishing test-retest reliability because association and agreement are not synonymous concepts.^{129–131} A correlation coefficient assesses the strength of relationship between two variables; it quantifies how strong the tendency is for one variable to increase (or decrease) as the other increases. In contrast, agreement means two measurement are the same (e.g. the actual numeric/categorical results produced by two methods/time match). Accordingly, perfect association does not result in perfect agreement. Weighted Kappa coefficient is a recommended method to establish agreement for ordinal data because it considers the degree of disagreement between two raters or times.^{129,130,132} Test-retest reliability of the breast survey was assessed using Weighted Kappa with Quadratic weights.¹³³ There was a statistically significant agreement between the two responses of the breast knowledge and attitudes to breasts and breast issues for all 39 survey items ($p < 0.05$). The strength of agreement was classified as good to very good according to Landis and Koch (1977) with values ranging from 0.61 to > 0.91 ,¹³⁴ thus establishing the test-retest reliability of the breast survey.

* Figure 2 near here*

Discussion

Previous breast education studies have mostly focused only on knowledge, awareness and attitudes to breast self-examination and breast cancer in adolescent populations.^{40,41,45,46,135} No studies have attempted to educate adolescent girls about other topics such as bra fit and appropriate breast support. Previous breast education studies have not used validated tools to evaluate the impact of their breast education programs. To address these gaps in the literature, the present study used a rigorous, multi-step process to develop and evaluate the validity and reliability of a breast survey. This was the first study to develop an evaluation tool that evaluates not only adolescents' knowledge in multiple aspects related to breasts but also evaluates attitudes to breasts and breast issues and the likelihood of engagement with positive breast habits (Appendix 1).

The breast survey was developed and validated based on the specific recommendations on survey development for adolescents.^{59–61,95} The results of the study support the validity and reliability of the 39-item breast survey. The developmentally appropriate breast survey assesses breast knowledge, attitudes to breasts and breast issues, and the likelihood of engagement with positive breast habits in adolescent girls. The survey includes 10 subscales that assess the knowledge of “breast variation and bra fitting”, “breast anatomy and breast pain”, “breast bounce and breast sag”, “sports bras”, “breast awareness”, “attitudes to breasts and breast issues” and “positive breast habits”.

Each subscale within the survey addresses a specific breast concern which is consistent with the breast needs of adolescent girls and is of great importance to them.^{2,3,29} As presented in Figure 1 and Table 1, five items measure the subscale labeled “breast variation and correct bra fit”. This subscale reflects on adolescents' knowledge on various breast sizes, shapes, breast changes during the menstrual cycle and their understanding on criteria for choosing a

well-fitted bra. Knowledge of breast sizes and shapes have implications for choosing a well-fitted bra, particularly because the size, shape, and position of breasts change throughout the menstrual cycle and throughout life.¹³⁶ A further subscale labeled “incorrect bra fit” consists of two items that assess the knowledge of adolescent girls with regard to incorrect bra fit criteria. Three items are used to capture adolescent girls’ knowledge regarding bra purchasing criteria, for example trying on a bra before making a purchase.

The subscale on breast anatomy and breast pain consists of five items that evaluate adolescent girls’ knowledge on what breasts are made of including changes of breasts during pregnancy as well as breast pain. Three items in a further subscale measure the knowledge of adolescent girls on breast bounce and breast sag, which highlight the possible link between breast bounce and breast sag.^{10,13,17} The sports bra subscale consisted of three items that assess whether girls know about the importance of wearing a sports bra, and its potential impact on reducing breast bounce and breast pain.¹⁷

Breast awareness subscale consists of seven items and evaluates the knowledge of adolescent girls on breast cancer and the importance of early detection, and whether they know what being breast aware means. In addition, two items within a further subscale measure signs of breast cancer. Attitudes to breasts subscale consists of five times that capture adolescent girls’ feelings towards their breasts and the impact of breasts on their sports participation. In a separate subscale, four items measure the likelihood for adolescent girls to practice positive breast habits such as wearing a sports bra or checking their breasts.

As shown in Figure 1, overall scores are composited for conceptually relevant subscales using “meaningful grouping” approach.¹¹⁷ Researchers and health educators can use the subscales separately or can combine them as presented in Figure 1 depending on their own specific research questions and needs. Conducting some preliminary analysis (e.g. reliability

analysis) is recommended to check if combining specific subscales is appropriate and performs well enough.^{47,48}

Limitations

Although a convenience sampling strategy was used, which limits the generalization of the study, the study has very large sample sizes and participants from diverse ethnic backgrounds which makes it easier to assess the representativeness of the sample and to generalize the results.¹³⁷ The survey items were generated based on the breast concerns reported by adolescent girls in previous studies, however, these may not cover all girls' breast concerns. Although the survey can be used to evaluate adolescent girls' knowledge about different aspects related to breasts (e.g. breast awareness, bra fit, and breast anatomy), their attitudes towards breasts and breast issues and the likelihood of engagement with positive breast habits, it might not be suitable for evaluation of all types of breast education programs due to content differences.

Translation to health education practice

This paper produced a valid and reliable breast survey to measure multiple aspects of breast knowledge, attitudes to breasts and breast issues and the likelihood of engagement with positive breast habits in adolescent girls. Of the 10 subscales of the 39-item breast survey, eight subscales measure knowledge in multiple aspects related to breasts and two subscales measure attitudes to breasts and the likelihood of engagement with positive breast habits. Researchers and health educators can use the whole survey or certain subscales depending on their needs as presented in Figure 1. Assessing adolescent girls' breast knowledge, attitudes to breasts and the likelihood of engagement with positive breast habits will help to inform the design of appropriate breast education programs to address specific needs and concerns. With further testing in older populations this survey could potentially be used in other groups.

Impact or outcome evaluation is essential to assess the effectiveness of any education program.^{30,138} To ensure that programs achieve their purpose, it is essential to use an appropriate evaluation tool.^{53,54} Utilizing high quality evaluation tools results in a more robust evaluation and greater confidence in the findings.⁵³ Therefore, if breast education programs are designed to address adolescent girls' breast concerns and improve their breast knowledge, attitudes to breasts and breast issues, and practice of positive breast habits, the developmentally appropriate breast survey may also offer a means to determine the impact and success of such programs.

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* Appendix 1 near here*

In Press

Table 1. Rotated factor loadings of the breast survey

Items	Rotated Component Coefficients									
	1	2	3	4	5	6	7	8	9	10
Item 30	0.811									
Item 33	0.804									
Item 31	0.776									
Item 34	0.764									
Item 27		0.674								
Item 26		0.673								
Item 29		0.639								
Item 25		0.566								
Item 24		0.426								
Item 21		0.312								
Item 6			0.576							
Item 5			0.465							
Item 8			0.446							
Item 3			0.383							
Item 13				0.675						
Item 15				0.656						
Item 37				0.422						
Item 39					0.592					
Item 35					0.566					
Item 36					0.552					
Item 38					0.388					
Item 11						0.715				
Item 10						0.557				
Item 7						0.368				
Item 2							0.548			
Item 16							0.547			
Item 1							0.504			
Item 17							0.456			
Item 20							0.422			
Item 19							0.747			
Item 18							0.618			
Item 12								0.691		
Item 9								0.536		
Item 14								0.450		
Item 24									0.718	
Item 28									0.693	

*Negatively worded items

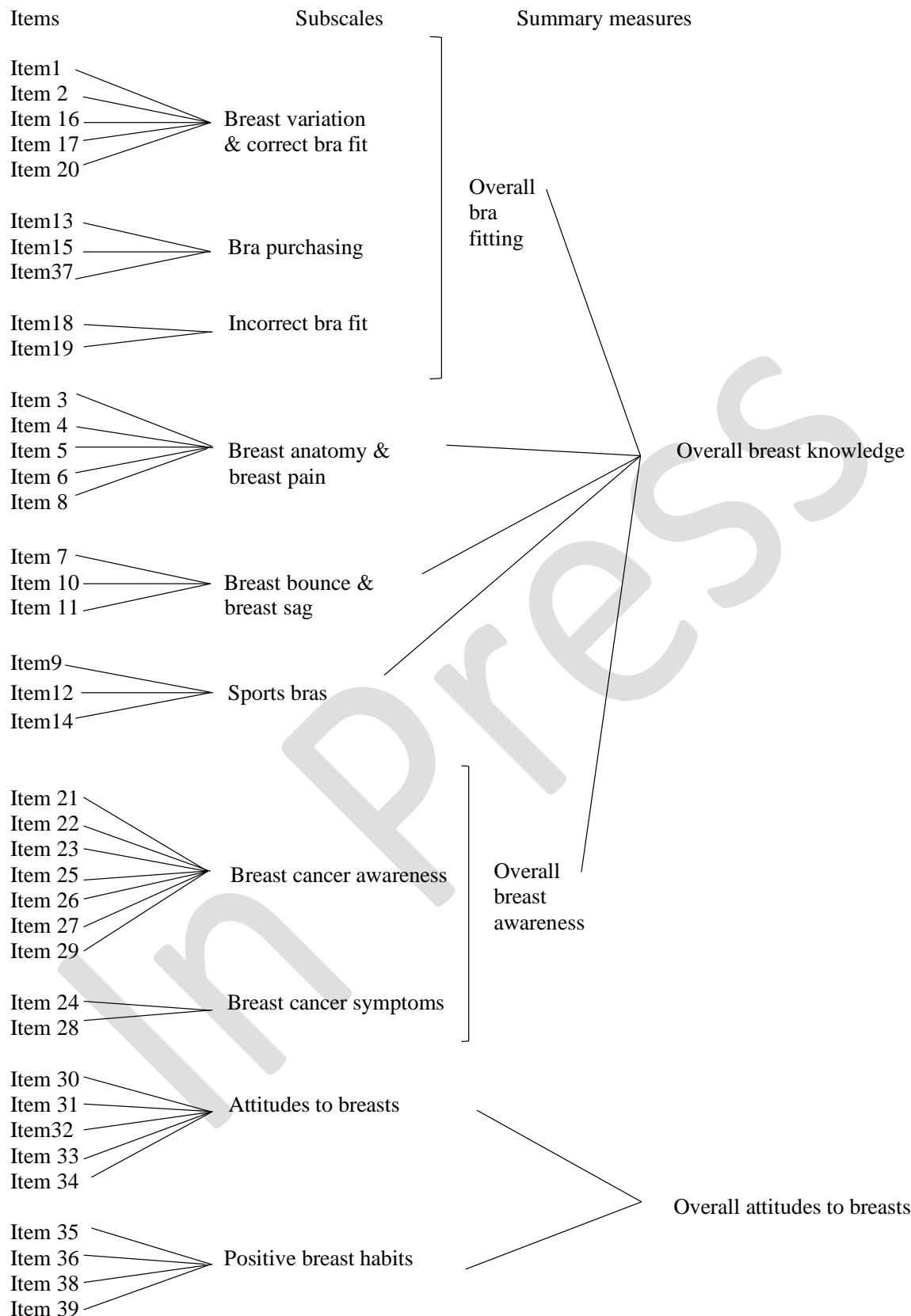


Figure 1. Final breast survey items ($n = 39$), subscales ($n = 10$) and summary measures. The subscales are collapsed into an overall knowledge, overall attitudes, overall bra fitting, and overall breast awareness scores

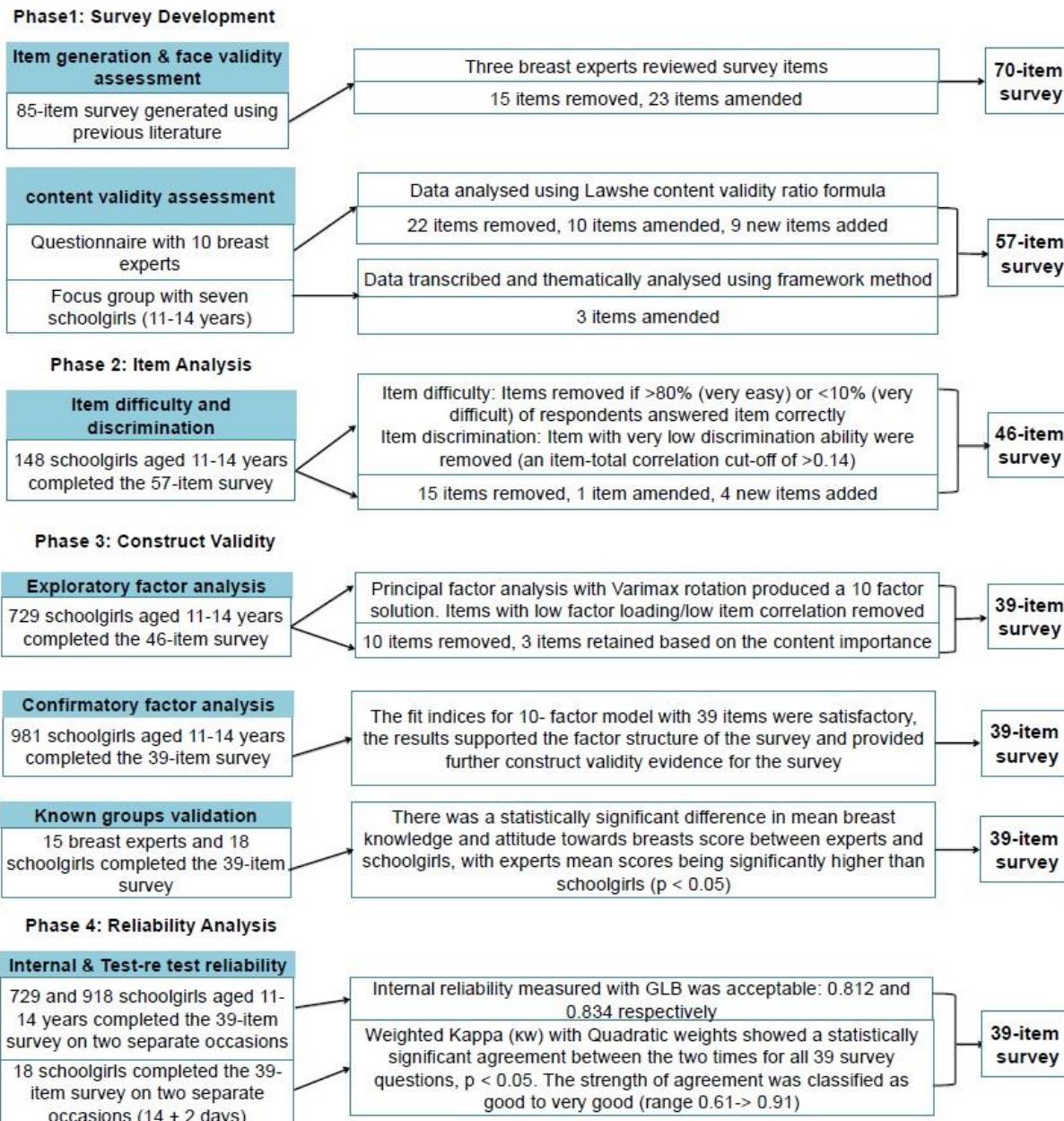


Figure 2. Steps followed during phase 1 (survey development), phase 2 (item analysis), phase 3 (construct validity assessment) and phase 4 (reliability assessment) of the breast survey development

Breast survey items (n:39):

1. The size and/or shape of left and right breasts are rarely the same.
 2. Breast size and/or shape can change throughout the menstrual cycle.
 3. Breasts contain fat, milk ducts and ligaments.
 4. There is no muscle in the breasts.
 5. During pregnancy breasts may become bigger and lumpy.
 6. Breast pain may be caused by breast bounce.
 7. Breast bounce can lead to breast sag.
 8. Girls with small breasts and girls with large breasts can get breast pain.
 9. Wearing a sports bra when exercising can help reduce breast pain.
 10. Breast bounce can be prevented.
 11. Breast sag can be delayed.
 12. The best way to reduce breast bounce is by wearing a sports bra.
 13. A bra needs to fit well to provide enough support.
 14. Only girls with big breasts need to wear sports bras*.
 15. It is important to try on a bra before buying it.
 16. Breast tissue should not bulge out the top of the bra cup.
 17. When wearing a bra the under-band should be level at the front and back.
 18. Bra underwire should sit on breast tissue*.
 19. In a well fitted bra the under-band should be tight and the cup loose*.
 20. In a well fitted bra the under-band should be firm and the breasts should fill the cups.
 21. All women can get breast cancer.
 22. Breast lumps do not always mean breast cancer.
 23. If breast cancer is detected early, the chances of recovery are better.
 24. Having discharge from one or both nipples may be a sign of breast cancer.
 25. Being breast aware can help to detect breast cancer at an early stage.
 26. Every girl needs to know how her breasts look and feel normally.
 27. By being breast aware any unusual changes in breasts may be noticed immediately.
 28. A change in the size and/or shape of a breast may be a sign of breast cancer.
 29. All girls should check their breasts regularly, regardless of breast size.
 30. I am embarrassed by my breasts*.
 31. I feel good about my breasts.
 32. I sometimes avoid physical activity because of my breasts*.
 33. I wish my breasts looked different*.
 34. I am happy with the shape and size of my breasts.
 35. I have recently checked my breasts.
 36. I always wear a sports bra when exercising.
 37. If I were to buy a bra, I would definitely have my bra fitted in a shop by a professional.
 38. If I had any breast concerns, I would feel comfortable to talk to someone about them.
 39. I know how to check that my bra fits correctly.
- (*negatively worded item)