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Author (s):	Shagufta Riaz[1], Sharjeel Abid[1], and Muhammad Tauseef Khawar[2]
Affiliation (s):	[1]Department of Textile Engineering, School of Engineering and Technology, National Textile University, Faisalabad, Pakistan. [2]Department of Clothing, School of Engineering and Technology, National Textile University, Faisalabad, Pakistan.
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A Review on Innovative Design and Development of Women's Intimate Apparel

Shagufta Riaz[1], Sharjeel Abid[1], Muhammad Tauseef Khawar[2*]

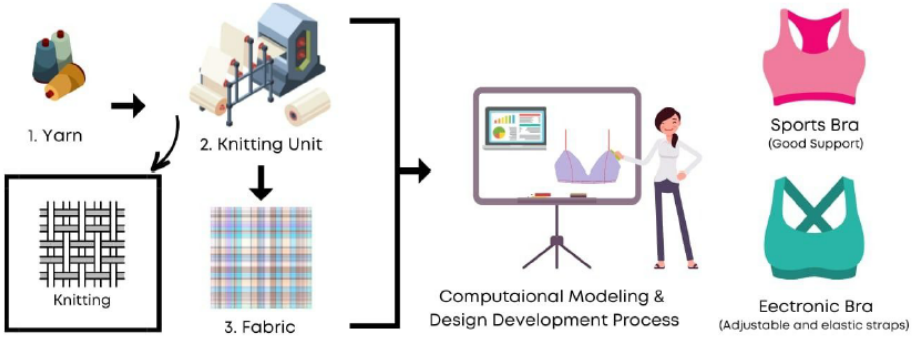
[1]Department of Textile Engineering, School of Engineering and Technology, National Textile University, Faisalabad, Pakistan
[2]Department of Clothing, School of Engineering and Technology, National Textile University, Faisalabad, Pakistan

ABSTRACT Women's insight into the quality of life has become much clearer now. They are now aware of their health, and overall perceptions of life. Women wear various intimate garments like corsets, panties, pantyhose, bras, and girdles. This overview highlights the lack of comprehensive research about different attributes, characteristics, development procedures, challenges faced by the wearer, and advancements in women's intimate apparel. Mostly, the bras are selected based on bra cup size & shape, elastic bands, the material used for construction, aesthetics, different hooks & eyes, and functionality and sustainability aspects. Different novel developing techniques, new stitching, and seamless methods are reshaping intimate garments. The market share for smart robotics, or intimate garments with a specific function is elevating with time. Various categories of intimate apparel have been utilized as necessities and amenities. There is a massive technological transformation in the intimate garment section. Day-by-day changing demands of women and evolving mindsets caused textile and apparel researchers to focus on aesthetics, functionality, comfort, quality, body fit, design, and style. Therefore, the technological advancements in terms of developing techniques, different components, and construction patterns have been described in detail. Furthermore, the attributes associated with aesthetics and functionality are also elaborated upon.

INDEX TERMS bra, comfort, developments, functionality, intimate

*Corresponding Author: tauseef0822@gmail.com

GRAPHICAL ABSTRACT



I. INTRODUCTION

Intimate garments primarily provide comfort as well as microenvironment health to people as they directly contact the skin. As compared to outwear apparels, the need for comfort as well as antibacterial levels of performance and criteria of intimate outfits is comparatively more rigid. Therefore, for intimate fabrics healthy textiles have got significant attention in the research field. Subsequently, psychological and bodily tendencies of the users are also affected by the level of comfort and ease, the succeeding relating elements such as bending ability, permeability of air, surface friction, permeability of moisture and hydrophilic character are also an important concern [1]. Due to the use of improper fit bras and associated harmful synthetic material base, most common issues related to skin are chest acne, reddish cacked itchy rash, perspiration, and allergic reactions which are the main causes of discomfort [2]. Currently, customers prefer comfortably fit and personalized clothing according to their physique. Also, seamless attires are preferable choice for women because they are as comfortable as second skin, without leaving unpleasant scars or marks. Furthermore, they are comparatively more comfortable and provide better comfy fitting through removing stitches as well as seams. Its distinctive set of appealing attributes of silhouette give several designs to manufacture soft, natural as well as light and sleek body impression [3].

Comfort element of intimate fabrics is more important because of direct contact with skin as compared to outwear apparels. There are different types of intimate apparels for women such as well-designed panties, bra, corset,

stockings, camisole, and girdle. If we talk about men's intimate apparels, they are comparatively simple in design. Even though men intimate apparels have become functional and more fashionable, the items are continuously targeted on socks, underpants and undershirts solely [4]. Common fabrics that are used to manufacture intimate fabrics are spandex, cotton, polyester, silk, nylon, and rayon. Nevertheless, new kinds of manufacturing fibers provide new alternatives to intimate garment's designers. Important features that are of prime importance are sustainability, adaptability and performance, cold sensation, and moisture control. Yarns and fibers which have these features are discussed in the next sections. The properties of intimate fabrics are of prime importance such as durability, antiodour, antibacterial, comfort and ease, freedom of movement, lightweight and easy handling. Important fiber suppliers, for instance Lenzing, Nylstar, Toray and Invista have introduced various kinds of fibers which are functional and ideal for use in intimate clothing [5].

The production of perspiration as well as external humidity dampens the outfits and may increase weight of the garment along with stickiness between body and the apparel, therefore leading to sensorial irritation along with a sticky sensation. Sticky sensation, concerning surface tension as well as friction of water, at the interface of skin and fabric is generally related to the assumption of clamminess and clinginess (a sense of irritation). This explains the adhesion between two types of surfaces, for instance, a damp fabric in contact with the skin. Skin and fabric friction is a prevalent element which affects the sensorial ease and comfort of the person wearing them [6]. When moisture levels are increased, skin becomes soft; this will increase the friction and contact area coefficients between skin area and fabric [7]–[9]. Additionally, liquid connections may be produced between interacting areas, raising the friction along with adhesion. Gwosdow *et al*. observed that increase in skin dampness is linked to increased skin and fabric friction as well as discomfort feeling. When the shear pressure and contact force is higher for extensive period of time, it may cause different types of dermatological issues that include abrasion, irritation along with other types of skin injuries [10], such as decubitus [11], [12] or even blisters that are formed due to friction [13].

The breasts have no muscular tissues and bone fragments that implies that there exists very little bodily support. Consequently, extreme activity at the time of physical exercises may result in discomfort, soreness, ache as well

as injuries and sagging skin [14]. The brassiere had been probably the most marketed intimate product of the 1950s. At that time, the prominent designs were cone shaped and the preferred color was pink [15].

Bra or brassiere pattern goes through an extended procedure of manufacturing process which includes several key elements like selection of material, design creation as well as grading. The pattern and manufacturing procedures are very complicated, which comprise of numerous design engineering phases, sophisticated techniques as well as and several trial runs [16]. The brassiere is by far the closest fitted apparel used by women of all ages. It is made to provide support to the very soft tissue of the upper part of female body. The outfit is designed to precisely conform to the contours of the human body.. Furthermore, these specifications of the clothing should ensure both comfort and aesthetic appeal.. Simultaneously, to accommodate for the change in shape and size within the female population, the industrial item must fulfill these challenging standards across a wide range of dimensions. It was obvious that the style and design procedure depends greatly on the experience of the creative designers and requires an excessive degree of knowledge. Several essential areas of the procedure were determined: material choice, design development along with grading. All these and additional subjects created the framework of a study of skilled and creative designers [17].

Nevertheless, pain, discomfort and even injuries can be cured by donning sports brassieres, which are usually made to handle increased breast movements and minimize breasts ache at the time of strenuous exercises. Sports brassieres have 3 significant features: managing increased breast movements, controlling temperature, dampness as well as supplying support [18]. Healthcare items, sportswear and intimate garments are undoubtedly utilized under wet conditions. The choice of garments stuff is certainly essential to make sure workout overall performance, wear ease and comfort and textiles that reduce stickiness discomfort appear to be a suitable option. Objective options, for example water absorbent capacity, friction between fabric and skin along with surface roughness are not actually good indicators for stickiness discomfort simply because numerous other factors also cause due to which this uncomfortable sensation occurs. That is why, it is to this particular sensation, and it is actually complicated to separate all the related variables mainly because of the interaction causes [19]. Hence,

an effectively designed bra must apply sufficient contact force to restrict the movements of breast without creating distress to the individual [20].

Fitting issues are much more visible in bras because of their intimate interaction with surface of the body as well as sophisticated construction. The bra makes direct skin contact. Improper bra force leads to uncomfortable tactile feelings causing itching or discomfort. Because of the bodily and emotional changes, a result of post-menopause, older females may possibly encounter trouble in wearing the bra and modifying small fasteners, brassieres fitting issues, insufficient support, pain while doing physical activities, severe force as well as psychological troubles [21].

The present study is aimed at the development of intimate garments according to different assessment standards which deals with bodily and psychological parameters. These parameters include type of fabric, size, design, shape, antibacterial, aesthetics, colors and dying as well as fabric processing standards. This study will elaborate all requirements and assessment parameters for intimate garments for all ages of women and men. The present study has also highlighted the common problems of intimate garments and suggested the improvement of designs for both genders.

A. PROPERTIES AND PARTS OF BRA

Bra is probably the womanliest necessary clothing which is needed to fulfill the aesthetic requirements and physical health as well as ease and comfort of the wearer. Usually, athletics activities add huge pressure on tissues surrounding the breasts. A fine bra provides the ideal support and proper protection against injury in breasts. Most females use bra between ten and twelve hours each day in their lifetime. Configuration of bra is shown in Figure 1. Consequently, it is essential to pick and use a bra which provides good fitting with keeping in mind the parameters of comfort and support [22].

FIGURE 1. Basic bra front, back, and side view

B. FITTING

Bra requires a sophisticated manufacturing, a small part of clothing that can provide protection along with support and deal with all shapes, sizes as well as breast weight [23]. The women having large breasts must contemplate that they must use a bra well suited for their attire

ensuring there is no overflow from the cup. While color may not be a primary concern, it is important to note that many aesthetically pleasing bras often sacrifice comfort.

[24]. The fitting is a deciding element for apparel purchase in the United States of America as well as in other countries [25]. The biggest challenge women face is looking for a best fitted bra that considering comfort while shaping the physical structure into the desired silhouette [26].

C. WIRE TYPE

These are generally manufactured from plastic layer, metallic element, and wire gauge. If we talk about large size bra, the wire must be twofold resistant to provide the proper support [27]. The property of a wired bra is that it must lie on the chest without moving, pressing, or hugging the soft tissues. The breast measurement includes projected measurement as well as diameter; the projected measurement includes the length from the chest wall to breast tissue which protrudes. In the bra, the breasts measurement is initially determined by the manufacturer and design of different waist size. For instance, different shapes are pre-classified based on the cup size. Company of bras utilize the exact same wire measurement to 36 B, 34C, 32D and 30DD. Almost all types of sizes have the exact same size along

with the cup of the very same volume. These have various breast projections related to the waist size [28].

D. CENTER GORE

Also referred to as middle front or even bridge, it features an enormous significance if we talk about support. The firmness and protection provided by the front side of the bra is referred to as center gore. The center gore size can modify by bra designing as well as the requirement for protection. Generally, the center gore increases in height, and the spacing between the cups should be reduced based on the expansion of the cup size [28].

E. UNDERBAND

The underband is generally known as foundation of the brassieres, extending from the mid-side to the front.. This part of the bra is normally developed to support approximately 80% of the breast.. The underband part of the bra is specifically engineered to provide upper support. Some bras may lack a waistband and feature floating cups, with the waistband and center gore not being joined. This kind of design and style provides considerably more lightness but undoubtedly affects the support particularly for larger bras. For large size bra, it is recommended to utilize powernet as well as twenty percent elastane along with lining for the wings. The quantity of elastane will significantly increase the ease and protection for large size breasts. However, this property can be enhanced when the bone is positioned on the side fitting seams of the bra [24].

From the perspective of comfort, it is essential to recognize the close relationship between mechanical parameters and overall comfort. Because there are physical variables which are a measure of fine ergonomics of the apparel design, the two are directly associated with ways of cutting, stitching, modeling, along with anthropometric statistical tables applied for this function. Exceptional functionality is usually associated with the application of ideal components for this objective. Also, for intimate garments the measurement of the physique has to be evaluated to ensure that the item utilized is probably the most suitable for these types of wearing [29].

II. BIO-MECHANICAL AND PHYSICAL BACKGROUND

A. BIO-MECHANICAL CHARACTERISTICS OF BREAST

The breast is composed of various parts and structures, each serving a unique function. About a third of the breast is made up of fatty tissues. The rest of the breast part is made of other structural parts named lobules and ducts. Lobules and fats have empty spaces between them which are filled by fat tissues. In the breast, there are no muscles; however, muscles are present just beneath each breast which protects the rib. Lymphatic system exists in breasts and with the help of blood vessels and lymphatic vessels fluid goes into lymph nodes. During pregnancy, the volume of breasts increases, and usually weighs somewhere between 0.4 - 0.6 kg, specifically during lactation period. Very fragile stretching filaments present in the breasts provide support. The secondary support is provided by the outer layer of the skin [22].

During strenuous activities, breasts collide with foot strikes made and these kinds of repetitive activities cause permanent damage to breasts such as irreversible stretching of the breast skin along with sagging. This happens when stretching ligaments work continuously, ultimately causing breast sagging. Increased motion of breasts is the most prevalent trigger of uncomfortable movement during exercise, physical activity, or workout. Since breasts lack internal anatomical bio-mechanical support, they require external support. External support provides compression (thus restricting movement of stretching fibers) and weight support depends on personal requirement as well as shape [30].

B. MECHANICAL CHARACTERISTICS OF BRA

The most crucial element influencing comfort and performance of a brassiere is a good structure of 3-dimensional (3D) bra. It is the distribution that should be considered while manufacturing a good functional bra. For instance, the anterior straps of the bra must be placed in a way that they make a straight line in alignment with the nipples and create a pull. The front straps should provide support to breasts in the vertical direction. To prevent the straps from causing irritation to shoulders, the fabric of the strap must be broad enough for increased pressure distribution. Moreover, to steer clear of irritation underwires, fasteners and hooks must be covered. A good functional bra does not irritate ribcage area or the armholes. Hence, all these elements must be considered in the making of a good bra. Dynamic contact

can be made through contact in between bra and the breast skin [31]. Another essential element which influences the performance criteria for the support is the fabric stretch. The movements of the upper torso are directly related to the elasticity factor which in turn prevents the breast movement. Like vertical support, horizontal support should also be maintained and the most crucial factor that affects horizontal support is the elasticity of the fabric. The fabric must be elastic enough to permit the expansion of breasts during breathing. Conversely, the movement in the vertical direction should be minimum by limiting the elasticity factor in that direction. That means the vertical movements are restricted through limiting the stretching ability of the straps.

The force from the bra on the surface of the skin is generated by the frictional slippage as well as the stretch of the fabric at multiple directions. The mechanical attributes of the fabric are concerned with the efficient elastic recovery as well as the smaller tensile modules. These mechanical characteristics are geometric non-linearity and material linearity.

III. ANATOMY OF BREASTS

Even though the shape and size of women breasts differ from person to person but almost all breasts are generally tear shaped. Just about 2/3rd of the breast is made up of breast tissue, and the remainder is comprised of fat tissues called superficial fascia, that is actually changes when a woman puts on or loses body weight [31], [32]. Breast displacement related to workout is actually hard to reduce because of minimum natural breast support [33]. The sole muscle which lies in the breast area is actually glandular structure [34]. For that reason, the support of breast is based mostly on weak suspensory structures called Cooper's ligaments. Calling these fibers as ligaments is actually inaccurate, because they are certainly ligaments which connect muscles with bone and support joint parts, they are commonly called fascial planes which are mainly meant to separate the glandular structures of the breast into lobules and during lactation these ducts empty into the nipple [35]. Skin is actually an elastic and thin cover which provides secondary support to the breast [36]. A nonlactating female breast and anterior thoracic wall is shown in Figure 2.

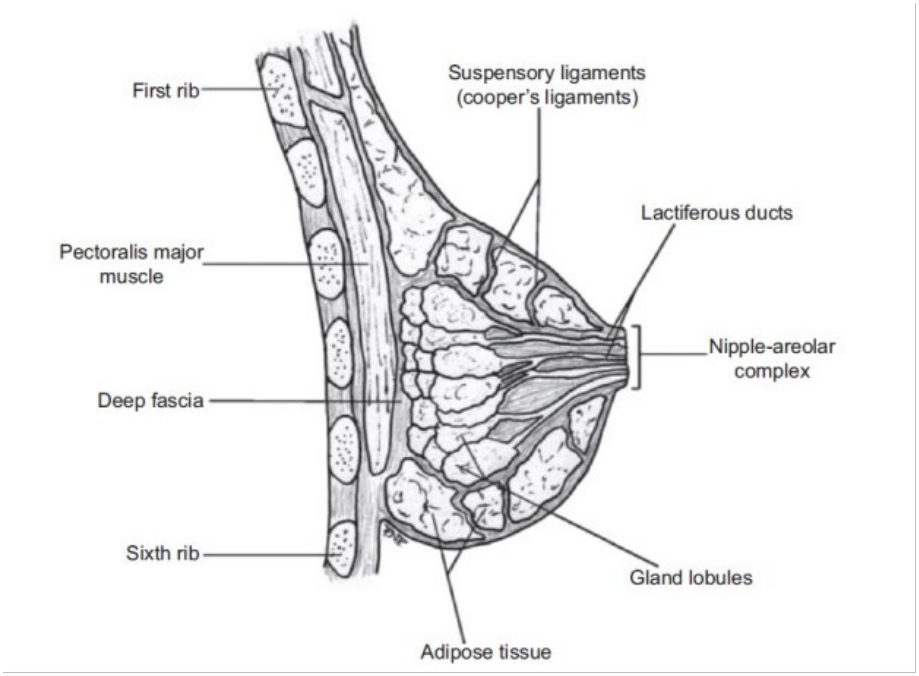


FIGURE 2. Diagram of a non-lactating female breast and anterior thoracic wall [37]

IV. NEW PRODUCT IDEA OR DESIGN DEVELOPMENT PROCESS

During the new product idea or design development process, a statistical based analysis called conjoint analysis can help indicate the ideal product development. Individuals make their assessments on the mix of various product properties to select products which hold the greatest advantage. In this structural framework, the producer is required to be able to create progressive recommendations and use those suggestions practically in the minimum time. The utilization of conjoint research also can disclose the benefits and probably the best product arrangement for customers to find each feature of brassiere goods, which consequently can act as an essential reference point for the style and design of innovative products. As demonstrated, specific knowledge regarding the research and development processes is required [38]. Hence, production of entirely new items is dependent on communication process. If consumers' demands and preferences are considered by manufacturers and then incorporate those ideas with the modern designs of professional creative designers, then new

products can be made with significantly increased utility. This can help consumers, designers, and manufacturers with the issue of inconsistent recognition [35].

V. BRASSIERE PRODUCT ATTRIBUTES AND EVALUATIVE CRITERIA

When buyers purchase products, they contemplate about extrinsic as well as intrinsic attributes of the product. Intrinsic characteristics are those which change the physical properties of the product when an experiment is performed to change them [39]. And extrinsic attributes are those which are not part of the main product [40]. Each of those attributes help buyers to know the difference between purchase objective and observed value [33]. Furthermore, these attributes ought to be modified into the model for creative designers. During this period, customers evaluate products on different characteristics, with regards to the things they contemplate most significantly, and the product qualities which have an impact on the identification of codesign. Intrinsic attributes consist of physical features (such as shoulder strap, color and lining), tactile properties (such as warmth, fabric softness and silkiness) along with functional components (e.g. comfort, durability and increased cleavage); the extrinsic attributes involve name of brand and cost discovered 12 attributes which are directly related with the consumers' choices towards outfits [41]. These twelve attributes are choice of styles, fitting, occasion specific, ease of care, brand specificity, economical cost, fashionableness, comfort, attractiveness, quality and color [33].

VI. EFFECTS OF POOR BRA DESIGN

A. BRA SUPPORT

Among the list of different kinds and range of bra elements, straps are most important to provide support to breasts. Nevertheless, bra wearers make complaints related to the fitting requirements of straps. It may cause discomfort when the straps drop off an individual's shoulder or become loosened. Nevertheless, an extra tight shoulder strap may trigger headaches and cause severe nerve injury [42]. In case a strap is too tight it causes disfigurement of the shoulder as well as discomfort by digging into shoulders. This also induces pressure on the nerve i.e. cervical nerves and also disturbs venous and arterial drainage [43].

By taking health concerns into account, a sports bra is manufactured in a way to restrict the increased mobility of the breasts and restricted movement feature is essential for women who are into sports or have large breasts. While doing strenuous workout, increased bouncing pressure on the breasts causes harm in several ways such as sagging [44]. Not having sufficient support from the brassieres may cause breasts to appear appalling. Additionally, bra wearers might feel pain and can have the occasional injuries because of stretching out of ligaments as well as the soft tissue [45].

When it comes to a strapless bra, the support greatly depends on the underband and underwires. However, unpleasant discomfort may occur in case hard underwires are utilized for support [45]. Furthermore rashes, pain, itching and breathlessness may also happen due to tight and wide rubber spots which are generally non-breathable. The reason is that the pressure from straps is entirely shifted to elastic band in strapless bra which results in injury of lymph nodes [45].

B. BRA CUPS

Bra cups are often made from several cut and sewed elements to give a framework that fits the wearer's breasts properly. Many users, however, are uneasy because they cause injury to their skin. According to a survey, conducted on 400 female athletes revealed that the seam across the nipple area causes the most skin irritation and bruising. The irritation can be produced by several factors such as protuberances, seam edges of stitches in as well as binding in particular bra designs. If the seams are big and bulky, or if the seam is overlocked by pesky threads, the problems will likely be far more severe.

The 3-dimensional (3D) form of a bra cup can be developed using a variety of techniques such as molding, seaming, structured knitting, darting, gathering, and pleating. Sophisticated pattern design, mold design and knit gauging is needed to support the 3-dimensional (3D) curvature of a female's body. Or else, the body form will not fit within the cup, and the sides may protrude. The curved form of bra cup sides is required to be close fitting and during designing a bra cup pattern, designers should think about how the bra cup curve would fit [45].

C. TYPES OF MOLD CUP MATERIAL

The materials [46], [47] used in the mold cup generally include urethane sponge, woven fabric, and punctured sponge. To bond fabric to sponge,

various functional materials are used. The urethane sponge mold has excellent shape stability, can be formed in a wide range of thicknesses and shapes, and is not costly; therefore, it is often used. However, it has poor breathability and can cling to the skin and be uncomfortable. To compensate, the woven bra cup is often used in summer due to its good breathability. However, its thickness is fixed and cannot be adjusted, and thus, it has low shape stability. Alternatively, the punctured mold cup has good breathability and is flexible, due to the small holes in the sponge. Different types of mold cup types of bras are described in Figure 3.

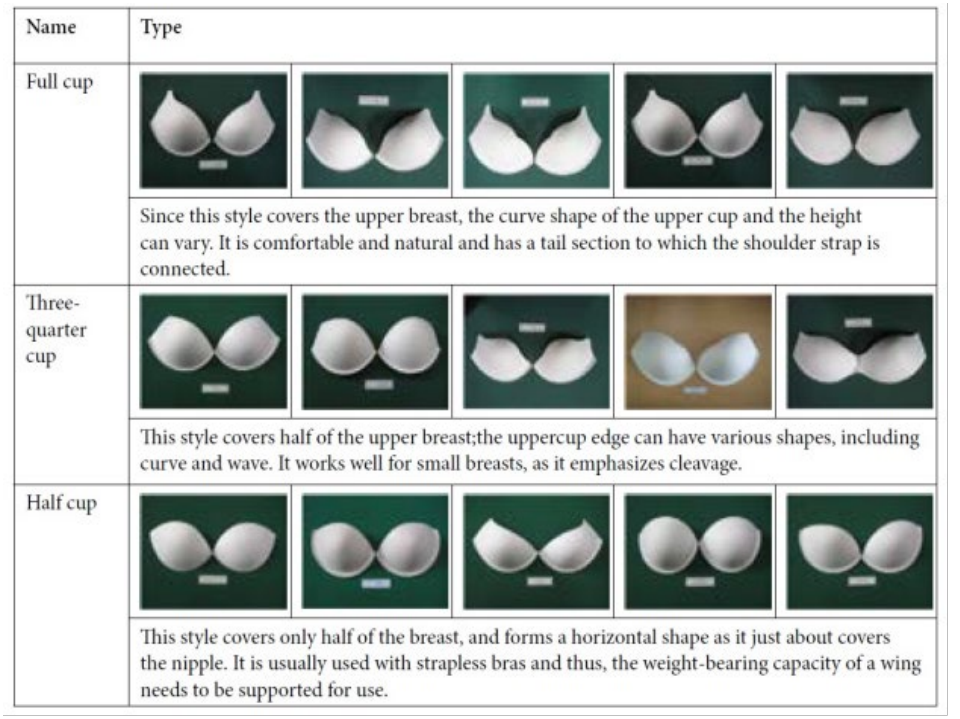
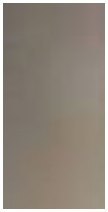
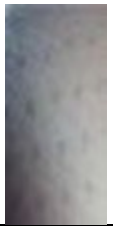


FIGURE 3. Mold cup types and characteristics by cup height [50]

However, it has a weaker shape stability than the sponge mold cup and the range of thickness is limited due to the punctures. To address these disadvantages, our mold cup was developed to reduce the discomfort of the sponge clinging to the skin and to enhance breathability by using embossing embedded mold. Mold cup materials were investigated, and their pros and cons are summarized in Table [46]. Material based advantages and disadvantages of mold cup are explained in Table I.

TABLE I

TYPES, ADVANTAGES, AND DISADVANTAGES ACCORDING TO THE MOLD CUP MATERIAL

Type	Picture	Characteristics	Advantages	Disadvantages
Sponge mold cup		Thermoformed mold by adding the urethane sponge to a mold	The shape stability is excellent. It can be manufactured according to the desired thickness. It is economical.	There is no breathability. It is difficult to absorb sweat. There is humidity within the mold.
Woven cup		Thermoforms by adding sandwich fabric that is woven specifically for better breathing to a mold	It is not thick. It has excellent breathability. It has good shape resilience.	It is difficult to adjust the thickness. The shape stability is weak. It is not suitable for small breasts. It is expensive.
Punctured mold cup		Molds made by bonding interlock fabric to the exterior and interior by puncturing a urethane sponge.	It is densely punctured. The mold cup is flexible and has good breathability. It is comfortable.	The shape stability is weak. It is slightly expensive.

D. BRA UNDERWIRE

Many women prefer the uplifting support which an underwire provides, but they also dislike the rigidity and strain it puts on their bodies. Underwire problems can include wires with the wrong curve diameter and length, as well as irritation from the wire pressing through the fabric or friction on the wearer's body. To avoid stiffness, there are 2 layers of binding material covering the wire. Nevertheless, if the bra is frequently washed, the binding covering, particularly in the bar tack region close to the center front, may become worn out, and the underwire can cause a hole in the fabric, posing a risk to the consumer. Two British ladies perished amid thunder, according to worldwide news reports, because their bra wires were comprised of

metallic components [45]. A comparison of innovative underwire innovations with traditional underwires is shown in Table II.

TABLE II

A COMPARISON OF INNOVATIVE UNDERWIRE INNOVATIONS WITH TRADITIONAL UNDERWIRES (RATING FROM 1 TO MAXIMUM 12345) [5]

Type of Underwire	Silicone	Conventional	Cushioned	3D	Linkage
Main Feature	More flexible, soft, and lightweight	Metal or stiff plastic frame in the form of J	Molded with the foam cup as foam is included	An inclined underwire with a particular inclination angle	It consists of several linking elements that are joined together by a joint
Durability	12	12345	12345	12345	123
Comfort	12345	12	1234	123	123
Support	12	123345	12345	12345	123
Easy to fit	1234	123	12	1234	12

Healthcare has reported that tight brassieres might obstruct the normal working of the lymphatic system as well as result in an accumulation of carcinogenic substances in the restricted areas [48]. According to a research, women with breast cancer used tight bras the majority of the time [51]. Extreme pressure on the under bust can create a barrier for the elimination of toxins from the breast due to incorrect curve diameter and length and thus increasing the risk of breast cancer [45]. Furthermore, wearing a bra, particularly one with underwires, can obstruct normal lymphatic system and cause anoxia (lower than usual oxygen content), which is linked to increased risk of cancer and fibrosis [50].

E. BRA SHAPE AND SIZE

It has been reported that 70% or more of women wear the incorrect bra size. Bras that aren't properly fitted might cause health issues, particularly back difficulties. However, most bras are mass-produced, resulting in a balanced garment scaled by average cup size and bust girth which makes getting a perfect fit difficult. The fact that one's physique may not fit completely inside the so-called norm is ignored in such a building. Commercial bra design does not consider changes in the human body over time or differences in individual forms. Even if two women have the same cup size

and breast girth, a particular bra will not fit them precisely the same. Because women's breast forms, bust distances, and breast muscle distribution vary, a precise fitting bra is essential. After three months of wearing a 'well-fitted' bra each day a week, female breasts may become better developed. Breast distortion is less of an issue, especially for individuals with pendent breasts [51].

F. ELASTIC UNDERBAND

Rib plastic bones and tight elastic bands in bras can irritate the sternum and apply a force directly on a woman's lymphatic system, causing redness, pain, and even breast cancer. Due to insufficient ventilation and sweat, the tight elastic underband might cause oedema or rashes. The vertical wiring, particularly in strapless bras, grips the breasts with support mostly provided by the underband; this may enhance the pressure on the breasts as well as make the underbust uncomfortable [45].

G. HOOKS AND EYES

Because of the hot temperature and inadequate sweating, a Taiwanese hospital reported an increase in instances of skin irritation caused by metal bra hooks and eyes. Back hooks' bulkiness and thickness would cause chafing on the skin. Furthermore, an excessively tight fastening would cause the back side of the bra to ride up [45]. A Comparison between traditional and new hook-and-eye (H&E) tapes is shown in Table III.

TABLE III

COMPARISON BETWEEN TRADITIONAL AND NEW HOOK-AND-EYE (H&E) TAPES (RATING FROM 1 TO MAXIMUM 12345) [52]

Hook and Eye Type	Fastener with magnets	Traditional	Butterfly	Cushioned	Soft edge	Seamless
Main feature	Closure in one step and easy to use	Cost-effective, easy to use and simple	Slim appearance, Metal-free and corrosion-resistant	Padding is made of foam and rubber	Round corners and multi-directional stretch aid in keeping the bra, in place	Comfortable, no skin irritation, External and internal surface is neat and clean, slimmer hook and eye tape, sewing thread is not utilized, no stiffness because the same fabric is

Hook and Eye Type	Fastener with magnets	Traditional	Butterfly	Cushioned	Soft edge	Seamless
						used on the back side
Weight	12345	123	12	1234	12	12
Thickness	12345	1234	12	12345	123	12
Easy to use	12345	123	12	123	123	123
Softness	12	123	123	1234	12345	12

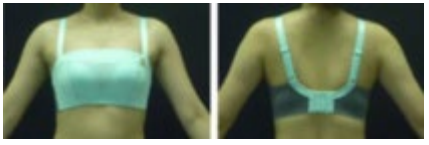
VII. EFFECT OF PRESSURE BRA ON BREAST

Bra is classified into three categories based on pressure criteria. These types are low pressure bra, moderate pressure bras and high-pressure bras. It is the amount of pressure exerted by bra when they are worn. In terms of materials of high-pressure bra, the elastic material is the main component of high-pressure bra. This elastic material is a blend of polyurethane and polyamide while the moderate pressure bra is composed of 5-10% elastic and 90-95% cotton fabric. The composition of low-pressure elastic bra is primarily pure cotton and support in the case of low-pressure bra is provided by the design of the bra. Elaborating on the discussion on high pressure bras, displacement of internal organs, bones distortion and muscle strain are the harmful impacts of wearing a high-pressure bra. The greater is the damage to a female's body if the value of pressure is high. European women from 16th-19th century used to wear high pressure bra made of non-elastic fabric. These high-pressure bras inflicted serious bodily harm and death eventually. Even though several improvements have been made in the current bra design, but the bra-wearing issues are persisting. These can cause diseases of breasts such as spilled liquid, breast hyperplasia as well as breast cancer [53]. Furthermore, Different bra composition and their attributes are elaborated in Table IV.

TABLE IV

DIFFERENT BRA COMPOSITIONS AND THEIR ATTRIBUTES [54]

Sr. #	Percentage of Components	Characteristics	Graphical Illustration
1	(a) Spandex:10% (b) Nylon: 90%	Support: Light Straps: Adjustable and elastic Pads: Inserted	

Sr. #	Percentage of Components	Characteristics	Graphical Illustration
2	(a) Spandex: 21% (b) Nylon: 79%	Cups: Molded Straps: Adjustable and elastic Pads: Air holes in pads	
3	(a) Spandex: 19% (b) Nylon: 38% (c) Polyester: 43%	Cups: Molded Pads: Air holes in pads Racerback	
4	(a) Spandex: 12% (b) Polyester: 88%	Support: Medium Compression: For small size Cups: Molded, for large size Racerback	
5	(a) Lycra: 23% (b) Nylon: 77%	Cups: Molded with wires Straps: Adjustable and elastic Fabric: Double layered Front closure	
6	(a) Spandex: 18% (b) Nylon: 82%	Straps: Adjustable and elastic Fabric: Double layered Cups: with wires	
7	(a) Spandex: 27% (b) Nylon: 73%	Straps: Adjustable and elastic Cups: Molded with wires	
8	(a) Spandex: 18% (b) Polyester: 82%	Support: Light Cups: Molded Fabric: Double layered Racerback	

Sr. #	Percentage of Components	Characteristics	Graphical Illustration
9	(a) Spandex: 20% (b) Polyester: 80%	Support: Light Cups: Molded Racerback	
10	(a) Spandex:10% (b) Nylon: 5% (c) Polyurethane: 10% (d) Polyester: 75%	Support: High Pad: Inserted Racerback	
11	(a) Spandex: 18% (b) Cotton: 24% (c) Nylon: 58%	Support: Light Straps: Adjustable and elastic	

VIII. DISCUSSION

Intimate garments primarily provide comfort as well as microenvironment health to people as they directly contact the skin. Compared to outwear, the need for comfort as well as antibacterial performance and in intimate apparels is comparatively more rigid. Comfort element of intimate fabrics is subsequently more important because of direct contact with skin as compared to outwear apparels. There are different types of intimate apparels for women such as well-designed panties, bra, corset, stockings, camisole, and girdle. If we talk about men's intimate apparels, they are comparatively simple in design. Conventional bra making process is lengthy, starting from choosing the appropriate fabric type, creating a design, and sewing elements because it might take months to obtain a suitable fit for a targeted size. Trial and error process is used by fit technicians to examine the materials, fitness and pattern of the bras which is worn by the model to check the fitting. Fit technicians determine whether the created sample is suitable or how to change the fit. The attributes of the fitting are noted before another bra sample is manufactured. This method is repeated until five or more iterations are completed. This method is expensive and inefficient. It takes years to develop a designer’s expertise to understand the curvature, support, shape and three-dimensional (3D) bra stretch for the lingerie industry’s succession planning. Because the breast sizes vary in three dimensions (3D), commercial bra designs in predefined sizes are only graded up or down depending on the variation in linear (2 dimensional-2D) bust circumferences between two designs and sizes.

The ideas of pattern making, and bra fitting are not generally supported by the scientific theory. Bra fitting is evaluated very subjectively. It is challenging to quantify support, shape, and bra comfort in numerical figures. Since there are no muscles or bones in breasts, the pressure exerted on the breast area by bra cups falls in minimum or no measurement range and is about 0.8 kilo Pascal. Therefore, a good scientific method to address these evaluation concerns might be computer simulation for bra fitting [36].

When selecting intimate garments, several significant attentions come into mind to ensure comfort, style, and performance. Firstly, fitness and fabric are very important; choosing breathable, soft materials that interact the body without irritation can increase the wearing experience. It's also crucial to choose the correct size, as improper fits can lead to discomfort and lack of support. Additionally, personal style should not be ignored while choosing garments, it should reflect individual taste while fulfilling their desired purpose, whether for everyday wear or special occasions. Furthermore, hygiene is another key factor, emphasizing the need for breathable fabrics and regular replacement of worn items. In the end, paying attention to ethical considerations, like choosing sustainably produced items, can really enhance your satisfaction with your choices. This way, your intimate garments become not just a reflection of your personal style, but also a responsible decision that aligns with your values.

A. CONCLUSION

Intimate garments are described as a human being's second skin; thus, it is a very important layer with basic functional requirements for a style symbol. Various categories of intimate apparel have been utilized as necessities and amenities. Now a days, the intimate garment sector is experiencing significant technological advancements, driven by the evolving preferences and demands of women. As a result, textile and apparel researchers are increasingly focused on aesthetics, functionality, comfort, quality, fit, design, and style. Innovative techniques, including new stitching and seamless methods, are transforming the landscape of intimate apparel. Additionally, smart intimate garments are emerging alongside traditional options, capturing a substantial market share with specific health-related functions. Today, intimate apparel ranks among the most sought-after products in the fashion industry. Conclusively, being mindful of ethical considerations, such as sustainable production practices can add an extra

layer of satisfaction to your choices, making intimate garments not only a personal statement but also a responsible one.

Author Contribution

Shagufta Riaz: conceptualization, methodology, formal analysis, investigation, validation, writing – original draft. **Sharjeel Abid:** conceptualization, data curation, visualization. **Muhammad Tauseef Khawar:** data curation, methodology, formal analysis, validation, writing – review & editing.

Conflict of Interest

The authors of the manuscript have no financial or non-financial conflict of interest in the subject matter or materials discussed in this manuscript.

Data Availability Statement

Data supporting the findings of this study will be made available by the corresponding author upon request.

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