

AN INVESTIGATION OF BREAST SUPPORT FOR OLDER WOMEN

By

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Abstract

Profound changes occur within the female breast with increasing age; glandular atrophy, increased skin laxity and stretched Cooper's ligaments cause an inferior lateral migration of the breast tissue. However, the current lingerie market predominantly revolves around bras designed for younger women that older women may feel are inappropriate for their physique. Literature regarding age-appropriate clothing has postulated that bras should be designed based on specific shapes, populations and usages. Yet the bra preferences of older women have been neglected in the literature. By determining women's requirements, the performance of current bras may be ascertained, and subsequent alterations may be recommended for bra design in order to optimise bras for older women if required.

The aims of the current thesis were to: provide a wider understanding of the bra requirements of women aged 45 to 65 years, determine the key bra performance variables for this population, develop procedures to assess these variables and to determine the current appropriateness of a small sample of bras for this population.

To achieve the research aims the thesis contained five studies. The first study was exploratory in nature, using focus groups and interviews to develop a knowledge base on the bra preferences of women aged 45 to 65 years. A survey was subsequently designed and implemented to determine the key bra performance variables among a wider sample of the population. The results of these studies identify the general dimensions that women consider when purchasing a bra (comfort, support, aesthetics, practicalities, and psychological aspects). From these dimensions, 11 key bra performance variables that are of importance to older women were derived (comfort, support, bra's ability to stay in place, appearance under clothes, silhouette, breast shape, breast lift, shoulder straps, discreetness, fabric and fit). Methods to quantify the key bra performance variables were required to assess the performance of current bras for older women. The third experimental study developed methods which minimised the limitations of existing procedures, and determined the validity and reliability of these methods. As a result of this study, methods to assess the 11 key bra

performance variables were deemed acceptable for both objective and subjective measures.

In the fourth study, two bras were selected from a popular and unpopular brand; the performance of these bras was assessed with regard to the 11 key bra performance variables. The results indicate that women aged 45 to 65 years preferred a bra that minimises breast kinematics, provides greater breast projection and lifts the breast sufficiently. Although differences lay between the bare breasted and bra conditions, the two bras performed similarly despite the difference in popularity. The final study incorporated a four week wearer trial to elucidate any changes in performance that may appear with increased usage. Subjective ratings of breast support and the bras' ability to stay in place were lower following the wearer trial. The bras tested performed well for the bra variables; comfort, fit, support and shoulder strap position. However, the remaining key bra performance variables may require alteration to ensure their appropriateness for women aged 45 to 65 years. It is concluded that women aged 45 to 65 years are generally cognisant of changes to their breasts as they age, subsequently seeking bras that are different from those they previously would have worn. The findings of this thesis suggest that alterations in bra design are required to optimise bras for older women.

Declaration

Whilst registered as a candidate for the degree of doctor of philosophy, I have not been registered for any other research award. The results and conclusions embodied in this thesis are the work of the named candidate and have not been submitted for any other academic award.

Dissemination

Risius, D., Thelwell, R., Wagstaff, C., & Scurr, J. (2012) Influential factors of bra purchasing in older women. *Journal of Fashion Marketing and Management*, 16 (3), 366-380.

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Risius, D., Milligan, A., & Scurr, J. (2012). Biomechanical breast support requirements for younger and older women during walking. Presented at the Helal and Harries Prize and Olympics Meeting. Royal Society of Medicine. London, Friday 21st September 2012.

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Chapter 1.

Introduction

The social obsession with youthfulness is well documented; with older women in particular feeling pressured to overtly battle the signs of increasing age (Baltes & Carstensen, 1996; Clarke & Griffin, 2008; Clarke, Griffin, & Maliha, 2009; Oberg & Tornstam, 1999; Twigg, 2007). Tactical choices regarding outward appearance may mask a woman's chronological age and allow competition for romantic partners, employment and social recognition (Clarke et al., 2009; Clarke & Griffin, 2008). Although clothing has an influence on outward appearance, the clothing preferences of older women have been neglected in the literature (Twigg, 2007, 2012). In particular, bra preferences have been largely ignored, despite the bra being used as a social tool to reduce the signs of increasing age (Sukumar, 2007).

The bra was allegedly the most advertised underwear item of the 1950s and designs were predominantly 'pink and cone shaped' (Caldwell, 1981). With fashion greatly adapted since then, mature women have stated that, during the post war era, they would not 'have been seen dead in what (they are) wearing now' (Paulson & Willig, 2008). Such statements indicate that the bra preferences of women may change over time; indeed, it has been suggested that the majority of mature consumers hold different priorities for fashion garments than younger consumers (Birtwistle & Tsim, 2005). However, the current lingerie market centres on designs for younger women; and it is unknown whether these bras are suitable for older women, or whether older women may feel these designs are inappropriate for their current physique and personality (Birtwistle & Tsim, 2005).

Clarke et al. (2009) discussed age-appropriate clothing, and found women differentiated between clothing that was designed for particular age groups and body shapes. In addition, women commented that their choice of colour and style had been influenced by their change in body shape as they aged; but whether older women feel their bra preferences have also been influenced by ageing warrants investigation. Many bras on the market are typically advertised to a broad population, yet it has been suggested that bras should be designed based on specific shapes, populations and usages (Krenzer, Starr, & Branson, 2000). Further, selecting specific age ranges for which clothes are designed is also

deemed important to indicate that a retailer recognises the changes in women's body shape with increasing age (Birtwistle & Tsim, 2005; Twigg, 2012).

Twigg (2007; 2012) highlights the need for clothing to be appropriate to an individual's physiology. Anatomical research identifies profound changes within the female breast with increasing age, specifically so during the menopausal transition (Rosen, 2001). A combination of glandular atrophy, increased skin laxity and stretched Cooper's ligaments cause an inferior lateral migration of the breast (Brown, Ringrose, Hyland, Cole, & Brotherton, 1999). These anatomical changes alter the size, shape and internal support of the breast (Rosen, 2001) and research has indicated that 46 per cent of women aged 35 to 65 years are dissatisfied with their upper torso and breast area (Deeks & McCabe, 2001; McLaren & Kuh, 2004). Although Deeks and McCabe (2001) provide no justification as to the age range of participants, their results show that older women become increasingly dissatisfied with their own appearance. Hence, the bra may become more important in reducing the signs of increasing age (Sukumar, 2007). Dissatisfaction and psychological changes with age may therefore be influential with regard to perception of bra performance, and should be investigated in order to determine the appropriateness of current bras for older women.

The population age range included within the current programme of work is 45 to 65 years. This is a life stage when profound changes occur due to menopause, and is often used as the demarcation of the 'older woman' (Birtwistle & Tsim, 2005; Kite & Wagner, 2002; Queniat & Charpentier, 2012). An age range of 45 to 65 years incorporates the period during which the majority of anatomical changes associated with ageing occur within the breast, allowing the exposure of the widest possible range of bra related problems associated with ageing. Indeed, the influence of ageing on women's bra preferences and bra appropriateness is an important area of investigation. However, it is currently unknown whether ageing may influence bra design preferences, consumer behaviour and opinion of the bra market (Paulson & Willig, 2008; Sukumar, 2007).

Given the documented anatomical changes in the human female breast and psychological changes with increasing age, the appropriateness of modern bras

for women aged 45 to 65 years is unknown. By determining women's preferences, the performance of current bras may be ascertained, and, if required, possible alterations may be recommended for bra design in order to optimise bras for this population.

1.1 Aims of thesis

With the above considerations in mind, the three main aims of this thesis are as follows to:

1. Provide a wider understanding of the bra requirements and preferences of women aged 45 to 65 years.
2. Determine the key bra performance variables for women aged 45 to 65 years, and develop procedures by which to assess these variables.
3. Determine the current appropriateness of a small sample of bras for women aged 45 to 65 years.

1.2 Thesis summary

Limited research has been conducted regarding the clothing requirements of older women; however, the existing studies have followed similar research designs; conducting initial exploratory investigations, confirming primary variables by implementing a larger scale survey, and following up with laboratory testing to provide quantitative information which may be used in an applied setting (Birtwistle & Tsim, 2005; Kim, Hong, & Scheurell, 2004; Liao & Lee, 2010; Roe, 2004). This is the general structure in which this thesis was conducted within this under investigated topic.

In chapter two of this thesis, literature regarding human female breast anatomy is reviewed, including the influence of ageing and menopausal transition on the anatomical structures of the tissues. The psychological changes with increasing age are discussed, leading into the purpose of an appropriate bra and the negative consequences of inappropriate bras. In the final sections of chapter two, women aged 45 to 65 years are considered as bra consumers and the psychological impact of appropriate bras for this age range is considered.

In line with the review of literature in chapter two, chapter three presents a study to build a knowledge base on the bra requirements of women aged 45 to 65 years, by exploring a holistic view of their attitudes, beliefs and experiences

Chapter 1

regarding bras using qualitative research methodology. The lack of published research in the area prompted the use of focus groups and interviews in order to develop an understanding of bra related issues in this population. The findings presented in chapter three address the first aim of this thesis and add to the literature base by indicating the general dimensions and themes pertinent to bra use among older women. The information presented in chapter three was vital in determining relevant topics to include within subsequent studies.

In order to address the second aim of the thesis and follow the research structure utilised in previous literature (Birtwistle & Tsim, 2005; Kim, Hong, & Scheurell, 2004; Liao & Lee, 2010; Roe, 2004), chapter four aimed to condense the qualitative information presented in chapter three and determine the key bra performance variables for women aged 45 to 65 years. By implementing a survey designed around the data themes established in chapter three, it ensured that only relevant questions were included, and a larger sample of the population was targeted. A secondary aim of chapter four was to identify whether factors such as age, band size, cup size, HRT use or parity influenced the type of bra worn by women aged 45 to 65 years, or the importance ratings of bra performance variables. This chapter established the key bra performance variables that were of specific interest to women aged 45 to 65 years, which had previously not been considered within bra related literature.

Chapter five initially presents a review of existing methodologies to assess each of the key bra performance variables. The review highlighted the dearth of suitable methods for assessing the key bra performance variables and an absence of reliable methods to measure these. In order to quantify bra performance for women aged 45 to 65 years, chapter five within this thesis aimed to design a set of suitable methods and procedures to assess the key bra performance variables determined in chapter four. Hence, two studies are presented within chapter five, aimed at examining the reliability and validity of newly designed methods and procedures. Study A details the development and reliability testing of methods to assess the key bra performance variables for women aged 45 to 65 years. Test-retest reliability of the methods during same day, same week and same month trials is presented. Study B assessed construct validity by determining whether the methods for the key bra performance variables

could detect a difference between two bras of known structural difference. Based on the findings of studies A and B, the procedures developed to assess an everyday bra's performance for women aged 45 to 65 years were deemed acceptable for use within the current thesis.

Due to the anatomical and psychological changes with increasing age, the appropriateness of bras for older women is currently unknown. Having designed methods and procedures to assess the key bra performance variables, chapter six aimed to address the third aim of this thesis and determine the appropriateness of two bras for women aged 45 to 65 years. Chapter six investigates whether any objective or subjective differences exist between bras with high sales figures and bras with low sales figures for women aged 45 to 65 years. From an applied perspective, chapter six incorporated correlations between objective measurement and subjective preference ratings, in an attempt to generate practical advice for optimising bra design for women aged 45 to 65 years (Constantakos & Watkins, 1982; Kim et al., 2004). This is the first study to investigate the appropriateness of bras for older women. A summary table is provided to outline the key bra performance variables that were deemed appropriate among the bras tested. The summary table also details the bra performance variables that were not deemed appropriate, hence identifying bra design features that require alteration to improve bras for women aged 45 to 65 years.

It is acknowledged that a longer duration of exposure to a product may be required in order to develop a greater understanding of the product's virtues and shortcomings (Moutinho & Evans, 1992). Indeed, the results of chapter six indicated that participant's did not feel they had been permitted sufficient time wearing the bra to assess it properly. Therefore, to increase the external validity of the findings within chapter six, chapter seven further addressed the third aim of this thesis by assessing the appropriateness of bras for women aged 45 to 65 years over a prolonged period of time. In the first study in this research domain to examine prolonged bra use, chapter seven assessed the key bra performance variables using the same methodologies as chapter six, but with a four week wearer trial between two testing sessions. The aim was to determine whether a longer period of wear resulted in different objective and subjective findings to a

brief laboratory testing session. Participants completed a bra appraisal diary over a four week period. They were also asked to record the hours of wear and number of washes throughout the wearer trial period. The findings presented in this chapter present novel information on the influence of a four week wearer trial on bra performance, which had not previously been considered within the literature.

Chapter eight of the thesis provides a general discussion of the programme of research. Specifically, chapter eight considers the unique findings of the programme of research, progression within each study, the development of knowledge in this research domain, limitations of the research design, conclusions, and recommendations for future studies.

Chapter 2.

Review of Literature

This chapter critically evaluates relevant research into the ageing breast, focusing on how this may affect bra requirements. Specifically, the chapter covers a variety of potentially influential factors on bra preferences and requirements in older women, including anatomical, psychological and bra related aspects.

2.1 Anatomy of the breast

The breast spans an area from the second rib to the sixth intercostal cartilage vertically and the sternum to the axilla laterally (Gefen & Dilmoney, 2007), although much individual difference exists in the extents of the breast tissue. The breasts consists of three main components; skin, subcutaneous tissue and the corpus mammae (Brenner, Golan, Srebrnik, Martinez de Morentin, & Wohl, 2005) and accounts for approximately 3.5% of total body fat in females (Katch et al., 1980). Ageing and menopause are understood to be influential in the anatomy of the female breast (Del Carmen et al., 2007; Haars, van Noord, van Gils, Grobbee, & Peeters, 2005; Rosen, 2001).

Menopause has been defined in previous literature as a decline and cessation of ovarian function (Brenner et al., 2005). The level of the primary female sex hormones oestrogen and progesterone decline as the woman becomes incapable of pregnancy. A woman is defined as post menopausal when she has not experienced menstruation for 12 months or more, this includes any spot bleeding (National Health Service Website, <http://www.nhs.uk/Conditions/Menopause/Pages/Treatment.aspx>). A decreased level of the female hormones oestrogen and progesterone has many effects on the body. Ageing is known to progressively reduce the relative density of the breast, even after the effects of varying body mass index are accounted for ($p = 0.00$) (Del Carmen et al., 2007). Average densities of women aged less than 54, 54 to 58 and over 58 years were found to be 26.1%, 18.9% and 14.3% respectively (Haars et al., 2005), although during the years of peri menopause the density can increase and much individual difference is seen. However, because Haars et al. (2005) investigated relative density, increases and decreases in body mass and subsequently adiposity of the breast may have influenced the findings, despite the true amount of dense tissue being unchanged. Parenchymal changes are also caused by hormonal changes during

ageing, superfluous glandular tissue is no longer maintained when fertility decreases, and the reduction in density is due to this atrophy of the glandular tissue (Rosen, 2001). Glandular atrophy in the ageing breast may be affected by genetics, endocrinology, number of children or 'parity' and environmental influences (Russo & Russo, 1996).

The change in vertical position of the breast is an outwardly visible effect of ageing; the breast suffers progressive inferior migration and the areola diameter typically decreases with age (Brown et al., 1999). Breast ptosis (sag) has been linked to reduced dermal elasticity, laxity of the Cooper's ligaments and the superficial fascia (Brown et al., 1999; Gefen & Dilmoney, 2007). Riggio, Quattrone and Nava (2000) investigated the breast tissue of six cadavers and 21 patients during breast surgery and found that the entire shape of the breast is altered with age. The angle of the inframammary fold shifts from obtuse to acute as the fascial support is progressively weakened (Riggio et al., 2000). However, the cadaver dissections were conducted on individuals aged over 69 years, inferences made based on these findings therefore relate to only post menopausal women. Further investigation is required to determine the precise influence of ageing on breast shape.

2.1.1 The skin

The skin of the breast is physiologically the same as the skin on the entire body. It is comprised of three layers, the epidermis, dermis and hypodermis. The most superficial layer is the epidermis, a 'dead' layer of cells called the stratum corneum; cells in this layer are flat and composed primarily of keratin, a fibrous insoluble protein (Gefen & Dilmoney, 2007). Cells in the dermis are made of collagen and elastin fibres and are embedded in a thick medium of water and glycoproteins. The hypodermis is the deepest layer of the skin and is variable in thickness depending on the body region and individual changeability (Gefen & Dilmoney, 2007). The skin is less elastic than fibres within the breast and therefore may provide the most support to the breast tissues (Hindle, 1991).

Ageing produces a regressed epithelial structure and increasingly relaxed dermal frame, the epidermis is much thinner post menopause, this may be due to the stratum corneum's reduced capacity to retain water (Utian, 2009). The skin is a significant source of oestrogen synthesis and storage, therefore not only is the

skin of the breast affected by the menopause, but it can itself further develop the effects of ageing (Utian, 2009). Research has shown that menopause causes a reduced rate of collagen synthesis and therefore a drop in soluble skin collagen of up to 30% in five years, which may cause rapid thinning of the skin during this period (Utian, 2009). Thinned skin is less extensible than thicker, more hydrated skin and therefore displaces less when the tissues underlying it move (Escoffier, Rigal, Rochefort, Vasselet, Leveque, & Agache, 1989).

2.1.2 The corpus mammae

The corpus mammae primarily consists of functional tissue or 'parenchyma', this glandular tissue contains the milk producing cells that become active during pregnancy. Each breast contains six to ten milk ductile systems with numerous lobules in each (Rosen, 2001). These ducts are generally between 2 mm to 4.5 mm in diameter and have no uniform shape; they are thus frequently elongated or distorted (Gefen & Dilmoney, 2007; Wren, 1996). The supportive tissue around the parenchyma is known as the stroma. This tissue contains numerous capillaries, lymphatic drainage systems and suspensory ligaments (Rosen, 2001; Tanis, Nieweg, Olmos, & Kroon, 2001).

Fibrous strands extend from the dermis of the skin to the posterior fascia under the breast tissue; these are the suspensory ligaments or 'retinaculum fibrosa', commonly referred to as the Cooper's ligaments (Riggio et al., 2000; Rosen, 2001). These ligaments are more apparent in the superior anterior portion of the breast (Bannister, 1995), although some extend into the posterior retromammary space and connect with the pectoralis major fascia. These ligaments are understood to be the primary support for the breasts (Gehlsen & Stoner, 1987; Page & Steele, 1999).

The Cooper's ligaments within the stroma may be irreversibly stretched when exposed to large repetitive forces produced in activities such as walking and running (Page & Steele, 1999). Although Page and Steele (1999) inferred this based on previous literature, this may increase the level of ptosis in the breast and this topic warrants further investigation. The ligaments of older individuals are shown to have approximately 65% less strength and 40% less elasticity than younger ligaments (Noyes & Gross, 1976), indicating that greater external support is required to compensate for the reduction of internal support in the breast.

Although Noyes and Gross's study was conducted on ligaments in the knee, inferences may be made to all other ligaments in the body, including those in the breast. The Cooper's ligaments may therefore be weaker and less retractable in older women and thus the breasts will not reform to their original shape.

The ducts and alveoli occupy a large volume in the breasts of young women, after the withdrawal of oestrogen the glands and ducts undertake atrophic changes, reducing the ratio of glandular breast tissue to fat (Wren, 1996). The total volume of the breast may also reduce due to these atrophic changes in parenchyma (Tonkelaar, Peeters, & Noord, 2004). The ductile system remains but lobules shrink, collapse or distend, a thickening in lobular membranes has also been observed in some post menopausal women (Rosen, 2001). It is unknown whether parenchymal changes affect the consistency of the breast tissue or how this may influence the natural support within the breast.

2.1.3 The subcutaneous tissue of the breast

The fatty tissue directly beneath the skin of the breast is known as the subcutaneous tissue. Similar to the stroma, it comprises of connective tissues, blood vessels, and lymphatics (Brenner et al., 2005). The level of adipose tissue within the subcutaneous layer fluctuates with body mass changes (Love, 2000). There are also individual differences in the elasticity of the subcutaneous tissue, suggested due to the individual alterations in breast shape and position seen following bra use (Ashizawa, Sugane, & Gunji, 1990).

There are fewer changes to the subcutaneous tissue during the later stages of the ageing process than in other components of the breast, although research has suggested a greater occurrence of ochrocytes (cells pigmented with fat) in post menopausal women (Rosen, 2001). This change in tissue composition may affect breast stiffness. For example, Krouskop, Wheeler, Kallel, Garra, and Hall (1998) investigated the visco-elasticity of different mammary tissues and found that breast fat had a constant modulus despite varying strain rates, unlike glandular tissue which is more elastic at high strain levels. It may be inferred that an ageing breast, which sees an increase in relative amount of fat, may therefore become less elastic (Krouskop et al., 1998). This limit in breast movement means stretch receptors in the tissues are not activated as frequently, and may explain the reduced levels of mastalgia experienced by post menopausal women.

2.1.4 Breast size

The majority of literature reports involution of the breasts after menopause (Rosen, 2001); however, some lingerie experts have reported an increase of approximately one to two cup sizes in population breast size after 40 years of age, this was attributed to menopause in 80% of cases (Tonkelaar et al., 2004). Gynaecologists have suggested a size decrease is observed due to a reduction in glandular mass, but other research conversely reports an increase in breast size followed by a decrease only when correlated with reduced body mass (Tonkelaar et al., 2004). Indeed, as adipose tissue constitutes an average of one third of the breast tissue, breast size is believed to fluctuate with body mass (Love, 2000). However, this was suggested among pre menopausal women and no inferences may be made as to the ratio of glandular to adipose tissue in the breasts of peri or post menopausal women.

A longitudinal study of 1130 Dutch women reported 18% of women bought a larger bra size after menopause, whereas just 2% bought a smaller size (Tonkelaar et al., 2004). Body mass and waist and hip circumference correlated with an increase in bra size. Those women with a body mass increase of more than 3.5 kg across the five year longitudinal study showed a 2.5 times greater occurrence of increased bra size than those with a body mass reduction of more than 0.5 kg (Tonkelaar et al., 2004). Despite both body mass and bra size being self-reported and thus potentially inaccurate, this study suggests changes in breast size in later life may be primarily due to body mass changes rather than hormonal changes. A study of body mass changes during menopause concluded an average mass gain of 2.5 to 4.1 kg (Wing, Matthews, Kuller, Meilahn, & Plantinga, 1991). This research implies there is likely to be a change in the majority of women's breasts during menopause due to an increase in fat mass. Contradictory to this, some research suggests the hormonal changes during menopause do not cause body mass gain, but progressive ageing does (Utian, 2002); chemical fluctuations may therefore be less influential to body mass gain than progressive slowing of the metabolism. Many studies purporting menopause as a cause of gains in body mass may need to reassess the true causes of the results they observe.

2.1.5 Hormone Replacement Therapy (HRT)

Women experiencing menopause may suffer severe symptoms due to chemical fluctuations; additional hormones may be taken in order to control these symptoms and improve the quality of life for women during peri and post menopause (NHS website, <http://www.nhs.uk/Conditions/Menopause/Pages/treatment.aspx>). Hormone replacement therapy can be administered in various ways, including via tablets, implants, patches or creams and gels. Dosage is gradually reduced until treatment is ceased typically within two to five years or when the symptoms have stopped (NHS website, <http://www.nhs.uk/Conditions/Menopause/Pages/treatment.aspx>).

Although the morphological affects of HRT are relatively unknown, it is suggested that menopausal breast atrophy may be attenuated with the use of HRT (Rosen, 2001). Hormone replacement therapy can reduce ptosis by increasing or maintaining breast density, the additional oestrogen supplements the bodies diminished production and retains parenchymal mass (Haars et al., 2005). Despite HRT increasing breast density in post menopausal women (Colacurci et al., 1998), it can increase the prevalence of mastalgia and body mass (Colacurci et al., 1998; Tonkelaar et al., 2004). This confounds data regarding natural breast changes during ageing and should therefore be considered as an influential factor when investigating the ageing breast. A contradictory study by Utian (2002) found no evidence that HRT influences body mass, although this study only followed patients up to a two year period (Utian, 2002). Further investigation is required to understand the influence of HRT on breast density, mastalgia, and hence, bra requirements.

2.1.6 Mastalgia

Irregular oestrogen levels during peri menopause can cause clinical manifestations such as breast pain, swelling and nipple tenderness (Prior, 1998). However, it has been reported that post menopausal women typically suffer the fewest number of breast related symptoms (Weideger, 1978) and that many women experience cyclical mastalgia increasing in severity until menopause; when it frequently ceases (Wisbey, Kumar, Mansel, Peece, Pye, & Hughes, 1983; Gateley & Miers, 1991). The Cardiff Mastalgia clinic reported that 51% of women had their breast pain alleviated by menopause (Gateley & Miers, 1991). Similarly, a longitudinal study following 438 Australian women through pre, peri and post

menopause found that breast tenderness decreased with menopausal transition (Dennerstein et al., 2000), although the study did not account for the use of HRT amongst the cohort. This is consistent with hormonal research theory that high levels of oestrogen can cause breast tenderness, because oestrogen is believed to lessen comparatively with mastalgia (Prior, 1998).

Women with mastalgia are often prescribed painkillers or advised to buy a more supportive bra (Hadi, 2000). Research recruiting women with mastalgia from an outpatient surgical department found that sports brassieres reduced symptoms in 85% of women, whereas pain killers reduced symptoms in just 58%, 42% of which experienced side effects from the drugs (Hadi, 2000). However, Hadi's study did not specify the age range of participants. It is unknown whether mastalgia may influence the breast support requirements of older women; however, appropriate breast support is known to reduce the incidence of breast movement related mastalgia (Hadi, 2000; Scurr et al., 2009). It is therefore inferred that appropriate breast support for older women may help reduce the level of mastalgia experienced.

2.1.7 Biomechanical support

It is important that a bra provides support to the breast (Scurr et al., 2011); breast support is frequently assumed to mean the reduction in multiplanar breast displacement, velocity and acceleration (Scurr, White, & Hedger, 2009, 2011, White, Scurr, & Hedger, 2011). The stretch of structures within the breast can be reduced by limiting the displacement of the breast tissue; thus potentially reducing breast ptosis in later life (Shangold & Murkin, 1985). In line with this observation, 'breast support' is used here to describe reductions in three-dimensional breast displacement, velocity and acceleration. Mason et al. (1999) identified a linear relationship between mastalgia and displacement (Mason et al., 1999), minimisation of breast movement is therefore vital for acute and chronic breast comfort. Velocity of breast movement, particularly at the highest and lowest point during movement, has been shown to significantly affect the level of pain experienced by women (Scurr et al., 2009). McGhee, Steele and Power (2007) compared breast discomfort during standard treadmill running and during under water running in a cohort of pre menopausal women, this produced velocities of $100.0 \pm 25 \text{ cm} \cdot \text{s}^{-1}$ and $31.3 \pm 17 \text{ cm} \cdot \text{s}^{-1}$ respectively. The additional support of the water slowed breast velocity but did not significantly reduce total breast

displacement, yet participants reported less pain during under water running (McGhee et al., 2007). This may imply that appropriate breast support should include reduced breast velocity in addition to breast displacement. As ageing affects the physiology and anatomy of the breast tissue, it may potentially affect the biomechanics of the breast. In addition, Wood et al., (2012) showed that cup size influenced breast movement during exercise (Wood, White, Milligan, Ayres, Hedger, & Scurr, 2012), thus women may require a different level of breast support after every life event that may affect bra size, including the menopausal transition (Lorentzen & Lawson, 1987).

2.2 Psychological effects of ageing

Ageing is frequently studied from a physiological perspective, ageing is not claimed to be directly linked to a woman's wellbeing, but for women the effects of their body's changes can be deeply psychological (Dennerstein, 1996). In Winterich and Umberson's (1999) study, one participant stated she was 'ageing rapidly, that's distressing in a culture where physical attractiveness is our most valuable asset' (p. 69), indicating her concern with looking older. Indeed, to be seen as aged can be emotionally distressing for women, ageing has even been described as 'womanhood sliding away from you' (Ballard et al., 2009; p. 278). However, these citations (Ballard et al., 2009; Dennerstein, 1996; Winterich & Umberson, 1999) did not include the psychological influence of ageing in relation to clothing preferences or requirements.

Research that contributes to the literature in this regard highlights the social obsession with youthfulness; suggesting that older women in particular feel pressured to overtly battle the signs of increasing age (Baltes & Carstensen, 1996; Clarke & Griffin, 2008; Clarke et al., 2009; Oberg & Tornstam, 1999; Twigg, 2007). Perceptions of body image are often negatively affected by menopause and ageing, when numerous physical changes occur in the female body (Baltes & Carstensen, 1996; Clarke & Griffin 2008; Clarke et al., 2009; Oberg & Tornstam 1999; Twigg, 2007). Physical changes can impact the way others interact with women, negatively viewed features may discredit an individual's personality (Clarke et al., 2009; Clarke & Griffin 2008; Goffman, 1968). Women suffering psychologically with the body changes of ageing may be comforted by wearing empowering underwear, feeling attractive can improve confidence and social wellbeing (Clarke & Griffin, 2008; Clarke, Griffin, & Maliha, 2009). The bra may be

principally worn for support, but it may also be a social tool. However, clothing choices of older women have been described as a 'negotiation' due to age related constraints (Twigg, 2007, p. 298), indicating that women are not wholly satisfied with the clothing options available to them. The literature currently lacks a definition of an appropriate bra for older women, and the psychological impact that bras may have upon a woman's wellbeing.

2.3 Brassieres

Limited anatomical support for the breasts means women may wear additional external support daily. Although it is cited that brassieres should primarily be worn for comfort and support, it is also suggested that the majority of women wear them largely to meet perceived social expectations (Sukumar, 2007). Shangold and Murkin (1985) suggest that wearing effective support can also minimise the effects of breast ptosis by unloading the internal supporting structures (Shangold & Mirkin, 1985).

2.3.1 The structure of brassieres

The cup is a fundamental component of the brassiere and is in direct contact with the breast, the two cup sections are connected together via the centre gore. Underwire may run through channelling around the base of the cup, whilst the underband runs along the bottom of the bra and anchors the bra to the body (Chan, Yu & Newton, 2001). Traditionally, brassieres fasten at the back with hook and eyes attached to the side wings of the bra, however, front fastening bras are available that have attachments on the centre gore. The shoulder straps attach to the cups at the apex, they are designed to hold the cups in place rather than support the full mass of the breasts (McGhee & Steele, 2010). Shoulder straps may incorporate an adjuster in order to cater women of varying heights (Chan, Yu & Newton, 2001).

2.3.2 Correctly fitting brassieres

Research suggests the prevalence of ill-fitting bras is high due to the lack of standardisation in brassiere fitting techniques (McGhee & Steele, 2006; White & Scurr, 2012; Wood, Cameron, & Fitzgerald, 2008). The traditional bra fitting method involves taking the circumference at the fullest part of the breast and the under band circumference and calculating the difference, this method has been described as so inaccurate to be deemed completely worthless (Pechter, 2008; White & Scurr, 2012). These two measurements can be affected by respiratory

state and posture, which can alter bra size calculation by up to four band and cup sizes (McGhee & Steele, 2006). It has also been suggested that ptotic breasts may elicit further problems for bra fitting due to the change in circumference around the top of the breast (McGhee & Steele, 2006). This current method of bra fitting was developed in 1935 and was designed for up to cup size D (Greenbaum, Heslop, Morris, & Dunn, 2003; White & Scurr, 2012); sizes beyond a D cup may therefore not be suitable for this bra size calculation method. Consequently, the occurrence of problematic bra fitting substantially increases in larger breasted women (Greenbaum et al., 2003; White & Scurr, 2012). In addition to the flaws of the traditional bra fitting method, there is no consensus regarding the requirements to describe oneself as a 'trained bra fitter' and there are frequently considerable discrepancies between the same bra size in different styles and brands (Greenbaum et al., 2003). Recent literature recommends adhering to certain fit criteria, rather than particular measurements (White & Scurr, 2012).

Being professionally and correctly fitted has been listed as essential for an adequate bra (Haycock, Shierman, & Gillette, 1978). Wearing a bra that is too small can more than double the downward pressure on the shoulders due to the posterior strap acting as a pulley (Ryan, 1984), this can cause pain in the trapezius muscle due to muscle ischemia. Indeed, when women ceased wearing a bra for two weeks pressure on the shoulders was reduced and they professed to be pain free (Ryan, 2000). A report on ill fitting bras details one individual whom, after just 25 days of wearing the wrong sized bra, sustained bilateral pressure ulcers 30 cm long, these evolved full skin loss and extensive damage to chest wall muscles. This pressure necrosis was caused by the excessive tightness of the bra band (Elackattu, Babade, Brodell, & Dewer, 2007). This unfortunate woman highlights the importance of correct fit in brassieres. Many bras on the market are typically advertised to a broad population and it has previously been suggested that bras should be designed based on specific shapes, populations and usages to ensure optimum fit (Krenzer, Starr, & Branson, 2000). As the female body shape changes with age it may be appropriate that older women wear bras designed differently to those for younger women to avoid acute and chronic injury.

Older women may face greater challenges in finding a well-fitting brassiere due to anatomical and physiological changes induced by the ageing process. Indeed,

Ashdown and Na (2008) utilised three-dimensional body scan data to compare younger (19 to 35 years) and older women's (55 years and over) upper body posture and found significant changes between the two cohorts. Specifically, differences were shown between 21 of the 36 measures between the age groups. Asymmetry was also greater in the older cohort compared to the younger cohort when comparing the left and right side of the body, which may influence brassiere and clothing fit, as all high street apparel is patterned symmetrically (Ashdown & Na, 2008). Changes that may affect brassiere fit in addition to asymmetry included; thoracic posture, shoulder length and shoulder angle. Ashdown and Na's (2008) also found that the older cohort had larger breasts that were positioned farther apart on the chest wall. These data were collected with participants wearing their own brassiere; it is possible that differences observed were due to the brassiere type rather than anatomical differences. Similar research has investigated the effect of body shape on perceived brassiere fit (Chen, LaBat, & Bye, 2010), and found that back curvature, bust prominence and shoulder slope significantly affected participants perception of brassiere fit. However, Chen et al.'s (2010) study included only women aged 18 to 25 years, and therefore inferences regarding older women's bra fit issues cannot be made. Indeed, previous research has quoted one participant stating 'I don't think retailers recognise the changes in body shape as women grow older' (Birtwistle & Tsim, 2005, p. 457).

2.4 Brassieres for Women aged 45 to 65 years

The majority of current bras are manufactured based on sample sizes of a 34B prototype model (Hardaker & Fozzard, 1997), sizes are then scaled up or down based on this prototype size. The consideration of breast ptosis or postural changes within older women are not mentioned in the literature regarding bra design (Hardaker & Fozzard, 1997), although it has been suggested that significant changes in the breast area require the seams of clothing to be changed (Twigg, 2012). As women's body shape alters with age, the potential for poor brassiere fit may increase. These age related changes may not have been considered by the apparel industry and the availability of well-fitting brassieres for older women warrants investigation.

Women aged over 45 years have been the focus of previous studies regarding older women's clothing preferences, as they are believed to have the highest

disposable income and constituted approximately 44% of the female population in the UK in 2011 (Birtwistle & Tsim, 2005). In addition, menopause is reported to occur at an average age of 52 years, with symptoms typically beginning at around 47 to 48 years of age (McKinlay, Jefferys, & Thompson, 1972). Sixty five is considered the demarcation point at which women are considered to enter 'old age' (Kite & Wagner, 2002; Queniart & Charpentier, 2012). Hence, an age range of 45 to 65 years incorporates the period during which the majority of anatomical changes associated with ageing occur within the breast, allowing the exposure of the widest possible range of bra related problems associated with ageing.

Women aged over 45 years were brought up in the mid 20th century; colloquially described as a time of 'mammary madness' (Rosen, 1973), with the brassiere allegedly the most advertised underwear item of the 1950s (Caldwell, 1981). Brassieres in the post war era were predominantly pink and cone shaped (Paulson & Willig, 2008). Many women interviewed in a study investigating women's views on brassieres referred to these pink cone shaped bras as 'ghastly' and 'like the ones Madonna wears that people laugh about' (Paulson & Willig, 2008, p. 117). With fashion greatly adapted since then, one 72 year old lady stated she would 'never have been seen dead in what (she is) wearing now' (Paulson & Willig, 2008). This statement implies women may want and need a different bra design at different ages. Although there is allegedly a high resistance for this generation of women to grow old (Birtwistle & Tsim, 2005; Twigg, 2012), it appears most may have acknowledged a physical change and now desire clothing to suit their current physique and current fashion.

In addition to anatomical changes in the breasts during the ageing process, the literature indicates there are differences in clothing preference over time (Birtwistle & Tsim, 2005; May-Plumlee & Little, 2001; Twigg, 2012). Previous studies regarding bra design have focused on women aged 20 to 29 years, and have identified key features of bra design that are important to that population, such as fabric, colour, neckline design, lace and detachable shoulder straps (Liao & Lee, 2010). Kim et al. (2004) conducted a similar study with a cohort of women aged 30 to 40 years in order to develop a 'sensible' bra for women of this age. Kim et al. (2004) identified certain variables of importance to women of this age, and briefly mention quantitative methods to assess these variables. However, the

article lacks detail as to how these variables were quantified, and the data analysis methods are unclear, the conclusions from this study are therefore questionable as the methodology is inadequately reported. Such a study has yet to be conducted for the bra design preferences of older women, who may have different preferences to the younger population. Future research in this area would determine the key bra performance variables for older women and subsequently inform the optimisation of bra design for older women.

Women are known to use human personality traits such as 'sophisticated' and 'fancy' to describe brassieres (Sukumar, 2007); the brassiere should therefore reflect the personality of the wearer. In order to do this, bras should be designed for specific populations and targeted towards certain personality types. The current brassiere market contains 'sports bras', 'girly bras' and 'sexy bras' (Sukumar, 2007); there is currently no acceptable or acknowledged brassiere for the 'older' woman. It is thought that different ages should be wearing different types of bras, either for social acceptance or physiological requirements (Sukumar, 2007). The colour of a bra can carry a social message, colours described as young include purple, yellow and pink, older colours include black, white and off-white (Sukumar, 2007; Twigg, 2012). Moreover, the 'age of colour' phenomenon was explained by the older woman's aversion to bright colours; it was claimed that bright colours make these women feel uneasy and they find comfort in duller colours (Sukumar, 2007; Twigg, 2012). Indeed, Sukumar's (2007) study found that black was the only colour generically favoured across all age groups. Sukumar's (2007) publication lacks information regarding the methodology with which information was derived, it is therefore unknown whether suggestions within the article are speculative or have an evidence base.

The current underwear market revolves around designs for younger women that literature suggests older women may feel are inappropriate for them. Appropriate clothing can help raise self esteem which is frequently distorted with age (Reel, Soohoo, Summerhays, & Gill, 2008). Humans are living longer than ever and the large numbers of females born after World War II are now approaching menopause or are already post menopausal (Birtwistle & Tsim, 2005). With this rapidly increasing population of women over 45 years, the bra requirements of

older women warrant investigation. It is important that older women's bra needs are understood and, if necessary, an age specific bra designed for their needs.

2.5 Summary

This chapter highlights the significant anatomical and physiological changes in the female breast with increasing age. The negative impact of incorrect breast support is documented, but the influence of bras on psychological well being among older women has yet to be investigated in the literature. The natural variation in the female breasts caused by ageing may necessitate a change in consumer behaviour and the need for age specific bras that incorporate preferred design features. Although previous literature on bra requirements has not included women over 40 years of age, it is important that brassieres are investigated for women aged 45 to 65 years independently to those for younger age groups.

Currently, the key bra performance variables for older women have not been defined, and subsequently, the appropriateness of bras for older women has yet to be determined. This programme of research will contribute to the literature by addressing these unknowns. Due to the absence of published information regarding the bra preferences and requirements of older women, an initial exploratory research study is required to begin this programme of work. The following chapter therefore focuses on providing a knowledge base for bra requirements of women aged 45 to 65 years.

Chapter 3.

An exploratory investigation of bra performance variables for women aged 45 to 65 years

3.1 Introduction

Chapter two reviewed the literature on the ageing process of female breasts; which led to the premise for the need for age specific brassieres that incorporate the performance variables required by specific populations. Current literature provides sparse information regarding the brassiere needs of women aged 45 to 65 years; many assumptions have been cited without investigation to confirm theory. For example, Page and Steele (1999) suggested that the seams, hooks and underwire should be covered to minimise rubbing and chafing, although no information is provided as to how these criterion were produced. Similarly, it has been suggested (Page & Steele, 1999) that the straps of a bra should lie in line with the nipple in order to provide breast support directly in the line of vertical force produced by the breast. Indeed, breast support has often been cited as a vital feature of both everyday and sports brassieres (Haycock et al., 1978; Mason et al., 1999; Scurr et al., 2009). The ageing process is known to deteriorate the internal supporting structures of the breasts and therefore the need for external support from brassieres may be greater in older women (Rosen, 2001). Furthermore, it has been suggested that the majority of mature consumers hold different priorities for fashion garments than younger consumers, with additional factors such as merchandising and brand loyalty becoming influential in older women's bra selection (Birtwistle & Tsim, 2005). Despite this, no research has examined the breast support requirements of women over 45 years of age.

Previous research has indicated that an in depth understanding of the bra consumer is a prerequisite to sufficient sales, causing difficulty due to the complex range of interlinked factors considered by consumers when purchasing a bra (Dewsnap & Hart, 2004; Hart & Dewsnap, 2001). Despite this, only three articles could be found implementing qualitative research methods with regard to women's bra needs (Dewsnap & Hart, 2004; Hart & Dewsnap, 2001; Kim, Hong & Scheurell, 2004), these articles focused on marketing development in category management and the purchasing process, rather than preferences related to the bra itself. These studies found that purchasing bras was an unfavourable

experience for most women due to lack of attractive bras, lack of choice and lack of bras that fit, were comfortable, and provided the right shape (Dewsnap & Hart, 2004). These issues during bra purchasing indicate features of a bra that are important to women, however, they are briefly mentioned in Dewsnap and Hart's study as relating to the purchasing process and do not indicate the full range of bra features that are important to women.

Due to the lack of literature regarding older woman's bra needs, the study within the current chapter warrants exploratory research methods such as those implemented in previous research, (Dewsnap & Hart, 2004; Hanton, Fletcher, & Coughlan, 2005; Jones, Hanton, & Connaughton, 2002; Thelwell, Weston, Greenlees, & Hutchings, 2008). Focus groups and interviews are common data rich sources for subjective information. Focus groups are ideally suited to female participants who can thrive on the synergistic setting with much group interaction, thus developing ideas further than an individual interview might (Silverman, 2004). However, rather than evolving shared views, focus groups may also encourage a false consensus or limit divulgence of information due to the group environment; this can be combated by conducting additional individual interviews (Lotiosselik, 2003). Although interviewer bias is enhanced in individual interviews as the researcher plays a greater role in the conversation, this can be combated by focus group discussions (Roberts, 1981). To eliminate potential limitations posed by focus groups and individual interviews separately, both methods should be conducted to achieve optimum qualitative data collection (Jones et al., 2002; Wachterbarth, Streams, & Smith, 2002). Hence, combining group and individual interviews helps to highlight mutual experiences as well as giving interviewees the opportunity to disclose information that may be compromised by such public disclosure during group discussions (Barbour & Kitzinger, 1999). This multimodal approach to qualitative data collection may also enhance the validity of research by incorporating a variety of complimentary data collection methods (Morgan & Spanish, 1984; Barbour, 2008).

Dewsnap and Hart (2004), Hart and Dewsnap (2001) and Kim et al. (2004) refer to a limited number of variables that may be of importance to women. The lack of information regarding women's generic primary bra requirements, particularly within more specific populations, needs to be addressed. The extant research has

failed to qualitatively establish brassiere requirements for women aged 45 to 65 years of age, indeed, a broad qualitative view of women's perspective of the bra market and the ageing breast has yet to be investigated. Therefore, this chapter aimed to develop a more extensive understanding of older women's attitudes, beliefs and experiences regarding bras, to establish the potential key performance variables of bras for older women. This information will add to the literature by building a knowledge base on the bra requirements of older women, thus eliciting further research in the area.

3.2 Methodology

3.2.1 Ethical Approval

This study received ethical and scientific approval from the BioSciences Research Ethics Committee, in accordance with current University regulations.

3.2.2 Participants

In accordance with previous research (Patton, 2002; Mellalieu, Neil, Hanton, & Fletcher, 2009), participants were recruited using purposive sampling to ensure they were selected based on their suitability for the research purpose, this is believed to provide the optimum level of information. An announcement on the staff institutional bulletin was used to recruit participants, this subsequently elicited snowball sampling via word of mouth. Guidelines for focus groups advise between three and twelve participants are optimum for data collection (Silverman, 2004; Barbour, 2008) however smaller groups may facilitate more intimate accounts suitable for sensitive topics such as the female breast and bra needs (Lotiosselik, 2003). Twelve participants has been suggested to be sufficient to reach saturation of common themes within a homogenous and knowledgeable population (Guest, Bunce, & Johnson, 2006). Therefore, thirteen women aged 45 to 65 years (58.2 ± 4.4 years; mean \pm standard deviation) participated in this study. Participants were UK based females, with no surgical procedures to their breasts or any form of clinical breast treatment at any time, wore a bra on a daily basis and had not given birth or breast fed in the last year. Ten women were post menopausal, two were peri menopausal and one was pre menopausal. Participants were all from the South East of England and described themselves as middle class. All participants volunteered for this study and provided written informed consent prior to data collection.

3.2.3 Focus Groups and Interviews

Following an explanation of procedures, participants were organised into either focus groups or an individual interview scenario based on their availability. Two focus groups were conducted, providing a wealth of information and identifying key areas of interest. Subsequently, follow up interviews were conducted to further explore these themes. In total, five follow up individual interviews were conducted. This number is in line with previous research (Jones et al., 2002) and total participant numbers were above that deemed sufficient to reach saturation of common themes within a homogenous population and seen in related literature (Birtwistle & Tsim, 2005; Guest et al., 2006). Focus groups and interviews contained four and one participant(s) respectively.

Due to the absence of research in this area, the foundation of the focus group and interview questions was based on related breast research, including sports bra biomechanics and the physiological, anatomical and psychological effects of ageing. A pilot focus group (n=4) and individual interview (n=1) were carried out to screen all questions. Based on the feedback from the pilot study, minor alterations to question wording and order were made. Bias was reduced due to the researcher being heterogeneous to the participant's age range, similar assumptions were therefore not automatic and a more neutral interviewer perspective was elicited (Hurd & McIntyre, 1996). Pilot studies also familiarised the researcher with the demands of leading group conversations and helped to refine interview technique.

3.2.4 Data Collection

A semi-structure format for both focus groups and interviews was utilised (see appendix A for discussion guide), this ensured all participants were asked the same key questions but allowed flexibility to explore issues that arose and reorder questions according to the flow of conversation (Hanton et al., 2005; Thelwell et al., 2008). Initial questions were based on present information (e.g. "What is your current favourite bra?"), believed to be easier for participants to verbalise than questions relating to the past or future, therefore easing them into the conversation (Patton, 2002). If participants in focus groups and interviews were felt to have overlooked any important issues, a poster was presented to them with a variety of bra features listed; these were place of purchase, colour, seams, fabric, support, straps, brand, minimising, cleavage enhancing, underwire,

lightweight, padding, cooling, cost, matching underwear, maintains shape through washes and comfort. These items were included based on their reference in previous literature (Dewsnap & Hart, 2004; Hart & Dewsnap, 2001; Page & Steele, 1999). Participants were not asked directly about specific items on the list, but were invited to discuss anything they felt was important which had not previously been mentioned during the focus group or interview. If items were not considered important by participants they were not reported or discussed further in this thesis.

Questions were predominantly open ended, allowing participants to provide as much or as little information as they desired, rather than using dichotomous closed questions that may illicit a simple yes or no response (Patton, 2002). A variety of conversational probes were used, including generic (e.g. "Can you tell me why...."), clarification (e.g. "Can you tell me what you mean by...") and elaboration probes (e.g. "Could you tell me a bit more about...") to encourage greater disclosure from participants (Krueger, 1998). The final section of the conversation in focus groups and interviews provided a brief summary of the topics covered and participants were asked if there were any additional points they would like to discuss.

Focus groups and individual interviews lasted approximately 70 minutes and 30 minutes respectively. Both were conducted face to face in a participant's home and were audio recorded in their entirety. Audio recording allows researchers to focus on the conversation rather than frequently note taking, therefore only one researcher was present (Barbour & Kitzinger, 1999; Patton, 2002). The dictaphone was positioned centrally between participants to enhance sound capture (Barbour, 2008). Non-verbal communication such as hand gestures were noted to aid memory and understanding during transcription (Patton, 2002). To ensure non-verbal communications remained objective, only physical gestures were recorded, such as participants pointing to particular points of their bra (Lotiosselik, 2003).

3.2.5 Data Analysis

Recordings were transcribed verbatim resulting in 79 pages of single spaced text; the entire transcript was selected as the unit of analysis. Due to the absence of previous literature in this area and the exploratory nature of this inquiry, content

analysis was conducted in line with similar research designs from alternative disciplines (Birtwistle & Tsim, 2005; Hart & Dewsnap, 2001). Content analysis was inductive; this allowed the construction of data themes to avoid influence from other studies (Hanton et al., 2005). Abstracted phrases, key quotations and emergent underlying themes of conversation were grouped into raw data themes. These were clustered into higher order themes and subsequently key general dimensions established. For example, statements such as “I prefer the bra to be invisible” were included in the raw data theme, ‘Bras should be discreet’ in the higher order theme, ‘Appearance in Clothes’ and finally in the general dimension, ‘Aesthetics’. The categories created were comprehensive and no data was excluded on the basis that it did not ‘fit’ a certain theme (Krippendorf, 1980). Although there are many computer software programs that conduct qualitative content analysis automatically, it is believed that no computer system is capable of rationally conceptualising data into meaningful findings and therefore all analysis of this kind was done manually (Thorne, 2000).

Primary content analysis was conducted by the lead researcher; however triangulation of data took place throughout the analysis process, involving a secondary breast health researcher, a qualitative researcher with extensive content analysis experience and a novice in the area of both breast health and qualitative research (Fereday & Muir-Cochrane, 2006). A variety of individuals were used to triangulate the data, as previous research has suggested that members of the research team would maintain the same bias and preconceptions as the lead researcher (Fereday & Muir-Cochrane, 2006). Once data was initially organised by the lead researcher, triangulation was subsequently completed by others reading through the content analysis, leading to discussions and questioning of the wording of data with frequent references back to the original transcript. Triangular consensus was reached regarding the placement of raw data themes into high order themes.

Results report raw data themes and higher order themes for each general dimension, supplemented with a frequency analysis of raw data themes to demonstrate the number of participants mentioning each raw data theme (Birtwistle & Tsim, 2005; Hanton, et al., 2005; Thelwell, et al., 2008). Total number of comments within each general dimension (Σ) and mean number of participants

mentioning each general dimension (M) were calculated to indicate the commonality of data themes. Higher values for Σ and M indicate that these themes were discussed more often and by more participants, and may not infer importance. The general dimensions and higher order themes are presented in order of highest to lowest mean number of participants citing the general dimension or higher order theme, whilst raw data themes are presented in order of highest to lowest number of participant mentions.

3.3 Results

A total of 109 raw data themes emerged from the data; these were abstracted into 23 higher order themes which were further encapsulated within five general dimensions. Specifically, the general dimensions were; aesthetics, comfort, practicalities of bra purchasing, breast support and psychological aspects, in which there were 30, 28, 19, 18 and 14 raw data themes respectively (see figures 1 to 5). Frequency analysis showed the total number of mentions for comfort ($\Sigma = 180$) and aesthetics ($\Sigma = 151$) were similar, where as breast support ($\Sigma = 136$), practicalities of bra purchasing ($\Sigma = 95$) and psychological aspects ($\Sigma = 94$) were not mentioned as often. Similarly, additional analysis revealed that the mean number of participants that cited raw data themes within each general dimension was highest for aesthetics ($M = 4.30$), followed by comfort ($M = 3.64$), practicalities of bra purchasing ($M = 3.63$), breast support ($M = 3.28$) and finally psychological aspects ($M = 2.44$). Figures 1 to 5 depict the findings for each general dimension in order of commonality and are supported with verbatim quotations from focus group and interview transcripts.

3.3.1 Aesthetics

The general dimension of aesthetics encapsulated six high order themes: *shape*, *attractiveness of the bra*, *figure*, *appearance under clothes*, *lace* and *colour* (Figure 1). These six themes encompass all ideologies expressed by the participants regarding their bra aesthetics. The most commonly mentioned themes within *shape* were 'bras should improve one's outline' and 'unpadded bras are best', mentioned by eight participants. One participant described her changing view on bra padding:

I sometimes feel there are some very pretty bras out there but they're usually padded. I used to wear padded bras a lot when I was younger, I don't feel so comfortable in them now.

Within the higher order theme *attractiveness of bra*, 'liking a pretty bra' was the most commonly cited theme, mentioned by seven participants. The concept of a pretty bra is illustrated in the following quotation:

I don't want to go into this sort of middle-aged old lady with the plain, very plain stuff. I still feel very feminine, very sexy, so a bra should be too.

However, some participants felt that bras on the market could not be 'pretty' and meet other, more essential, performance criteria. Stating that:

They're very pretty but they're too skimpy or they're kind of push up Wonderbra type things, I'd like to find a prettier bra in my kind of needs, for my needs.

Within the higher order theme *figure*, the 'bras appropriateness to body type' was the most commonly cited theme and was mentioned by four participants. Participants described how different bras could be suitable for different individuals and figures. The following statement is from a participant discussing the bras affect on her figure:

I have quite a narrow space between the bottom of my back and my waist, I mean there's my waist, so if I don't hoist them up, then my boobs kind of run into my waist.

Within the higher order theme *appearance in clothes*, 'appropriateness for clothes' was the most frequently cited theme and was mentioned by all thirteen participants. Concern over the affect that the bra would have on outward aesthetics seen by others was evident. The following account reflects the desire for bras to enhance the item of clothing:

So that I look like I've got a tolerable chest underneath the garment that I'm wearing, something that enhances the garment I'm wearing.

Discreetness was also discussed with regard to a bras *appearance in clothes* and was mentioned by 11 participants. One participant described her concern with the visibility of her bra:

I prefer the bra to be invisible, or as invisible as possible. I certainly find it very strange the sort of modern idea of actually having your bra deliberately showing. You know, a colour that would show under the clothing as if it's some kind of fashion accessory.

The most commonly cited raw data theme within *lace*, with seven participants mentioning it, was that a bra 'needs lace to be attractive'. The participant's need for appropriate aesthetics was apparent, and indeed a key requirement of attractive aesthetics was a lace pattern on the bra. For example, the following quotation illustrates one participant's thoughts regarding lace:

I think that it's very much like a piece of machinery if it's not got something decorative on it. Just something lacy or I would feel it was purely a piece of machinery to fulfil a function rather than an attractive garment.

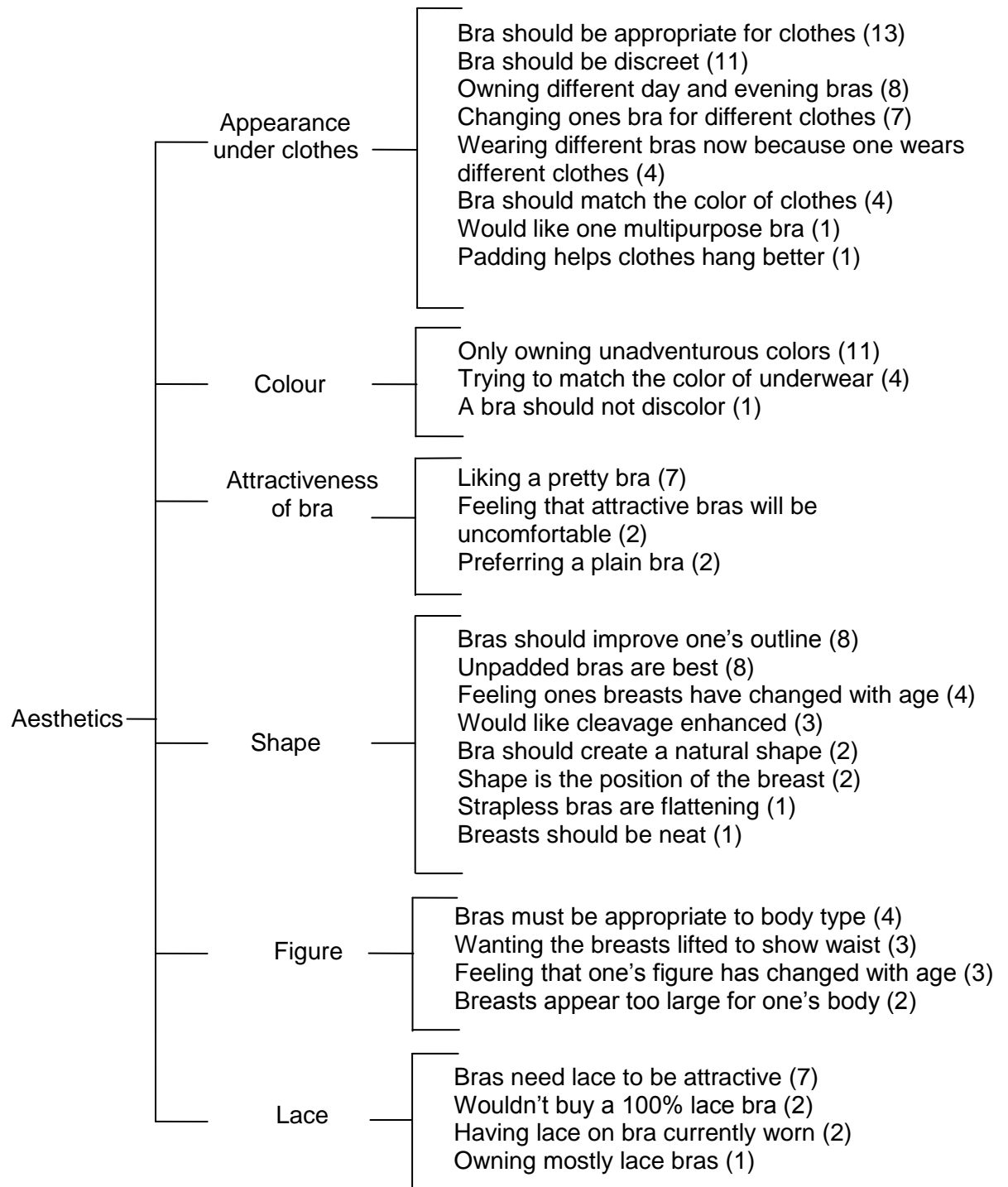


Figure 1. Aesthetics. Higher order themes are ranked in order of mean number of citations per raw data theme (number of participants citing raw data themes can be seen in the last column) (n=13).

Concepts relating to the bras colour were also a concern for participants. The most frequently mentioned theme within *colour* was participants 'only owning

unadventurous colours', mentioned by 11 participants. When asked what colours she owned, one lady stated:

I have white, I suppose you'd call it nude or beige...cream and black. I only have those four colours.

One participant's reason for predominantly wearing white bras is illustrated in the following quotation:

I always choose white, I think they're more suitable to go under the majority of clothes . I don't want red or pink or any of those sorts of colours.

3.3.2 Comfort

Comments relating to the overall comfort of a bra were grouped into one general dimension, these issues include: *shoulder straps*, *underwiring*, *fabric*, *bra fit* and *generic comfort* (Figure 2). The most frequently cited themes pertaining to a bra's shoulder straps were 'thick straps are best' and 'straps are commonly too far apart', each cited by five participants. The following quotation refers to both of these issues,

I need to have something that's got a really wide strap, because otherwise I'm continually yanking up the strap and that drives me mad. Obviously the shoulder straps need to be adjusted properly to the right length and not cut into you, but on the other hand, not constantly falling down.

Underwiring in a bra was commonly referred to when participants discussed comfort. The most common theme regarding *underwire* was 'wearing only underwire bras', for these nine women they would rarely wear a non-underwire bra. The following dialogue between two women was obtained during a focus group.

1: I'm happy with underwired ones, I think they give me a bit more support and shape

2: Definitely underwired

1: Yes I wouldn't buy anything else

The most frequently cited theme within the higher order theme *fabric* was 'the material should be smooth' and was mentioned by four participants. Participants typically stated not having a preference for fabric type, but when questioned about bra comfort the fabric was often mentioned as something that potentially caused discomfort.

What I find uncomfortable sometimes on bras I've had that are more fancy is that the lace or scratchy attachment, the decoration, can be quite scratchy and I really don't like that, I want mine to be nice and smooth as if I haven't got anything on.

Within the higher order theme of *bra fit*, 'finding discrepancies in fit between different bras' was the most commonly mentioned theme and was cited by five participants. Difficulties in finding a well fitting bra were commonly exacerbated by differences between and within brands, as suggested in the following quotation:

It's mainly fit that I have problems with, I can take six bras into a changing room and only one will fit me. Different makes vary don't they 'cause sometimes I'm a 36 or 34 and sometimes it's a B or a C, it's trial and error really which one I wear.

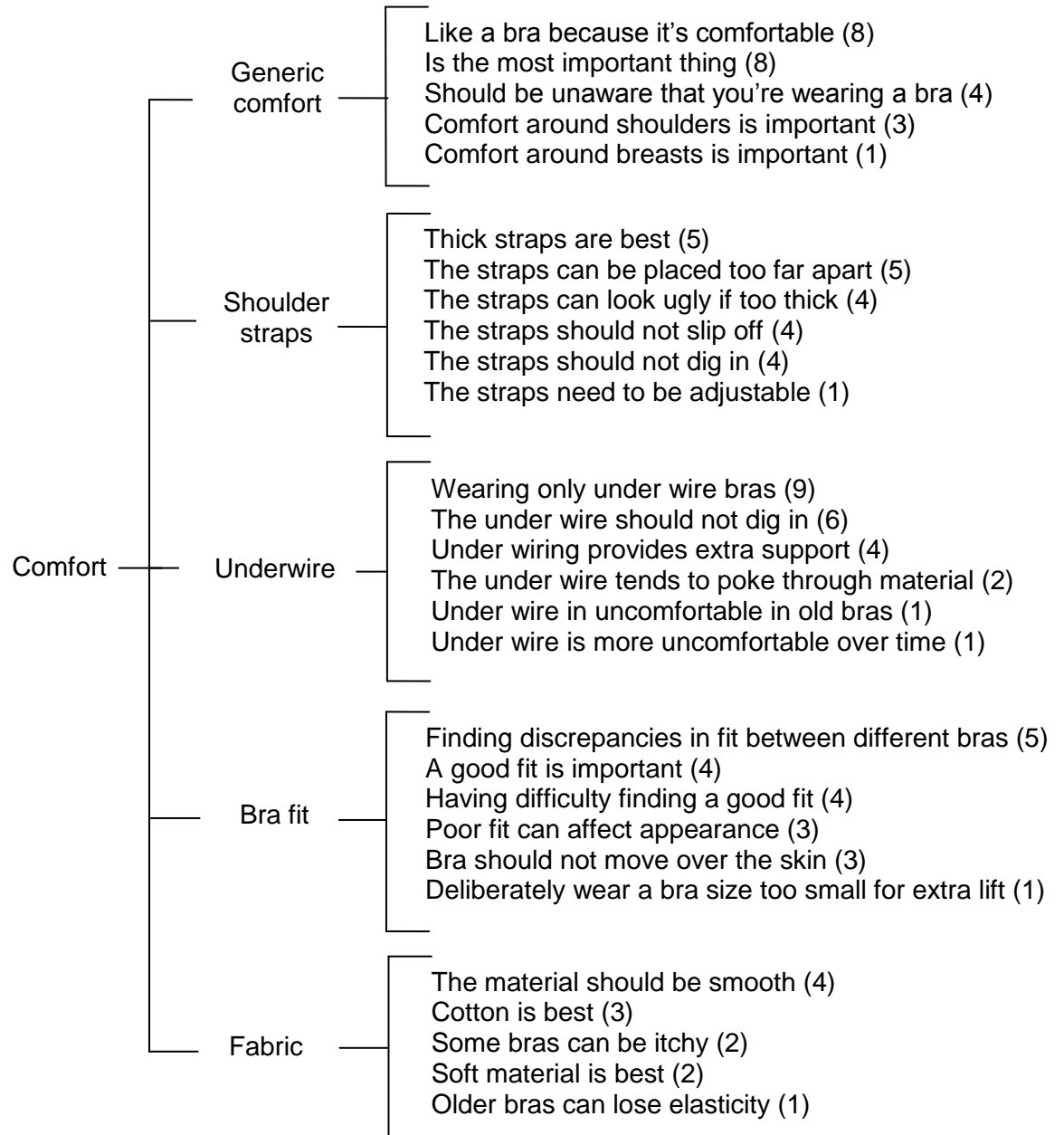


Figure 2. Bra Comfort. Higher order themes are ranked in order of mean number of citings per raw data theme (number of participants citing raw data themes can be seen in the last column) (n=13).

The two most common themes within the high order theme *generic comfort* were,

'liking a bra because it's comfortable' and 'comfort is the most important thing', each mentioned by eight participants. When asked what the most important feature in a bra was for them, nine women gave 'comfort' as their first response. Furthermore, when asked why their favourite bra was so good, the same number of women reported it being particularly comfortable. Comfort when wearing a bra frequently took priority over other bra criteria, for example, when questioned about the attractiveness of her bras, one participant responded

I'd much rather be comfortable to be honest, at my age you don't worry about thing like that. As you get older you don't care so much what you look like, and people don't notice what you look like to be honest. So I've gone for comfort more and more as I've got older.

3.3.3 Practicalities of Bra Purchasing

The general dimension 'practicalities of bra purchasing' encompasses a variety of higher order themes relating to factors considered during the purchasing process. The five higher order themes were; *the importance of good quality, availability and buying, affordability, choice of purchasing options and range and choice of bras* (Figure 3). Within the higher order theme *the importance of good quality*, the 'bra's ability to maintain its shape through washes' was the most frequently cited raw data theme and was mentioned by eight participants. Women stated the importance of the bra being of sufficient quality to endure multiple washes and wears; this is demonstrated in the following verbatim quotation:

The washing machines are too hard on them, I just don't think they last as well, I think the elastic does go quickly. Even if they wash reasonably well they don't look the same, a white bra doesn't look the same even if you wash it by hand.

The higher order theme *availability and buying* revealed four raw data themes, the most common was participants 'always going to the same shop' and was mentioned by 11 participants. Participants stated they purchased their bras from the same retailer every time, particularly for reliability and convenience. One participant commented that she 'doesn't look beyond M&S', when asked why this was, the participant stated 'I kind of stick to what I know really. I don't know of anywhere else to go particularly, or any other brands'. Similarly, the second most frequently occurring raw data theme within *availability and buying* was 'always buying the same bra'. This is demonstrated in the following quotation:

M&S has got my old faithfuls that they've been going with for quite a few years. I do tend to buy the same bra a lot of the time for everyday use. I've found something that's good enough and it hasn't occurred to me to challenge it.

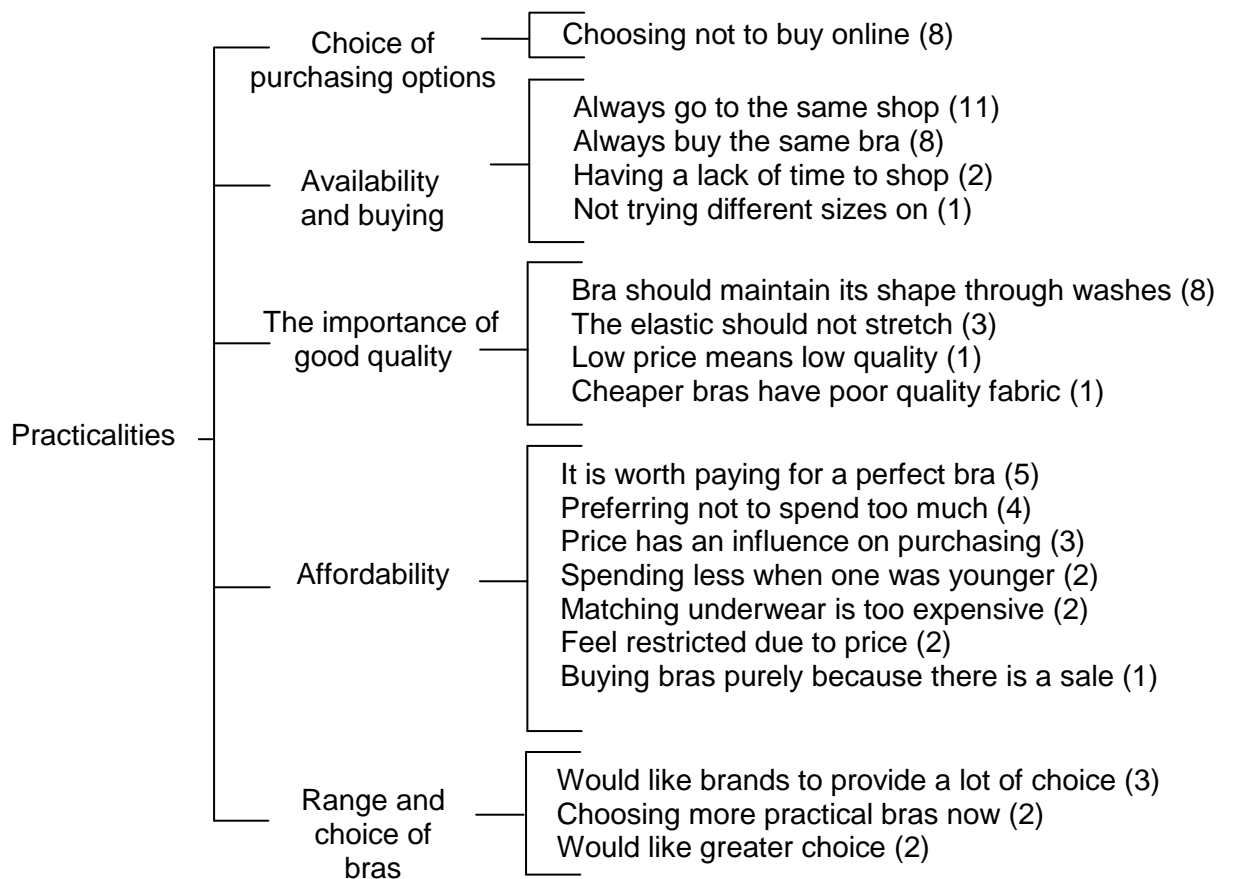


Figure 3. Practicalities of bra purchasing. Higher order themes are ranked in order of mean number of citings per raw data theme (number of participants citing raw data themes can be seen in the last column) (n=13).

Within the higher order theme *Affordability*, 'it is worth paying for the perfect bra' was the most frequently occurring theme and was mentioned by five participants. When participants were asked what the maximum amount they would spend on a bra was, many responded that if they found the perfect bra they would pay a lot, as the following quotation illustrates:

If it was a magical bra that was really brilliant. Money wouldn't be any object really.

Only one theme was cited within *choice of purchasing options*, the option to purchase online was discussed by participants and deemed unfavourable by eight participants. However, participants did state that they might purchase a bra online if they had had the exact bra and size before, although purchasing in store was still preferred. Many participants stated they would 'never buy online'. One woman explained her experience of purchasing two ill-fitting bras online:

In the end I just had to chuck them, I mean I suppose I could have paid the postage, but this is the problem sending them back, it's the postage and

everything else. No, I get books online you know from Amazon and places like that, but bras definitely I wouldn't.

In addition to *choice of purchasing options*, participants also commented that they wanted a *range and choice of bras*. Within this higher order theme, 'would like brands to provide a lot of choice', was the more frequently cited theme and was mentioned by three participants. One participant spoke about the lack of choice she experienced when bra shopping:

I would get the same bra every time I went I'd get the same bra. If I was very lucky I might get a black and a white, but normally just a white.

Some participants felt that the choice within brands and shops had improved in recent years:

Some shops seem to have much less choice don't they, John Lewis has a lot of bras but normally before they would only offer me two or three. Whereas nowadays especially at Marks at the Meadows I mean there is so much choice there, I mean you get a choice there better than anywhere else.

3.3.4 Breast Support

The general dimension breast support contains three higher order themes: *to provide uplift*, *to give general support* and *to overcome breast sag* (Figure 4). These three themes entail all comments by participants that incorporate aspects of breast support. The most common raw data theme within the higher order *overcoming breast sag* was 'gravity has had an affect' which was mentioned by six participants. One participant discussed the sagging she had experienced in her breasts with ageing:

Oh they have changed a bit, I don't know if it's so much sagging as, somehow not being so rounded. You know they're not firm, and it's the top half that seems to be flatter, and that has the effect of sagging. I think the substance goes from the top half of the breast.

In regard to how participants felt this age related breast sag affects their bra requirements, one participant stated:

They (her breasts) need more support rather than doing it naturally, so I would have a more supportive bra than I would have had when I was younger. I think my taste in bras has changed because my breasts have changed, my requirements are now different to what they would have been in my twenties.

To combat this breast sag, women reported relying upon bras to provide uplift. The most commonly cited raw data theme within the higher order *to provide uplift* was 'liking ones breasts to be "hoisted up"' and was mentioned by nine participants. A participant discussing her bra preferences stated:

I like to have uplift obviously, rather than just, one that, reminds me if I put something on over that I'd look like my granny.

This verbatim quotation shows the importance of bras providing sufficient uplift, and the negative influence insufficient uplift can have. Another participant claimed she wanted so much uplift that her breasts be “round my ears preferably”. Three participants defined uplift and support as the same variable. However, others described support in regard to their breast movement.

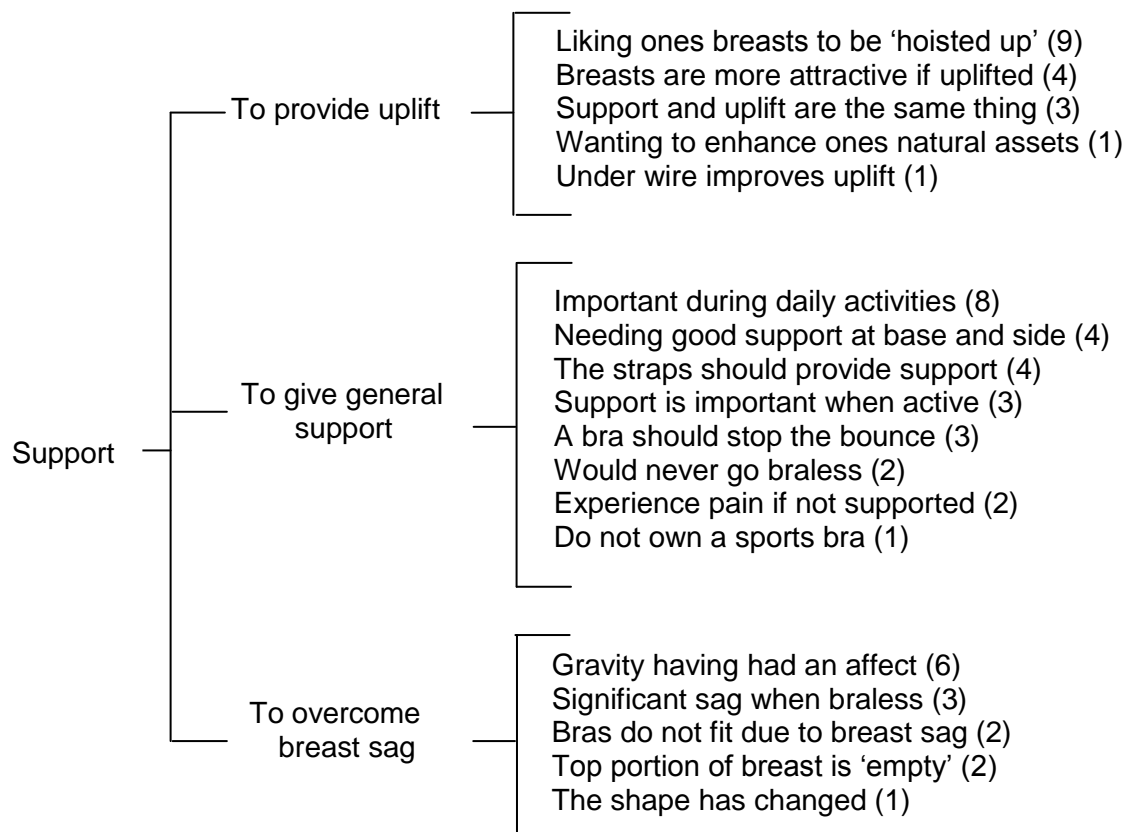


Figure 4. Breast Support. Higher order themes are ranked in order of mean number of citings per raw data theme (number of participants citing raw data themes can be seen in the last column) (n=13).

The most common raw data theme within *to give general support* was ‘important during daily activities’ and was mentioned by eight participants. Women stated that during daily activities the bra should support “at the top and the sides” in particular. The following quotation reflects the importance of breast support:

She’s got a bra that fits well so she’s not wobbling around, she’s supported. I think that’s important for me, that it’s supportive. Support for me is absolutely the most important thing in a bra.

3.3.5 Psychological Aspects

The general dimension of Psychological Aspects includes all psychological factors that affect bra habits, higher order themes were: *improving self confidence*, *avoiding being fitted*, *altering the perceptions of one's body* and *shop assistants influence on purchasing* (Figure 5). Participants typically related preferences within other general dimensions with a psychological reason. For example, within the higher order theme of *not being measured*, the most common reason was 'feeling embarrassed' and was mentioned by four participants.

Well the thing that's just occurred to me about this measurement thing is embarrassment, and the feeling that somehow once you've been measured you're somehow honour bound to buy something

Similarly, within the higher order theme *shop assistants influence on purchasing*, participants most frequently mentioned their experience of bra fitting and its influence on the possibility of them purchasing a bra. One participant reports her most recent experience of being professionally measured:

The lady brought me things that were totally not to my size and I went out without anything because I was being squeezed into things that weren't fitting at all and I was quite annoyed actually. Maybe it was just the lady I had, but she was determined I was a particular size because that's what my measurements said, and the fact that I was hanging out at the sides and the top didn't seem to matter.

Indeed, another participant questioned the training that 'bra fitters' were given:

Some staff seem much better trained, sometimes you just see, perhaps this woman has been on the food counter and then she's on bras and you think how much does she really know about it?

The most frequently cited theme within the higher order *to improve self confidence* was the way in which they 'feel better with a good bra'; this was mentioned by three participants. One woman described the way she wanted her bra to make her feel:

I want to feel glamorous. It's not exactly glamorous, but feeling good. Feeling you're looking your best.

The only theme within the higher order theme *altering perceptions of one's body* is, 'disliking the appearance of large breasts'. One participant describing herself as having 'large breasts' explained how this detracted from her appearance and desired a bra to minimise her bust:

I get quite upset sometimes about the size of my bust compared to the rest of me, I feel I look like a walking bosom.

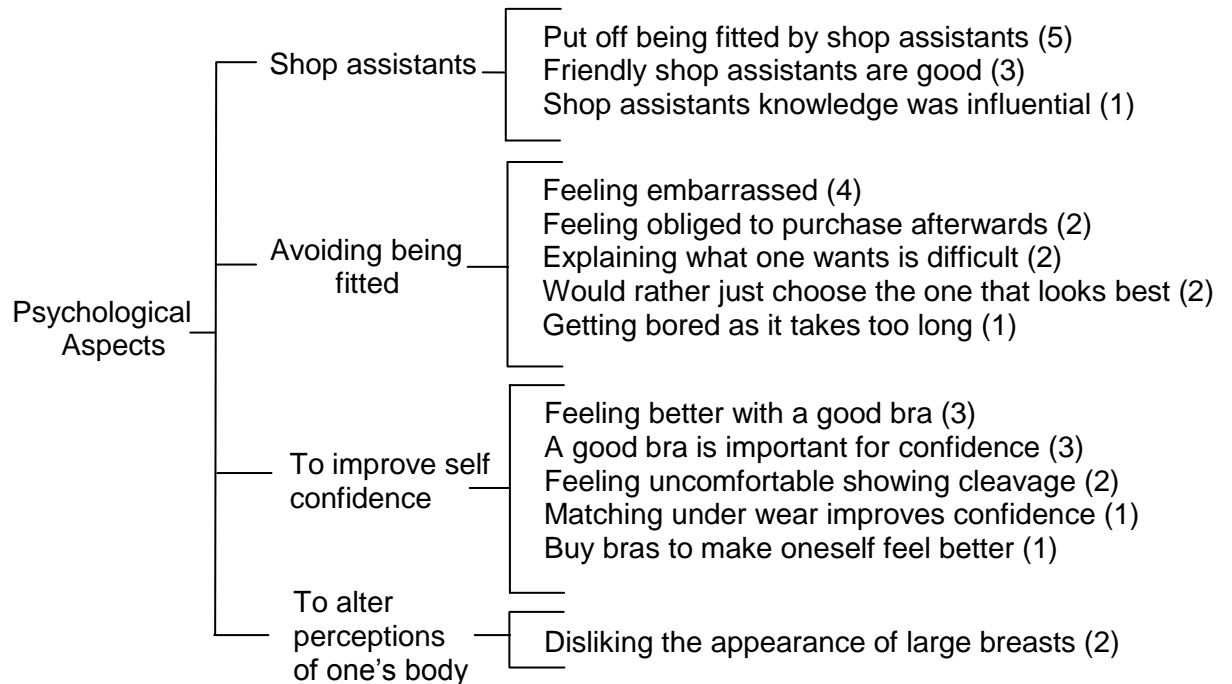


Figure 5. Psychological aspects. Higher order themes are ranked in order of mean number of citations per raw data theme (number of participants citing raw data themes can be seen in the last column) (n=13).

3.4 Discussion

The aim of this study was to explore the bra related attitudes, beliefs and experiences of women aged 45 to 65 years and develop a greater understanding of this population's bra preferences. These aims were met as the results show a variety of bra related factors that may influence women's bra purchasing; supporting previous literature (Hart & Dewsnap, 2001, Kim et al., 2004). Not only are variables directly related to the brassiere of importance (support, comfort and aesthetics), it is also apparent that variables relating to the purchasing process and psychological aspects are influential in brassiere preferences. The general dimensions identified were, in order of frequency: *aesthetics*, *comfort*, *practicalities*, *support* and *psychological aspects*.

The general dimension *aesthetics* demonstrates women's desire to appear outwardly attractive, with issues such as figure, breast shape and appearance in clothes as higher order themes. This is consistent with previous research that considered the influence of breast shape on figure and clothing (Godwin et al., 1998); however, this study was on post surgery outcomes rather than within the general population. Similarly, Hart and Dewsnap (2001) found that women discuss bras in relation to the affect they may have on the contour of clothing. It is

evident that the bra's ability to fit the shape and design of clothing is vital to produce the desired overall look because many women equate bras with outward appearance (Singer & Grismaijer, 2006).

Many participants felt they were forced to forfeit the bras attractiveness in order to achieve the necessary support. Indeed, one participant stated she could not purchase a bra with lace because all lacy bras lacked criteria that she prioritised more highly, such as support and good fit. Participants require an assortment of variables to be suitable before a brassiere may be deemed appropriate. When asked about the level of support required for everyday activities, one participant responded that she wanted "maximum support for minimum coverage", suggesting she wanted the bra to be both attractive and supportive. Unfortunately, one other participant described these two factors as 'mutually exclusive' and believed no brassiere could be sufficiently supportive and attractive. This indicates that participants were dissatisfied with the current bra market and could not find a bra that fitted all the criteria they desired. This finding contradicts suggestions from Page and Steele (1999) that modern bra designs are both functional and attractive. However, it confirms more recent findings that indicate women felt they must sacrifice either comfort or the bras attractiveness (Dewsnap & Hart, 2001). The optimisation of bras for older women warrants investigation to ensure all of their requirements are being met.

The colour of bras was discussed, with 11 women out of 13 stating they only owned conservative colours. Interestingly, Sukumar (2007) reported that every bra colour portrays a social message; colours associated with youth include pink, purple and yellow, whereas white, black and off-white are preferred by older women because they seek comfort in neutral colours. Women's opinion on the attractiveness of a bra can be affected by its colour, a report on one woman's feelings about her old bras referred to the 'ghastly pink' colour they were (Paulson & Willig, 2008). The negative feelings about her old bras are predominantly formed by memories of its colour, the influence of colour on a bras appropriateness for older women may therefore warrant investigation.

The majority of participants stated that comfort was the most important thing, and their favourite bra was simply the most comfortable. Higher order themes within the general dimension *comfort*, such as underwiring, shoulder straps and fabric,

are consistent with the findings of previous publications regarding sports bras (Page & Steele, 1999). Participants required an appropriate width and placement of shoulder strap so it did not dig in or slip off. Page and Steele (1999) suggested that straps need to be positioned in line with the nipple to best support the force, however, due to the lateral migration of the breast with increasing age; this may not be suitable in women aged 45 to 65 years due to increased likelihood of the straps slipping off. Changes in thoracic posture with increasing age have been found to include shoulder length, shoulder angle and thoracic kyphosis (Ashdown & Na, 2008; Chen et al., 2010). These postural alternations were found to affect the perception of bra fit, emphasising the importance of a more specialised bra design for older women to improve bra fit and minimise bra straps slipping off the shoulders.

Underwiring is also a consideration, the majority of women reported preferring underwired bras provided the wire did not dig in. Page and Steele (1999) suggested underwiring may chafe and irritate if it is not entirely covered with fabric. The brassiere is typically worn in direct contact with the skin for over 12 hours a day (Singer & Grismaijer, 2006), the constitution of the fabric is therefore important to ensure comfort and avoid chafing. Previous research is limited and non-specific when assessing different fabric types, however Paek (1983) described cotton as a 'wonder' fabric and regards it as comfortable, indeed 'cotton is best' was a raw data theme within the general dimension *comfort*. Regardless of fabric, literature suggests that if a bra does not fit properly it may cause discomfort due to protrusions into the breast (Page & Steele, 1999). Indeed bra fit was a higher order theme within *comfort*, with participants suggesting that a good fit is important, but many also reporting difficulty finding a well fitting bra.

The general dimension *practicalities* incorporates factors that are not directly linked to the bra itself, but imply the influence of the purchasing process in bra preferences. For example, 11 of the 13 participants reported always purchasing their bras from the same shop, of which eight participants reported purchasing the same bra every time. This supports previous research that indicates repeat purchasing is common and that women bulk buy the same bra for fear that it may be discontinued or become unavailable (Dewsnap & Hart, 2004; Yip, Law, & Wong, 2007). Despite this, raw data themes show women want a greater choice

of bras. This information suggests that brassiere manufacturers and retailers may have difficulty in converting women of this age to choosing a different product.

With regard to the higher order theme affordability, the results show that price was an influential factor for some women, although five participants stated they would pay a substantial amount if they found the perfect bra. Price has previously been cited as a concern for women when purchasing bras, particularly so for the less fashion conscious woman (Yip et al., 2007). The importance of price is consistent with the suggestions of previous literature regarding younger participants (Ross & Harradine, 2011). However, two participants in this study stated they spent less on bras when they were younger, there may be changes in the importance of price with increasing age, although it is unknown if the participant's socioeconomic status may have changed. Affordability was linked to the quality of the bra, with one participant stating "if you buy it cheap, you buy it twice". Manufacturers should therefore consider the compromise between costing and quality, as literature has questioned whether older consumers are prepared to spend their disposable income on goods and services (Szmigin & Carrigan, 2001). The influence of price in bra purchasing among different age groups and socioeconomic groups of women is unknown, future research could explore this topic in order for retailers to develop appropriate pricing strategies.

The results of this study concur with previous literature on bras by demonstrating that sufficient breast support is also an important factor in everyday bras for women aged 45 to 65 years during daily activities (Gehlsen & Albohm, 1980; Lorentzen & Lawson, 1987; Mason et al., 1999; Scurr et al., 2009; Starr et al., 2005). The higher order theme 'overcome breast sag' indicates participant's acknowledgement that their breasts have changed due to ageing and the requirements of a brassiere have therefore changed. This finding supports Sukumar's (2007) research that suggests different ages should be wearing different types of brassieres due to anatomical changes, and highlights the importance of research in this area.

Despite the importance of wearing an appropriately fitting bra (Page & Steele, 1999; White & Scurr, 2012), many participants mentioned avoiding being professionally fitted due to embarrassment, feeling obliged to purchase afterwards

and difficulty explaining needs to the bra fitter. The higher order theme *shop assistants* also reflects the influence that employees in the shop can have on bra fitting and purchasing. It may therefore be important for stores to hire knowledgeable and friendly shop assistants to ensure women aged 45 to 65 years return to their shop (Yip et al., 2007). Raw data themes including 'a good bra is important for confidence' and 'bras should be appropriate to body type' are consistent with health psychology research that suggests older women feel uncomfortable in the wrong clothing (Birtwistle & Tsim, 2005; Paulson & Willig, 2008). This indicates that brassieres should be suitable for every individual and catered to the needs of older women in particular to enable them to feel psychologically comfortable (Sukumar, 2007).

The methods used within this study are frequently implemented as a qualitative research tool in a variety of areas and are a valuable tool in breast related literature. Despite the valuable insight provided by such techniques, there are some inherent limitations when attempting to apply and generalise such findings. Focus groups and interviews are extremely time consuming, this often leads to small participant numbers. This study reported exploratory results from thirteen participants, it is therefore necessary to investigate further on a larger sample number prior to confirming key performance variables. Literature does not indicate the optimum approach to collecting qualitative data; it is only advisable that a variety of methods should be conducted when discussing sensitive topics such as brassiere requirements (Jones et al., 2002; Wacherbarth et al., 2002). However, the lack of use of qualitative methods within breast health research means that the findings of this study advance knowledge in the area. The equivalence of data collected from interviews and focus groups is unknown, although previous research has combined results of both and summed the participant numbers (Jones et al., 2002). Differences in data provided in focus groups and interviews may indicate whether the sensitive nature of discussing bra requirements causes an omission of information or elicits greater response during a group environment, the results of such a study could influence future methodology within this research area, by identifying the method which produces the richest data. However, this was not the aim of the current study.

Exploratory methods have been criticised due to the complex nature of the data produced, causing an inherent inability to define the key consumer insights that are of greatest importance (Dewsnap & Hart, 2004), subsequent methodologies are often required to determine key information from the content analysis. In addition to ageing, physiological changes to the breast caused by hormonal differences may impact upon bra consumer behaviour (Rosen, 2001); variables such as puberty, pregnancy and breast feeding were not appropriate to this cohort and therefore were not within the scope of this study, but are areas of interest for future research.

3.5 Summary

This qualitative investigation of older women's bra requirements has identified problems with bra provision for this cohort, confirming the primary rationale for this thesis. The results suggest that women aged 45 to 65 years are aware of changes in their breasts with age, and both their requirements and preferences for bras have altered as a result. This supports the assumption by Sukumar (2007) that different ages should be wearing different types of brassieres due to anatomical changes.

This chapter explored the bra requirements of women aged 45 to 65 years and identified factors that are considered important for an appropriate bra, the factors were; aesthetics, comfort, support, practicalities and psychological aspects. The results suggest that bra requirements are multifaceted, thus providing implications for the brassiere market. Anecdotally, most raw data themes regarding brassiere variables were identified by the participants with reference to 'improved self-confidence', therefore, by optimising the general dimensions and themes, self-confidence may be improved. From an applied perspective, it is important for manufacturers to consider the priorities of different populations so that brassieres are optimum for every wearer. Having qualitatively established influential bra related factors for women aged 45 to 65 years, this programme of research progresses to quantify and rank the importance of these variables across a larger sample of the population. This is an important subsequent step in order to distinguish the key bra performance variables from the numerous extraneous variables cited within this qualitative study, providing valuable information for future fundamental studies on the bra requirements of older women.

Chapter 4.

Identifying key bra performance variables: A survey based study

4.1 Introduction

Chapter three presented the findings from a qualitative exploration of the bra preferences of women aged 45 to 65 years, yet it remains unclear which of these data themes are of key importance to this population. The findings from the study presented in chapter three reflect a broad view of influential factors, these included; the importance of the bra fitter's knowledge, breast changes with age and lack of time when shopping. Indeed, many of the emergent themes identified in chapter three did not directly relate to bra performance and thus, gave little indication of a bra's suitability to women age 45 to 65 years following purchase. In order to determine how appropriate current bras on the market are for women aged 45 to 65 years, it is necessary to understand the importance of key variables that affect the consumer when wearing a bra. Such information will assist the development of the most appropriate methods to test the suitability of bras for this population.

A study by Liang (2008) involved women aged 16 to 61 years, and found that older women are more influenced by the material and brand of a bra; however, the method of establishing this claim is unclear in the document. Liang's (2008) study supports the overarching rationale of this thesis by suggesting differences in bra preferences among different age ranges. Yip et al. (2007) investigated the bra habits of Chinese women aged 18 to 35 years and found that purchasing variables included functional and aesthetic concerns irrespective of fashion consciousness. Fit, quality, price, style and store atmosphere were deemed to be the most important variables when purchasing a bra (Yip et al., 2007). Liang (2008) suggested that the functional properties of a bra are more important than visual properties, suggesting that women would prioritise fit, comfort and support over style, colour and brand. However, both studies distinguished two key variables; functional and aesthetic bra related concerns, the importance of which may be influenced by the wearer occasion, including sport, special and ordinary (Dewsnap & Hart, 2004; Liang, 2008; Yip et al., 2007).

Adequate bras have been described as being made of a strong, non-abrasive material (Haycock et al., 1978). Indeed a survey study of 56 university students

discovered that cotton was the preferred material due to its non-allergenic properties (Paek, 1983), indicating the importance of fabric type. Elsewhere, cost and appearance have been cited as important bra performance variables in women aged 18 to 40 years (McGhee & Steele, 2006). However, these results cannot be generalised to populations outside this age range, indeed the majority of studies have revolved around collegiate athletes and sports bras rather than the general population and everyday bras (Lorentzen & Lawson, 1987). This presents a gap in the literature where the key bra performance variables of older women in everyday bras are unknown.

Kim et al. (2004) studied everyday bras among women aged 30 to 40 years and determined a list of criteria that women wanted from a bra with a corresponding importance rating for each of those variables. Kim et al.'s study utilised a questionnaire to determine the ratings of importance for each bra variable, however, their cohort for the questionnaire included just 30 participants, which is substantially lower than questionnaire based studies are advised to recruit (Hinkin, 1995). Importance ratings were provided; however, no unit or description of the scale used is provided, therefore, the numbers cannot be interpreted or compared to other literature. This limits the applications of Kim et al.'s findings, as the prioritisation of key variables above others must be considered. For example, if one bra is rated worse than another for a particular variable, but the customer's importance rating of that variable is low, it may not be cost effective to spend resources improving that variable (Kim et al., 2004).

The aforementioned studies indicate bra related factors that are of importance to a variety of age ranges, however, with the exception of Kim et al.'s (2004) study, determining the performance variables of a bra was not the main aim of these studies, and therefore the variables are mentioned only in brief. Subsequently, previous research fails to distinguish which factors are most important to the appropriate performance of a bra. The key bra performance variables for women aged 45 to 65 years are therefore unknown, and must be distinguished from extraneous variables within the extant literature and within the findings presented in chapter three of this thesis.

Therefore, the first aim of this study was to assess the most important bra performance variables which determine its suitability for women aged 45 to 65 years. In accordance with previous research, a survey was used to gather data from a large sample of the population (Barrett & Kirk, 2000; Birtwistle & Tsim, 2005; Yip et al., 2007). This study also aimed to identify factors that may influence ratings of those performance variables and current bra wearing habits, these factors were: age, cup size, band size, HRT use and parity. This information advances knowledge in the area by providing a list of key bra performance variables for women aged 45 to 65 years which will ensure future research is focused on the relevant features of the bra when assessing the appropriateness for older women. It was hypothesised that:

H₁. There will be a significant relationship between the factors age, cup size, band size, HRT use and parity, and the bra preferences included in the survey.

H₂. There will be a significant relationship between the factors age, cup size, band size, HRT use and parity, and the bra style worn by a woman.

4.2 Methodology

A survey was used to allow a large sample to be obtained with standardisation of questions and minimum participant time requirements. The use of a survey also permitted a representative data set of women aged 45 to 65 years due to high participant numbers (Barrett & Kirk, 2000; Gillham, 2007; Litwin, 1995). Key themes identified in preliminary methods are useful in the survey design process, particularly for specific populations (Caplan, 1990; Krueger, 1998; Barrett & Kirk, 2000; Gillham, 2007). Therefore, information gathered in chapter three of this thesis contributed to survey content validity by ensuring a more extensive understanding of the population and an insight into the optimum wording of questions, therefore reducing the potential for misunderstanding in responses (Morgan & Spanish, 1997). Maximising response rate is critical when implementing surveys. A respondent friendly survey design (defined as a form that is easy for participants to complete, avoids confusion, and does not result in negative emotions towards the survey) and correct survey length will illicit optimum response rates (Dillman, Sinclair & Clark, 1993).

4.2.1 Ethical Approval

This study received ethical and scientific approval from the BioSciences Research Ethics Committee, in accordance with current University regulations.

4.2.2 Survey Development

Due to the absence of research in this area, it was necessary to design a new survey to evaluate bra performance variables. The survey used was developed in accordance with Hinkin's (1995) theory on scale development. Survey items were generated using a combined method of both inductive and deductive development, which has been shown to be the optimum method for capturing the area of interest, yet omitting any extraneous variables (Hinkin, 1995). Using the findings from chapter three, the variables were selected for inclusion in the survey. Deductive reasoning involved a thorough literature search to discover any items that may have been important to other age groups of women. For example, using strong and non-abrasive material was cited as important in sports bras (McGhee & Steele, 2006), therefore a question was included regarding the importance of appropriate fabric in an everyday bra. In order to develop an understanding of the sample population and observe factors which may influence key bra performance variables or current bra wearer habits, questions regarding respondents demographics, purchasing habits and bra fitting history were also included (Bowles, Steele, & Munro, 2008; Liang, 2008). An information sheet was included at the start of the survey, which included an explanation of the survey, listed the inclusion criteria, and stated that 'By completing this survey you are giving consent for the information you provide to be included in a study on the bra needs of women aged 45 to 65 years' (see appendix B).

Once items for the survey had been generated, an appropriate question format was chosen (Hinkin, 1995). A combination of selected responses (tick a box), specific responses (written answers) and scaled (rate on a scale of 1 to 5) questions were used. The variety of question formats reduces response fatigue and maintains respondent's interest in the survey, thus increasing response rate (Gillham, 2007). Based on the literature of survey scales, numerical analogue scales with extreme value descriptors were selected to assess the importance of performance variables. This form of scale was used as it is believed to hold greater responsiveness and indicates greater equality in distance between values than Likert descriptors (Gillham, 2007; Hasson & Arnetz, 2005). A scale length of one to five was selected in order to minimise confusion, maintain sufficient sensitivity and reduce response fatigue for participants, therefore maximising response rate (Hasson & Arnetz, 2005; Hinkin, 1995). This scale format also

matches those previously used in breast related surveys (Kim et al., 2004). An example of the scale is shown in figure 6. The use of an odd scale length provides a 'neither/nor' option which may create some redundant responses, but had been shown to reduce the possibility of social desirability bias (Garland, 1991), whereby participant may be neutral, but select the option that they feel the researcher requires. Questions were kept as simple as possible in order to minimise participants misunderstanding of questions and making incorrect inferences about the answers (Gillham, 2007). In accordance with survey recommendations (Frazer & Lawley, 2000), the questions were displayed in two columns on each page, in sanserif typeface, no questions were split between pages and all options were in a vertical arrangement in bold font. Headed paper was also used for all surveys to give a more trustworthy and scientific appearance (Gillham, 2007) (see appendix B).

Extremely					Not at all
5	4	3	2	1	

Figure 6. Numerical analogue scale used to assess key variables

A pilot test of the study was carried out in order to highlight any misleading questions, predict the time taken to complete the survey and to measure the test-retest reliability of the survey design (Hinkin, 1995). Eleven students and staff from the University of Portsmouth were recruited for pilot testing and validation of the survey. Pilot testing did not require participants to meet the inclusion criteria. Participants were recruited via convenience sampling. Pilot participants completed the survey on two separate occasions at least 24 hours apart, this ensured that the high agreement between trials was unlikely to be due to participants recalling their previously selected options, but did not allow time for a change in opinion (Dawson, Fitzpatrick, Murray, & Carr, 1998; Melzack, 1975). Results from the pilot survey were quantified using the numerical analogue scale questions; factual questions, such as number of children and breast feeding history, were not included in the reliability analysis due to the objective nature of the questions and anticipated accuracy of participant responses, but were visually checked for conflicts, of which none were found. Typical error of measurement (TEM) was calculated as 0.53 (equating to approximately half a rating on the 1 to 5 scale), using the common equation: $TEM = SD_{diff} / \sqrt{2}$ (Hopkins, 2000; Weir, 2005). Standard deviation expressed as a percentage of the mean resulted in a mean coefficient of

variation (CV%) of 8%, a change in mean of 0.13 was found (Ball & Scurr, 2010; Hopkins, 2000; Weir, 2005) A significant intraclass correlation coefficient of 0.88 ($p < 0.0001$) was also calculated. As the TEM and CV% were less than a rating different on the five point scale, and the correlation coefficient was high, the five point numerical analogue scale was deemed to have an acceptable level of reliability. A trained individual and a woman that met the inclusion criteria examined the survey for important omissions or inappropriate wording of items (Litwin, 1995). The approximate time taken by participants to complete all answers was ten minutes (Frazer & Lawley, 2000). As a result of the pilot study, changes made to the survey included adding the statement 'This survey should take no longer than ten minutes to complete.'. Two questions were re-worded to clarify their meaning, and four additional questions were added based on the feedback.

4.2.3 Survey Implementation

Participants were recruited via personal contacts and subsequently through word of mouth. In addition, an advertisement was sent through the University of Portsmouth intranet in order to recruit further participants, subsequently some surveys were emailed to participants, enabling them to easily forward the survey to friends and family. Thus a snowball sampling method was used, this method is believed to be more in-depth and a better representation of the population when real-world behaviour is of interest rather than an intervention (Gray, Williamson, Karp, & Dalphin, 2007; Wright & Stein, 2005). To help maximise response rate, surveys were posted and included a prepaid addressed envelope to return the completed survey (Dillman et al., 1993). Many surveys were returned with contact details included for a friend or family member wishing to participate. All participants met the same inclusion criteria as stated in chapter three.

In line with the extant literature in this domain, a minimum sample size of 76 participants was set (Carmichael, Bashyan, & Nightingale, 2006). This is the minimum number of participants previous survey based studies on breast health have used, however this increased to 450 women (Khan & Apkarian, 2002). A total of 260 surveys were sent out to potential participants, of which 208 usable responses were returned, resulting in a valid response rate of 80%. A further three surveys were returned blank, one respondents was aged 44 years and two had experienced some form of breast surgery and therefore did not meet the inclusion

criteria for this study. Responses came from a wide geographic area across the United Kingdom, from Manchester to the South coast (approximately 250 miles).

4.2.4 Data Analysis

Participant demographics and bra usage are presented as means and standard deviations of the appropriate units, results of scales are expressed as percentage of participants in each response group (Godwin et al., 1998). The numerical analogue scales within this study provide ordinal data, which by definition has a rank that is not assumed to have equidistant intervals (Jamieson, 2004). The calculation of central tendency when analysing ordinal scales suggest the mode is the optimum descriptor, rather than the mean which is frequently used inappropriately (Blaikie, 2003; Clegg, 1998; Jamieson, 2004). Key bra performance variables were therefore determined using the modes from the numerical analogue scales (1 to 5) (Blaikie, 2003; Clegg, 1998; Garland, 1991; Jamieson, 2004). It has been suggested that numerical analogue scales show directionality of opinion, rather than finite values, therefore variables with a mode of four or five are deemed important and rated as key performance variables, those with a mode below this are deemed unimportant (Garland, 1991; Liu & Arnett, 2000). If participants left a question blank or their response was unclear it was omitted as a missing value prior to analysis in order to avoid unreliable results (Gillham, 2007).

Principal component analysis (PCA) with varimax rotation (v16.0; SPSS Inc., Chicago, IL, USA) was conducted on the numerical analogue data in order to observe any commonality between variables. Prior to performing PCA, the suitability of data for factor analysis was assessed. The correlation matrix displayed numerous coefficients of .3 and above, the Kaiser-Meyer-Olkin measure of sampling adequacy value was 0.78, exceeding the recommended value of 0.6 and the Bartlett's test of Sphericity (Bartlett, 1954) was statistically significant ($\chi^2_{(105)} = 755.109, p = .000$), supporting factorial analysis of the correlation matrix. Following factor analysis, Spearman's rho correlations of the revealed factors with age, cup size, band size, HRT use and parity were conducted. A strong correlation was defined as a coefficient of greater than 0.5, moderate as between 0.5 and 0.3, and a weak correlation defined as below 0.3 (Cohen, 1988; Field, 2009). These variables were selected based on their potential influence on the

anatomy of the breast. Variables that are not influential to breast anatomy, such as bra purchasing history, were not included in statistical analysis.

Binary logistic regression was conducted on dichotomous questions regarding underwire, padding, lace, and sport bra use, in order to observe the influence of the predictor factors age, cup size, band size, HRT use and parity. All interactions had significance values greater than 0.05, indicating that the assumption of linearity in the logit had been met in all predictor variables within all outcome variables. All Durbin-Watson coefficients were within a 1.9 to 2.2 range, showing no autocorrelation was present between residuals of variables, thus independence of errors was confirmed (Field, 2009). The assumption of multicollinearity was checked using VIF values and tolerance values, which were all below ten and above 0.1, respectively. Cross tabulations were also checked for values below five, which were minimal. Therefore, the assumptions of binary logistic regression were met and the forced entry method was used due to its appropriateness for theory testing (Field, 2009; Pallant, 2005). Odds ratios of 1.5 were considered weak, of 2.5 were considered moderate and of 4 or above were considered strong (Rosenthal, 1996).

4.3 Results

4.3.1 Participant Demographics

The 208 respondents spanned across the entire 20 year age range (mean 56.28 ± 5.68 years); self reported body mass averaged 67.89 ± 12.08 kg. The majority of women were post menopausal (69%, $n=143$), pre and mid menopausal women were near equal in number (14%, $n=29$ and 16%, $n=32$ respectively). 11% (22) of the women were taking HRT. Reported bra sizes ranged from band size 32 to 44 inches and cup size A to J (32A to 44C and 32A to 38J respectively) with a mode bra size of 36C.

Average number of pregnancies was two (44%, $n=91$) and 86% ($n=152$) of women that had had a child breast fed for an average of six months. 12% ($n=25$) of women that responded had had no pregnancies. The majority of women reported themselves as being moderately active (53%, $n=109$) but 56% ($n=116$) of participants did not own a sports bra and most experienced no mastalgia (82%, $n=171$). Of those that did suffer with mastalgia, 63% of participants did nothing to relieve their mastalgia, 17% home treated with paracetamol, 10% took evening

primrose oil capsules which are reported to help ease mastalgia in 52% to 69% of women (Davies et al., 1998), and just one out of all the women suffering with mastalgia had been to her doctor.

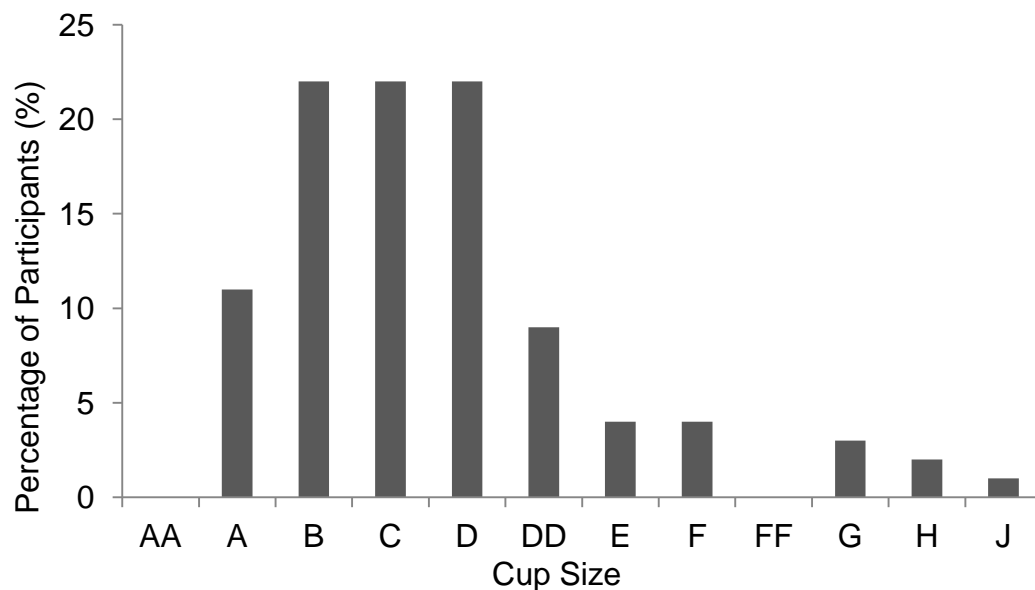


Figure 7. Percentage of participants of each self reported bra cup size (n=208)

When asked whether they had noticed any change in breast size since the age of 45 years, the majority of women reported an increase in size (51%, n=106). However, 39% (n=80) reported no size change and just 10% (n=21) reported a decrease in size. 20% of participants stated they noticed no significant change in their breasts since the age of 45 years, therefore four out of five women noticed some change in their breasts through ageing. When asked what the key change had been in their breasts since the age of 45 years, the top three verbatim responses were sagging (28%), an increase in size (24%) and feeling less firm (10%). These responses are noteworthy because this question was open ended and provided no list of options to choose from.

4.3.2 Bra Usage

In order to assess the UK bra market for women aged 45 to 65 years participants were asked which brands they had worn in the past 6 months, in the past 5 years and which brand they wore most often. Figure 8 shows the percentage of participants that have purchased each bra brand within each time frame.

The majority of participants reported having their bra size measured over a year ago (32%, n=66), 21% (n=44) had never been measured and 15% (n=30) could not remember how long ago they had been measured. Most women reported

purchasing a new bra every 6 months to one year (71%, n=146), resulting in a ratio of two to three bras purchased for each bra measurement. Nearly half of all participants (47%, n=96) reported that they had difficulty finding the bra size they needed when shopping. The average bra design worn was underwired (77%, n=158) and non-padded (71%, n=145). Approximately half of the respondents reported that the majority of their bras were lacy (49%, n=100) and that they owned different daytime and evening bras (49%, n=100). When asked if they would have worn their current bras in their twenties, less than half (43%, n=88) said no. Interestingly, when asked if they would now wear the bras they had worn in their twenties, 62% (n=126) said no.

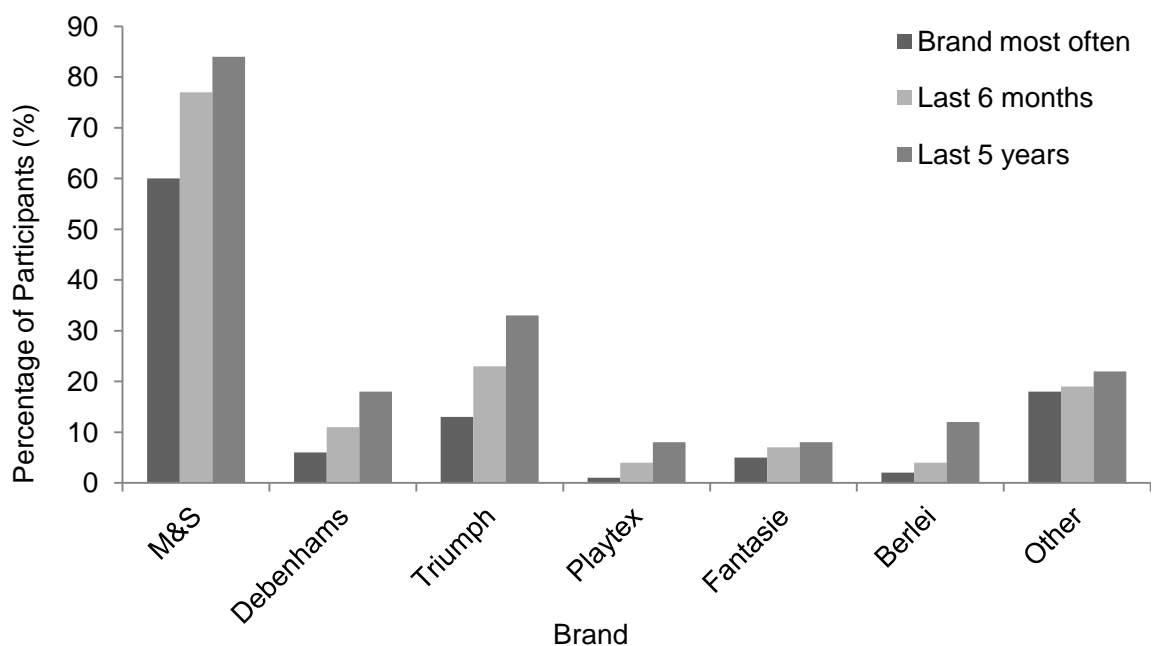


Figure 8. Percentage of participants who had worn each brand in the last 6 months, last 5 years and most often (n=208).

4.3.3 Key Bra Performance Variables

Table 1 shows the participant ratings from the numerical analogue scale questions. Bra performance variables are presented from the greatest to least percentage of participants rating each criterion important.

Table 1. *Ratings of key bra performance variables in order of percentage of participants rating the variable as important (n=208)*

Performance Variable	Mode	% rating as important	% rating as neutral	% rating as unimportant
Comfort	5	98.5	1	0.5
Stays in Place	5	97.1	2.9	0
Fit	5	93.3	5.3	1.4
Under clothes	5	86.1	9.1	4.8
Support	5	83.6	10.1	6.3
Discreet	4	80.1	15.5	4.4
Straps	4	73.0	21.3	5.7
Silhouette	4	76.5	16.8	6.7
Shape	4	76.2	19.4	4.4
Fabric	4	66.3	19.3	14.4
Lift	4	62.1	28.6	9.3
Colour	3	43.2	35.9	20.9
Price	3	40.9	42.3	16.8
Under wear	1	23.6	25.5	50.9
Brand	1	12.1	24.1	63.8

Principal component analysis (PCA) was conducted on these 15 bra performance variables. The Eigen values produced indicate the magnitude of the influence of each component and are used to determine the number of these components to be used in subsequent analysis. Principal component analysis revealed four components with Eigen values above one, explaining 24%, 15%, 10% and 8% of the variance respectively. Parallel Analysis (Field, 2009) showed three components with Eigen values exceeding the corresponding criterion value for a randomly generated data matrix of the same size (15 variables x 209 respondents). However, the third component was not greatly above the criterion value of Parallel Analysis (defined as 1 in Field, 2009) and inspection of the Scree plot revealed a turning point at the third component (figure 9), it was therefore decided that two factors would be included in further analysis.

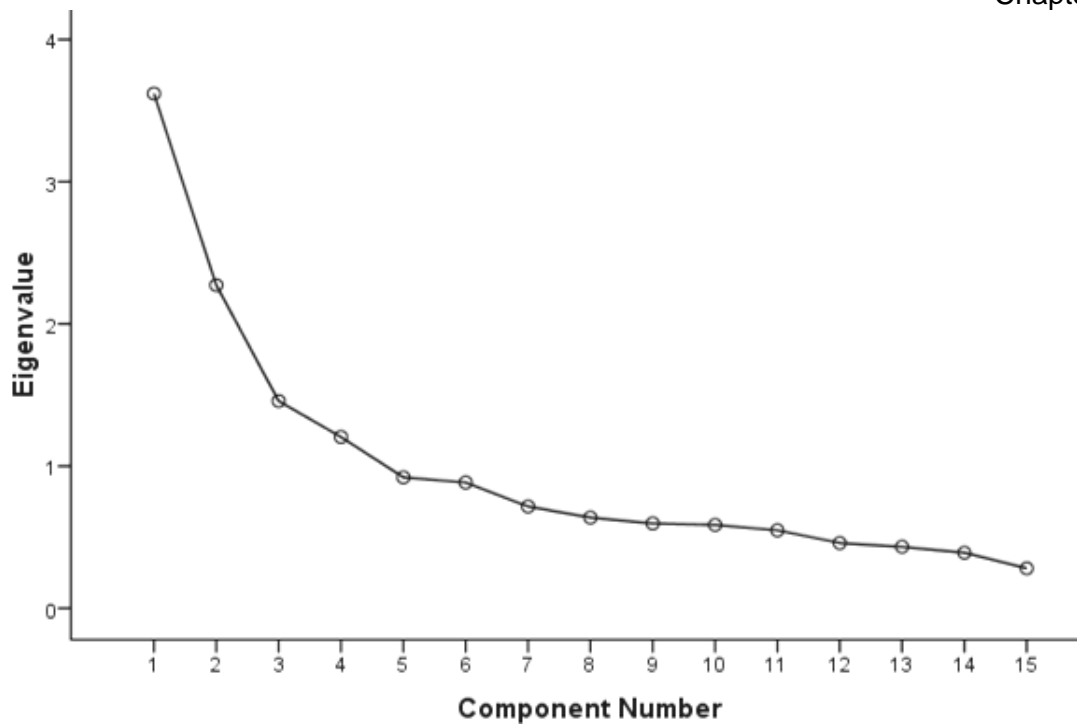


Figure 9. Scree plot produced during principle component analysis revealing a turning point at the third component, indicating that two components should be included in subsequent analysis.

Table 2. *Principal component analysis using varimax rotation of a two factor solution for bra performance variables. The higher the value, the greater loading the variable has on that factor (n=208)*

Variable	Factor	
	1	2
Silhouette	.799	
Appearance under clothes	.737	
Shape	.721	
Colour	.649	
Under wear	.553	
Lift	.504	
Price	.397	
Support		.733
Comfort		.727
Fit		.784
Stays in Place		.597
Straps		.530
Fabric		.456
Discreetness		.353
Brand		.335
Total variance explained		
24% 15%		

Varimax rotation revealed a simple structure (Field, 2009), with all variables loading predominantly on either factor. The two components explained a total of 39% of the variance, with component one contributing 24% and component two contributing 15%. Items regarding the wearer's perception (support, comfort, fit, stays in place, shoulder straps, fabric, discreetness, and brand) load strongly on factor two, whereas items regarding other's perception (silhouette, appearance under clothes, shape, colour, underwear, lift, and price) load strongly on factor one. The factors will therefore be interpreted as 'internal' and 'external' bra related factors respectively.

In order to determine whether there was a significant relationship between age, cup size, band size, HRT use and parity, and their rating of the two factors, Spearman's rho coefficients of factors one and two correlated with age, cup size, band size and parity were conducted. Table 3 shows only a weak significant relationship between cup size and internal bra related factors.

Table 3. *Correlation coefficients of factors one and two with age, cup size, band size, HRT use and parity (n=208)*

	Factor 1 (external)	Factor 2 (internal)
Age	.052	.065
Cup Size	-.045	.169*
Band Size	-.034	.093
HRT use	-.080	-.012
Parity	.040	-.003

Note: *= $p < 0.05$

In order to determine whether the same factors influenced the bra style worn, binary logistic regression was conducted using the forced entry method for underwiring, padding, lace and sport bra use, with the predictor variables age, cup size, band size, HRT use and parity. All models met the goodness of fit criteria based on both the Omnibus Test of Model Coefficients and Hosmer and Lemeshow tests. Results can be seen in table 4. The B -value can vary between -1 and 1, a positive value indicates a positive relationship (if the predictor variable increases, the likelihood of X occurring increases), whereas a negative value indicates a negative relationship (if the predictor variable increases, the likelihood of X occurring decreases). The Wald χ^2 statistic indicates whether the B -value for that predictor is significantly different to zero. If the Wald χ^2 statistic is significant, then the predictor has an effect on the outcome variable. The Odds Ratio

indicates the change in ratio of change in the outcome variable resulting from one unit change in the predictor.

Table 4 shows that the use of bra padding was weakly influenced by bra cup size and bra band size, with women of larger bra cup and bra band sizes less likely to wear a padded bra. Table 4 also shows that age weakly influenced the likelihood of a women wearing a bra with lace or using a sports bra, with older women more likely to wear a lace bra and less likely to use a sports bra.

Table 4. *Results of binary logistic regression conducted for underwire, padding, lace and sports bra use with predictor variables age, cup size, band size, HRT use and parity (n=208)*

	B (S.E.)	Wald χ^2	Odds Ratio
Underwire			
Age	-.06 (.03)	3.67	.94
Cup size	.20 (.11)	3.30	1.22
Band size	-.27 (.14)	3.68	.76
HRT use	-.11 (.62)	.03	.90
Parity	-.06 (.16)	.17	.94
Constant	5.50 (2.45)	5.02	243.60
Padding			
Age	-.02 (.03)	.39	.98
Cup size	-.35 (.10)	11.42**	.71
Band size	-.31 (.15)	4.12*	.74
HRT use	-.38 (.55)	.48	.68
Parity	-.08 (.14)	.32	.92
Constant	3.06 (2.13)	2.07	21.40
Lace			
Age	.09 (.03)	11.42**	1.10
Cup size	.07 (.07)	1.06	1.08
Band size	.06 (.12)	.21	1.06
HRT use	-.41 (.50)	.69	.66
Parity	.02 (.13)	.01	1.02
Constant	-4.84 (1.95)	6.17	.01
Sports bra use			
Age	-.05 (.03)	4.29*	.95
Cup size	.03 (.07)	.19	1.03
Band size	-.02 (.12)	.02	.98
HRT use	-.05 (.48)	.01	.95
Parity	-.06 (.13)	.25	.94
Constant	2.92 (1.88)	2.41	18.49

Note: * $p < 0.05$, ** $p < 0.01$

4.4 Discussion

Based on the findings from chapter three, this chapter aimed to determine the key bra performance variables for women aged 45 to 65 years, and identify factors

that may influence ratings of those performance variables and current bra wearing habits. This survey received a response rate of 80%. Response rates for postal surveys typically average 30% to 61%, and are often as low as 20% (Baruch, 1999; Bowles et al., 2008; Cummings, Savits & Konrad, 2001; Singer & Grismaijer, 2006). Bowles et al. (2008) implemented a survey in Australia regarding sports bra usage during physical activity and received a response rate of 65%, which was considered high. The high response rate for the sports bra related survey and for the survey used in the current research may reflect the interest from women in bra related research, and therefore the importance of research in this area.

4.4.1 Participant Demographics

Participants were predominantly post menopausal (69%); this was to be expected within the specified age range, as menopause is reported to occur at an average age of 52 years (McKinlay et al., 1972). Cup sizes ranged from A to J (figure 7) and band size from a 32 to 44. The mode bra size of respondents was 36C. However, this size is self-reported, and with 80% of women wearing the incorrect bra size, the accuracy of this may be questioned (Wood et al., 2008). The results show that respondents typically wore a non-padded, underwire bra; previous research has also suggested that older women prefer non-padded, underwire bras, whereas younger women prefer padded underwire bras (Liang, 2008). This is similar to the results found in this chapter regarding underwire use, that age was not a predictive factor of underwire use (see table 4), indeed none of the variables input into the model were predictors of underwire usage. Suggesting that anatomical variance may not be related to a woman's likelihood of wearing an underwire bra.

The mode number of pregnancies for respondents was two, with a range of zero to above five. The affect of parity was investigated with regard to women's current bra wearing habits and no significant affects were observed (see table 4). This suggests that, despite aesthetic changes in the breast following pregnancy previously reported in the literature (Rinker, Veneracion, & Walsh, 2008; Pisacane & Continisio, 2004), parity does not influence the bra worn by women aged 45 to 65 years. The anatomical affects due to breast feeding have not been found to influence the breast to any further extent than pregnancy alone (Rinker et al.,

2008; Pisacane & Continisio, 2004), breast feeding was therefore not included as an anatomical variable in statistical analysis.

It has been reported in literature that breast size decreases after menopause due to parenchymal atrophy (Rosen, 2001); although it has been anecdotally suggested that breast size may increase (Tonkelaar et al., 2004). The results show that 51% of respondents had experienced an increase in breast size since the age of 45 years, a greater percentage than previous research which found just 18% of women reported a larger bra size after menopause with this size increase attributed to general body mass increase (Tonkelaar et al., 2004). Irrespective of breast size changes, the results indicated that four out of five women had experienced some change to their breast since the age of 45 years; bras may therefore need to be designed to meet the changing needs due to age, such as sagging (28%) and reduced firmness (10%). When asked what the most significant change to their breasts had been since the age of 45 years, participant's responses frequently listed sagging, reduced firmness and an increase in breast size as changes that had occurring in their breasts due to ageing. These responses are particularly significant because this question was open ended and provided no list of options to choose from.

4.4.2 Bra Habits

When shopping, 47% of respondents experienced difficulty finding a bra that fitted; this supports previous research that suggested many women cannot find a satisfactory fit when purchasing a bra (Liang, 2008). However, this information may not be attributable to ageing, as no information is available to compare the percentage of younger women experiencing difficulty in finding the correct fit. In a study investigating bra fitting techniques, 6% of participants had to be excluded from the study due to their breast shape not allowing for correct fit of the bras (McGhee, Steele, & Munro, 2010). This suggests future research should consider the relationship between two of the key performance variables, bra fit and breast shape.

The results show that, for women aged 45 to 65 years, Marks and Spencer (M&S) is the market leader with 84% of women purchasing a bra from them in the past 5 years and 60% purchasing M&S bras most often (see figure 8). Potential reasons

for this dominance within the bra market can be seen in chapter three, with participants stating:

M&S has got my old faithfuls that they've been going with for quite a few years. I do tend to buy the same bra a lot of the time. I've found something that's good enough and it hasn't occurred to me to challenge it' and suggesting that M&S provide 'greater choice than anywhere else.

Previous research has also indicated that M&S is the market leader (Dewsnap & Hart, 2004). Similarly, M&S's Annual Report (2009) stated they had 25.2% of the market share and that one in three UK women wear an M&S bra. This finding is particularly interesting because 'brand' was not rated as a key performance criterion for bras in this chapter. Models regarding purchasing processes (Assael, 1981) may explain this with regard to brand loyalty, stating that consumers make consistently repetitive choices based on previous satisfactory products, thus simplifying the decision making process when purchasing any item (Assael, 1981). Another explanation for this market dominance may be that women go to shops that they feel match their own personality and self image (Hart & Dewsnap, 2001). This would suggest that women aged 45 to 65 years feel that M&S is an appropriate shop for women in their age range. However, other brands have been rated higher than M&S for certain bra aspects. For example, in a study using word association to investigate customer views of eight different brands, Playtex was rated highest for fit but lowest for attractiveness, Gossard was rated highest for attractiveness and BHS was rated highest for value/price (Dewsnap & Hart, 2004). Unfortunately, no age range of participants was provided for this study and so inferences regarding women aged 45 to 65 years cannot be made.

The most common colours of bras owned by women aged 45 to 65 years were white, black and beige. The results confirm findings from market research conducted in department stores which found white, black, nude and ivory were the top purchased colours (May-Plumlee & Little, 2001). However, the market research looked at percentage sales of a time period and so could not identify differences in colour preferences between age ranges. Research conducted by Richards and Sturman (1977) suggested that most women remained consistent over periods of time with regard to bra wants and needs. This study failed to define how long a 'period of time' and as this study was conducted over three decades ago these findings may not be applicable now. The results of this chapter found that 62% of women would not now wear the bras they had worn in their

twenties. Similarly, 43% stated they would not have worn their current bra when they were in their twenties. This may suggest either a change in preferences, a change in physical bra needs (for example, the required support, bra fit or breast shape) with increasing age, or a change in fashion. Even within the age range of 45 to 65 years, statistical analysis revealed that older women within the 45 to 65 year range were significantly more likely to wear a bra with lace, and were significantly less likely to own a sports bra (see table 4), thus partially accepting hypothesis two. No other variables input in the statistical analysis were predictors of bra lace or sports bra usage. Fundamentally, this suggests that a 20 year age range may be too great to generalise results, it is recommended that smaller age ranges be used in future bra related investigations, although the practicality of this to the bra market is unknown. From an applied perspective, bras designed for older women may require additional lace decoration in order to appeal to them.

The data indicates a bra purchasing to bra fitting ratio of two to three bras per one bra fitting. Women age 45 to 65 years appear to be purchasing bras more frequently than they are being bra fitted, this may explain the high percentage of women believed to be wearing the wrong bra size (Greenbaum et al., 2003; Wood et al., 2008). Fifteen percent of the total respondents could not remember when they had previously been bra fitted; therefore the frequency of bra fitting may be even lower than suggested. Unfortunately, no data could be found to compare this result to other age ranges, although Dewsnap and Hart (2004) stated that 50% of women wanted to be fitted for a bra. The reasons behind the low frequency of professional bra fittings require investigation, although chapter three of this thesis indicates some explanation as to why women are hesitant to be fitted (embarrassment, feeling obliged to purchase afterwards and finding it difficult to explain what they wanted to the assistant). The findings from this chapter suggest that women purchase approximately one to two new bras a year, whereas previous research has indicated that this value is between three to five (Hart & Dewsnap, 2001; Liang, 2008). As these previous studies included women aged 35 to 64 years and aged 16 years and over respectively, it may be suggested that younger women purchase more bras than women aged 45 to 65 years, although further investigation is required to determine this.

4.4.3 Key Bra Performance Variables

This chapter aimed to determine the key performance variables that are directly linked to a bras performance for women aged 45 to 65 years, whilst assessing any factors that may influence the bra style worn or the importance of the different variables. The results show that the key bra performance variables for women aged 45 to 65 years are: comfort, ability to stay in place, fit, appearance under clothes, support, discreetness, shoulder straps, silhouette, shape, fabric and lift. Boecker and Schweikl (1988) suggested that most products have between five and seven key performance variables, whereas the current findings reveal 11 key bra performance variables for women aged 45 to 65 years, indicating that bra requirements may be more complex than other products. Although the key bra performance variables for women aged 45 to 65 years have not previously been published, some literature has indirectly assumed the importance of specific bra performance variables. Such assumptions risk assessing incorrect variables which are not relevant to women, thus jeopardising the external validity of research in this area.

The current study determined 11 key bra performance variables for women aged 45 to 65 years; subsequent studies assessing these variables within this age range therefore have justification to do so. A study by Kim et al. (2004) used interviews to identify 21 key customer bra needs, subsequent surveys determined the most important variables as breast shape and wire related comfort. These customer needs parallel the results of the current study, but Kim et al. (2004) also included additional variables such as 'pressure sensation' and 'miscellaneous'. The fewer number of variables found in the current study in comparison to Kim et al.'s study may be due to the data analysis methods used. Kim et al. (2004) included all variables listed within preliminary interviews, whereas, the current study identified only the key performance variables by recognising those variables with a mode rating of 4 or 5, and with 50% or more of the sample identifying each variable as important. The current study therefore improves upon the methods used in Kim et al.'s study, as they themselves refer to the irrelevance of investigating attributes if the consumer rating of those attributes is not high.

A review paper by Page and Steele (1999) discussed sports bras and commented on fabric, support, shoulder straps and fit as important factors. This supports the

findings of this chapter by suggesting that these four variables are of importance for older women in everyday bras. Surgical journals often report the improvement of breast shape and lift post surgery (Hsia & Thomson, 2002; Brown et al., 1999; Godwin et al., 1998), which indicates that these are important breast related variables, supporting the findings in this chapter. Breast shape was also indirectly assumed to be an important variable in a study investigating the change in shape of the breast resulting from use of one type of bra (Ashizawa et al., 1990). Body form and silhouette have been investigated with regard to bra fit (Chen et al., 2010). Similarly, bra support has been researched in numerous papers; however, these principally regarded sports bras rather than every day bras (Gehlsen & Albohm, 1980; Lorentzen & Lawson, 1987; Scurr, White, & Hedger, 2010; White, Scurr, & Smith, 2009).

Price has previously been deemed less important than the fit, comfort and quality of a bra (Dewsnap & Hart, 2004), although other studies have included price as a top bra variable. For example, a study interviewing 4730 women asked 'other than price, what is the most important feature you look for when buying a bra?', providing two response options of 'appearance' or 'comfort' (Singer & Grismaijer, 2006). Singer and Grismaijer (2006) therefore assumed that there were only three performance variables of a bra; comfort, appearance and price. However, this assumption may have been invalid as results from this chapter indicate that price was not in fact an important feature for women aged 45 to 65 years. It was previously reported that older women paid greater attention to the material and brand of the bra (Liang, 2008), yet this chapter found that brand was important to only 12.1% of respondents. Many of these studies have opted to explore these bra variables without prior determination that they are relevant to women's bra purchasing or the performance of the bra. Results from this chapter provide reason to investigate 11 variables for women aged 45 to 65 years by confirming that they are key bra performance variables.

Principal component analysis of the key performance variables revealed 'internal' and 'external' bra related factors. This novel finding provides two groups of performance related variables that are allied to one and other. The two groups of variables can be used to explore associated factors without requiring a severe Bonferroni correction, and can also be used in future research to provide a more

holistic view of bra preferences if independent analysis of each factor is not suitable. Although bra research has not previously identified grouped variables through factor analysis, assumptions have been made in past research that reflects similar factors. For example, a scale from utilitarian to glamorous bras has been produced, which would indicate a scale of predominantly prioritising internal factors to prioritising external factors (Dewsnap & Hart, 2004). These results are similar to the suggestions by Singer and Grismaijer's (2006) study, which identified comfort (internal) and appearance (external) as two important bra variables, and Liao and Lee's (2010) study on codesign which suggests consumers consider intrinsic and extrinsic cues. This indicates two categories of variables, functional (internal) and visual (external). Contradictory research suggests that price was important for functionality (Yip et al., 2007), whereas this chapter identified price within external factors. Yip et al.'s (2007) work also highlighted a combination of functional (internal) and aesthetic (external) concerns, but without justification for the two categories. It has been suggested that the weighting on each of these factors may be influenced by occasion and intended use of the bra, with different every day and evening bras being the greatest differentiation (Dewsnap & Hart, 2004). This supports the results of this chapter, in which 49% of women reported owning different bras for daytime and evening usage. Bra retailers may therefore need to provide bras designed based on aesthetic concerns for glamour, and bras designed based on functional concerns for utilitarian use.

To address the second aim of this chapter, Spearman's rho correlations of internal and external factors with age, cup size, band size, HRT use and parity were conducted; parity, age, band size and HRT use did not correlate with either factor. However, a positive correlation was found between cup size and internal factors ($r_s = .169$, $p = .016$). Therefore, the hypothesis that a relationship would be found between bra preferences and age, cup size, band size, HRT use and parity can be partially accepted. Factor two is composed of variables regarding internal factors (support, comfort, fit, stays in place, straps, fabric, discreetness, and brand); women with larger cup sizes rate these variables as more important than women of smaller cup sizes. This is in concordance with previous research that shows larger breasts have a greater mass therefore require greater support (Gehlsen & Albohm, 1980; Lorentzen & Lawson, 1987) and that bra fitting with

larger cup sizes can be more troublesome (Greenbaum et al., 2003). It is therefore advised that manufacturers take cup size into account when designing bras. For example, the results indicate that bras for larger cup sizes require additional support, stronger straps and a better fit for the larger breast, as these variables are rated as significantly more important by women with a larger cup size. These results provide evidence that bra requirements are influenced by individual differences of women; hence specialised bra designs may be required for different populations.

In order to determine whether the factors age, band size, cup size, HRT use and parity influence the bra style worn by a woman aged 45 to 65 years, binary logistic regression was conducted. Hypothesis two can be partially accepted, as there is a significant relationship between some of the factors (age, cup size, band size) and some bra features (padding, lace, sports bra use), but not others (HRT use, parity and underwire). The results indicate that women with smaller cup sizes and smaller band sizes are 29% and 26% more likely to wear a padded bra than their larger breasted counterparts, respectively. This may be expected as women with larger cup sizes may have a lesser need for padding. Age was a significant predictor of women wearing a bra with lace or owning a sports bra, with older women approximately 10% and 5% more likely to wear lace and own a sports bra respectively. The odds ratio ($ExpB$) indicates the resultant change in the dependent variable per unit change in the predictor, and is therefore an indication of effect size (Field, 2009), these results should therefore be interpreted with caution due to relatively low odds ratios. However, bra manufacturers and retailers should acknowledge differences in bra habits of women with varying age, cup size and band size. However, HRT use and parity are not indicators of the style of bra worn and therefore may not need to be taken into account.

The methods used within this chapter were comparable to those in previous research (Birtwistle & Tsim, 2005; Kim et al., 2004), whereby a quantitative phase followed a qualitative phase of investigation. Although this increases the likelihood that the survey implemented is designed specifically for the cohort used in the qualitative phase in chapter three, it precludes the survey from being implemented with a broader sample of the population. Therefore, this survey may be of use for future research to investigate the key bra performance variables of other

populations. By using this questionnaire as a guide, questions may be removed, added or altered depending on the initial qualitative phase with a different population, in order to tailor the question to that sample. Future research should also quantify the 11 variables identified in this study to assess current bra performance for women aged 45 to 65 years.

4.5 Summary

The aim of this chapter was to determine the key performance variables of bras for women aged 45 to 65 years and to determine any factors that may influence the bra style and bra preference of older women. The key variables deemed important by the participants were: comfort, ability to stay in place, fit, appearance under clothes, support, discreetness, shoulder straps, silhouette, shape, fabric and lift. The results also suggest that women aged 45 to 65 years typically wear non-padded, underwired, white bras from M&S. The anatomical factors that influence the bra style worn were age, cup size and band size, and the only factor found to influence the preference of key performance variables was cup size. The results provide practical information for bra manufacturers and allow insight into the bra practices of women aged 45 to 65 years.

The results inform future research by determining 11 key bra performance variables, by identifying the average bra style worn by women aged 45 to 65 years (white, non-padded, underwire bra) and by highlighting band and cup size as influential factors of bra style worn. Where appropriate, subsequent studies should therefore recruit participants of the same bra size. Prior to assessing the performance of bras for older women, an appropriate methodological approach is required to measure each key performance variable. Future research should therefore determine a procedure with which to assess these variables. To best address the aims of the thesis, subsequent chapters centre only on the bra product itself, rather than extraneous factors, for example; practicalities of purchasing and psychological aspects.

Chapter 5.

Quantifying key bra performance variables: An assessment of the reliability and validity of new methods

5.1 Introduction

The findings from the study presented in chapter four of this thesis identified 11 key bra performance variables for a sample of women aged 45 to 65 years. The key bra performance variables found in chapter four are: comfort, ability to stay in place, fit, appearance under clothes, support, discreetness, shoulder straps, silhouette, shape, fabric and lift. Due to the documented anatomical and psychological changes in women with increasing age, the appropriateness of current bras for older women is unknown. In order to address the third aim of this thesis and assess the performance of bras for older women with regard to the key performance variables, suitable methods were required. It is hoped that by considering the key performance variables of a bra, a more complete product profile may be created (Liao & Lee, 2010).

A literature review of each key bra performance variable is presented in section 5.2. This review was conducted in order to identify appropriate methods to assess these variables. The review of literature details where current methodologies may be unsuitable for use within this thesis, and confirms the need for new/updated methods to be developed within this chapter. Determining the reliability and validity of new methods is an important phase in their development (Atkinson & Nevill, 1998; Currel & Jeukendrup, 2008). In order to examine the reliability and validity of current and new methods to assess the 11 key bra performance variables, this chapter is divided into two studies. Study A aimed to develop and determine the reliability of new methods to assess the 11 key bra performance variables for women aged 45 to 65 years. Study A involved test-retest trials over daily, weekly and monthly periods, and it was hypothesised that acceptable reliability would be determined over these time periods for each of the 11 key bra performance variables. Study B aimed to investigate the validity of the new methods by assessing two bras of known structural difference, in order to determine if the methods were able to identify differences between two bras for each of the 11 key bra performance variables.

5.2 Review of Literature

5.2.1 Comfort

Comfort has been defined as a 'pleasant state or relaxed feeling of a human being in reaction to its environment' (Vink & Hallbeck, 2012), and primarily incorporates the absence of discomfort. Research has suggested that the bra market is predominantly influenced by the fashion culture rather than women's needs and comfort (Greenbaum et al., 2003), despite chapter four of this thesis identifying comfort as a key bra performance variable. Indeed, it has been shown that up to 72% of women sometimes or always experience discomfort when wearing a bra (Signer & Grismaijer, 2006). With the average woman wearing her bra for over 12 hours a day, the discomfort caused by a bra may affect a woman for a large percentage of the day (Signer & Grismaijer, 2006).

The quantification of breast comfort has only been examined subjectively (e.g., Scurr et al., 2010; White et al., 2009, 2011). Previous research investigating breast comfort during activity has utilised a 10 point numerical analogue scale with start, end and midpoint descriptors in order to obtain a subjective rating of comfort (Mason et al., 1999; Scurr et al., 2009, 2010; White et al., 2009). Although this form of scale is advocated to record participant's breast comfort in different bra conditions, these studies were conducted during sporting activities, with women below the age of 45 years, and the reliability of the breast comfort scale was not presented. The scales also differed somewhat in their wording, referring to breast pain, breast comfort or bra comfort. It is therefore important to clarify the area of comfort that the participant is required to rate; the current study refers to generic comfort, where participants were asked to consider all breast/bra related aspects of the trials.

The majority of research objectifying apparel comfort centres on thermal comfort of clothing or pressure analysis, whilst matching these objective values to a subjective perception of comfort (e.g. Ayres, White, Hedger, & Scurr, 2011; Gho, Steele, & Munro, 2008). However, this format of quantification requires the selection of specific sites from which to take objective measurements. Specific areas of bra discomfort are unknown within the current study; therefore, an objective analysis of comfort was not possible without assuming the areas of the

breast/bra that should be assessed. Comfort must therefore be assessed subjectively in the current thesis.

A selection of subjective scale formats have been used in breast/bra related literature, including different lengths of visual analogue scales (VAS), numerical analogue scales (NAS) and Likert scales. Larroy (2002) presented correlations between VAS and NAS, with NAS suggested to be easier and more convenient to use. Other scale types have been used to assess bra comfort, for example, Kim et al. (2004) used a five point likert scale to assess 'overall wear comfort', although no detail is given regarding any descriptors used. Based on its use within the relevant literature (Mason et al., 1999; Scurr et al., 2010), a ten point NAS with start, end and midpoint descriptors will be used to assess comfort. The current study will add to the literature by investigating whether a ten point NAS is a reliable tool to assess the comfort of women aged 45 to 65 years during everyday activities, thus determining whether it is a suitable measurement tool for this setting.

5.2.2 Bra's ability to stay in place

In addition to being rated as a key bra performance criterion in the preceding study, bra slippage has been listed as one of the top bra problems among women in previous literature (Croft, 1965). No published data is available regarding the subjective or objective measurement of bra slippage. Hence, in order to develop such a method, inferences must be made from previous literature that has investigated the movement of other items of clothing over the skin. For example, Smith and Smith (2006) measured helmet slippage on pilots by placing markers on the helmet and on the skin; the difference of movement between the two was calculated as slippage. Methods to assess other types of clothing slippage may therefore implement a similar procedure by placing markers on the clothing item and on the skin to compare the difference in order to assess slippage over the skin.

Smith and Smith's (2006) study accounted for the movement of the head in six degrees of freedom in order for helmet slippage to be measured relative to the head; this suggests that the item of clothing that is being assessed for slippage should be assessed relative to the body segment it is worn on. Assessment of bra slippage should therefore ensure measurements are relative to the torso. In

addition to objective measures of helmet slippage, ability of underwear to stay in place has been subjectively assessed on a ten point numerical analogue scale in a previous study (Winslow & Jacobson, 1997). Therefore, both the objective magnitude of bra slippage and the participant's perception of that slippage will be assessed.

Participant's in Smith and Smith's (2006) study were exposed to simulated vibrations in order to elicit helmet movement that may occur during flights, movements patterns that may occur when wearing a bra should be replicated in order to measure bra slippage that may be present as a result of everyday activities. Everyday activities are reported to include dressing, moving about, transferring objects, cleaning, social activities and work (Legg, Drummond, & Langhorne, 2009; Bendstrup, Jensen, Holm, & Bengtsson, 1997). The survey results in chapter four showed that respondents believed appropriate breast support was most important during brisk walking and housework. Methods to quantify bra slippage among older women should therefore aim to replicate these activities within a laboratory environment, in order to elicit any bra slippage that may occur during a variety of everyday activities. The current method developed within this chapter incorporate a variety of activities to mimic; dressing (figures 13 and 14); cleaning (figure 15), brisk walking (figure 16) and transferring objects (figure 17).

5.2.3 Bra fit

A correctly fitting bra is suggested to be important in providing sufficient support to the breasts (McGhee & Steele, 2010; Page & Steele, 1999; White & Scurr, 2012). Without a well fitting bra, measurement of other variables may become inaccurate. For example, a bra that is too large may not accurately indicate the support provided by the bra or the bra's ability to stay in place, because the material may be gaping. McGhee and Steele (2006) have suggested that ptotic breasts may elicit problems for bra fitting due to the difference in circumference around the top of the breast compared to a non-ptotic, pert breast, and that the prevalence of ill-fitting bras is high due to the lack of standardisation in bra fitting techniques.

Previous studies have utilised the traditional method of bra fitting to assess appropriate fit (Greenbaum et al., 2003), however, this method has been criticised

by others (Pechter, 2008; White & Scurr, 2012). Literature now recommends that women be fitted according to best fit criteria, investigated by White and Scurr (2012). The best fit criteria include: the under band and shoulder straps tightened so as to be lifted approximately one inch from the skin and shoulder, the underwire not encroaching on any breast tissue, the cup neither bagging nor digging into breast tissue and the front centre of the bra being flat against the sternum. The best fit criteria (White & Scurr, 2012) were not published at the time this study was undertaken; therefore, these criteria were not used as an objective measure of bra fit. Instead, participant's subjective assessment of how well the bra fits will be considered. The results within chapter four indicate that women aged 45 to 65 years do not have regular professional bra fittings; it is therefore believed that a woman's self perception of bra fit determines the use of a bra. Subjectively assessing bra fit replicates a woman's experience within a fitting room; where she tries on a bra and decides whether it fits or not, ultimately deciding whether a bra is purchased and worn.

5.2.4 Appearance under clothes

It is believed that many women equate their bra with their outward appearance (Singer & Grismaijer, 2006). The results of the study presented in chapter four of this thesis suggested that around half of the sample own different bras for evening and day time use in order to most appropriately fit the clothes they wear during these periods. In a focus group conducted in chapter three, one participant stated "a bit of padding helps clothes hang better", indicating that the bras form could influence the appearance of clothes. Godwin et al. (1998) assessed the importance of the bras appearance underneath clothing, and required participants to rate their happiness with their post-operative appearance on a subjective rating scale from 'excellent' to 'unacceptable' (Godwin et al., 1998). No alternative methods were found to assess a bra's appearance underneath clothing; a subjective rating scale will therefore be used, and the reliability and validity of this scale determined in studies A and B of this chapter.

5.2.5 Support

Breast support, defined in chapter two as a reduction in multiplanar breast kinematics, has been investigated in previous studies (Lorentzen & Lawson, 1987; Mason et al., 1999; McGhee et al., 2007; Scurr et al., 2009, 2011, White & Scurr, 2012). A review paper by Zhou et al. (2011) discussed the different methodologies implemented in order to assess breast kinematics. The biomechanical analysis of

three-dimensional breast movement is typically coupled with participant perceptions of breast comfort during activity, to provide both objective and subjective feedback on a bra's ability to support the breasts. Recent studies have found that 44% of breast movement does not occur in the vertical direction (Scurr et al., 2009); therefore, it is advised that kinematic analysis include three-dimensional breast movement. McGhee et al. (2007) discovered a significant difference in breast pain when the velocity of movement was reduced due to water resistance during underwater running. Breast velocity should therefore also be a consideration when investigating breast support.

The breast biomechanics literature outlined above has failed to consider the effects of ageing on the breast, and instead has investigated sports bras rather than everyday bras. This literature also has yet to explore the support requirements of specific populations. The methods used to assess breast displacement and velocity are well established and the repeatability between five gait cycles has been reported using TEM and CV% during a test-retest protocol, and was deemed to be appropriate (Scurr, Galbraith, Hedger, & White, 2007; Scurr et al., 2009). However, the reliability of these methods across testing sessions remains unreported and will be investigated within study A of this chapter. As the previous literature has presented both objective and subjective methods to investigate breast support, both will be used within the current study.

5.2.6 Bra discreetness

Results from the study presented in chapter four of this thesis suggest women aged 45 to 65 years are concerned with the discretion of their breasts and bra underneath their clothes. To the author's knowledge; no studies have investigated the ratings of discreetness in bras, although discreetness of other products has been assessed. For example, Winslow and Jacobson (1997) provided a ten point NAS to participants involved in a study rating urinary incontinence pads, this study assessed each pad for 11 characteristics, including its discreetness, defined as 'does not show through clothes'. This description of discreetness is comparable to that provided by participants in chapter three of this thesis; therefore it will also be assessed using a ten point NAS. However, Winslow and Jacobson (1997) did not present the reliability or validity of this scale format when assessing discreetness, the studies within this chapter will therefore add to the literature by doing so.

5.2.7 Shoulder straps

The shoulder straps of a bra are key to providing support and stability (Zhou, 2011). However, if they are not an appropriate width or in the correct position they may not provide sufficient support and can cause muscular and nerve damage (Singer & Grismaijer, 2006). Ashdown and Na (2008) highlight the lack of modification for older women's needs in regard to clothing, and suggests different shoulder seams and straps may be necessary in clothing designed for older women. The shoulder slope and cross-shoulder measurements of older women were found to differ to that of younger women (Goldsberry, Shim, & Reich, 1996). Forward shoulder rotation and increased back curvature are also apparent in older women (Ashdown & Na, 2008). Extensive pressure from bra shoulder straps can also lead to bra strap grooves up to 3 cm in depth in severe cases (Mentz, Ruiz-Razura, & Miniel, 2007). Hence, the position of the load is important to minimise the risk of bra strap groove deformities and negative perceptual responses to position of a load (Stuempfle, Drury, & Wilson, 2004). The results from chapter three of this thesis also indicate that the position of the strap on the shoulder is important to women; and participants often mentioned that their shoulder straps sat too wide apart on their shoulders. To the author's knowledge, the position of the bra shoulder strap has not previously been investigated; new subjective and objective methods must therefore be established for this key bra performance variable.

5.2.8 Silhouette

The changes produced by wearing a bra may not only affect the breast itself; they may affect the overall body silhouette (Ashizawa et al., 1990). The typical silhouette for women aged 55 years and over was categorised as exhibiting a forward leaning head and neck, forward shoulder rotation and increased thoracic kyphosis (Ashdown & Na, 2008). The anterior half of the upper torso is therefore shorter relative to the posterior half. Garments designed and fitted for younger women typically do not fit the silhouette of older women, thus creating a bra designed for an older women's silhouette may subsequently improve the fit (Ashdown & Na, 2008). Methodologies to assess patient satisfaction with breast surgery outcomes included questions regarding how the patient felt about the general appearance of their breasts with respect to their overall body shape and balance (Godwin et al., 1998). This suggests that altering the breast profile, whether surgically or via a new brassiere, may affect body shape as a whole.

A recent article by Cha (2012) investigated the uplifting effects of bras by taking anthropometric measurements on 20 subjects, which included; chest, bust and under bust breadth and depth. The results showed differences in these measurements when women wore a bra and when bare breasted. These measurements indicate that the upper torso silhouette of a woman is influenced by bra use (Cha, 2012), however, reliability statistics are neglected within the article, and all measurements are taken using kinanthropometric methods, which are invasive and time consuming for participants (Godwin et al., 1998; Kim et al., 2007; Hsia & Thomson, 2002). Therefore, no appropriate methods objectively quantifying silhouette could be found, as subjective rating is common practice (Thompson & Gray, 1995). It is therefore necessary for new subjective and objective methods to be developed to quantify torso silhouette when in a bra and bare breasted.

5.2.9 Breast shape

Breast shape has been primarily investigated in plastic surgery journals; many articles refer to breast shape and breast aesthetics having improved post-surgery, but rarely give indications as to how the shape has changed or what features define the improvement. Literature frequently ignores the issue of breast shape in non-surgery related breast articles (Hsia & Thomson, 2003). Indeed, few objective methods have been developed to assess breast shape; however, those that do exist do not provide sufficient assessment of reliability to be deemed valid (Brown et al., 1999; Qiao, Zhou, & Ling, 1997; Smith, Palin, Katch, & Bennett, 1986; Westreich, 1997). For example, Smith et al. (1986) aimed to determine normal anthropomorphic values of breast shape using various linear measurements of the breast. This study failed to report any reliability statistics, however, using the mean and standard deviations presented, coefficients of variation (CV%) can be calculated that range up to 168% (nipple to lowest point of breast). Lack of justification for the linear measurements taken and lack of reliability means this method may not be suitable as an accurate measure of breast shape. Westreich (1997) deemed Smith et al.'s (1986) method incomplete and aimed to improve upon it in a population of women with 'aesthetically perfect breasts', therefore excluding women with ptotic breasts. Ptotic breasts have typically been excluded from the majority of breast shape studies due to the lack of aesthetic desirability and subsequent irrelevance to plastic surgery outcomes (Hsia & Thomson, 2003).

Westreich's (1997) article does not present the reliability of the methods, and includes measurements unrelated to breast shape, such as 'umbilicus to pubis' and undefined points such as 'just below the breast'. Additionally, values were only taken to the nearest half centimetre, suggesting a lack of precision.

Subsequent research that attempted to improve upon these methods reported typical error of the measurements ranging from 1.5 mm to 3.7 mm during two trials on the same day (Brown et al., 1999). However, this study failed to clarify whether the values obtained were acceptable, only reporting same day reliability and not reliability across testing sessions, and lacked sufficient detail on land marking for others to utilise the method. Brown et al.'s (1999) method also employed soft tissue landmarks, including lateral extent of the inframammary fold, which has been suggested to be the least reliable landmark on the breast (Kim et al., 2007). The breast is an intricate three dimensional mass, resting on a curved surface with unclear boundaries and few easily identifiable anatomical landmarks (Catanuto et al., 2008); methods attempting to use specific landmarks may therefore be inciting a high level of error into measurement.

Based on the literature, there is a lack of agreement regarding the optimum quantitative method to assess breast shape, with current methods presenting limitations in the subjectivity of landmarking, information regarding standardisation of procedures, applicability across different breast sizes and levels of ptosis, and presentation of reliability statistics. Indeed, many of the landmarks used within the extant literature reviewed above are obscured when the participant wears a bra. Therefore, new subjective and objective methods to assess breast shape are required that are applicable to both a no bra and bra condition.

5.2.10 Fabric

The brassiere is typically worn in direct contact with skin for over 12 hours a day (Singer & Grismaijer, 2006), therefore the constitution of the fabric is a factor when considering comfort and to avoid chaffing. Previous research is limited and non-specific when assessing different fabric types. Sports bra fabric is required to be strong to provide sufficient support and reduce bra slippage over the skin (Page & Steele, 1999). Similarly, sports bra material should be non-abrasive and predominantly non-elastic (Hardaker & Fozzard, 1997). However, no studies have investigated women's preference of material in everyday bras, despite this being

identified in the previous chapter as a key performance variable for women aged 45 to 65 years when selecting bras. The study presented in chapter three of this thesis highlighted that women had a preference for bras made predominantly of cotton. However, even bras advertised as 'cotton rich' may contain only approximately 62% of cotton, with 32% polyester and 6% elastane lycra constituting the remainder (<http://www.marksandspencer.com>). Bras not advertised as 'cotton rich' are made of varying combinations of polyamide, elastane lycra and polyester. Yoo and Barker (2005) investigated the relationship between different fabric types and comfort ratings of fabric using a seven point Likert scale after several trials wearing a one piece 'coverall'. Results showed that fabric constitution significantly affected the comfort ratings in different outfits. Similarly, Paek's (1983) study of clothing comfort and fabric constitution revealed a significant relationship between subjective comfort and fabric type and weave. As few women have knowledge of the varying fabric types, subjective ratings of preference may be the optimum measure for assessing the appropriateness of the fabric of bras.

5.2.11 Breast lift

A bra is suggested to reduce ptosis of the breast by lifting the mass of the breasts from the Cooper's ligaments (Singer & Grismaijer, 2006). Breast lift indicates a more youthful, pert breast outline than one that remains ptotic (Singer & Grismaijer, 2006). Results from chapter four indicate that 28% of women reported inferior migration of the breast since the age of 45 years. Bras designed for older women may therefore need to provide sufficient uplift to counteract this breast ptosis. As cited on numerous breast surgery websites, breast lift following mastopexy surgery (uplift surgery) is typically measured by calculating the distance between suprasternal notch and the nipple to indicate the vertical position of the nipple (e.g., <http://www.baaps.org.uk> and www.cosmeticsurg.com). This method has also been used in non-clinical settings to assess breast lift, for example by Westreich (1997) and Brown et al. (1999). Although this is the most common measurement to assess breast lift, the reliability of this method has yet to be determined when using motion capture systems compared to kinanthropometric measures, which have been previously reported with TEMs of between 3.5 and 3.7 mm (Brown et al., 1999). The reliability and validity of this method will be presented within the current chapter.

5.2.12 Reliability and validity testing

With the exception of breast support, which has been more extensively researched (Scurr et al., 2009, 2010), the literature search revealed limited appropriately reported objective or subjective methods for assessing the 11 key bra performance variables. Methods that were found lacked justification for the measurements, were only applicable to a bare breasted condition, or failed to report reliability. There is a need for reliable and valid methods to assess the key performance variables of a bra for women aged 45 to 65 years. Due to the limitations of previous methods used to assess these key variables, this chapter aimed to develop new methods and determine their reliability and validity.

The variables; breast shape, silhouette, breast lift, shoulder straps, breast support and the bra's ability to stay in place, will be assessed both subjectively and objectively. Whereas the variables; appearance under clothes, bra fit, comfort, discreetness and fabric, were considered subjective and therefore an objective measure to assess them was not sought. Due to concerns regarding response fatigue and response rate of postal surveys, chapter four of this thesis implemented a survey which utilised a five point numerical analogue scale. However, this scale format may not be appropriate in a laboratory setting where scales can be made more sensitive to detect change without concerns for response rate (Hasson & Arnetz, 2005; Hinkin, 1995). Indeed, the number of scale points used is a balance between the desired discrimination level and the reduction of response error (Coelho & Esteves, 2007). As is commonly seen in customer satisfaction measurement, a 0 to 10 NAS will be used to subjectively assess all of the 11 key bra performance variables for women aged 45 to 65 years (Coelho & Esteves, 2007). This scale format is a simple approach to quantify variables and easily identifies factors that may increase or decrease a rating of that variable, whilst keeping the format of scales the same for all variables avoids confusion for participants about how to answer questions (Dillman et al., 1993; Heil, 1993). Despite silhouette having previously been subjectively measured using a five point likert scale (Godwin et al., 1998); all key bra performance variables will be subjectively assessed with the same scale format, in order to reduce response effort for participants. The reliability and validity of this scale format for the 11 key bra performance variables will be assessed within this chapter.

Reliability can be defined as the consistency of measured performances and the absence of measurement error, which creates variations in the protocol (Atkinson & Nevill, 1998; Currel & Jeukendrup, 2008). Measurement error may occur as a result of technical errors, systematic bias and biological variance (Williams & Wragg, 2004). Despite a common understanding of the meaning of reliability, there is confusion in the terminology used to describe it; reproducibility, repeatability, agreement, concordance, stability and consistency have all been used interchangeably with reliability, but can also be used to mean reliability over different periods of time (Atkinson & Nevill, 1998; Weir, 2005; Williams & Wragg, 2004). Therefore, it is recommended that a clear description is provided in research articles for the terminology used and the duration being referred to, so readers may interpret the results appropriately.

Previous literature has advocated investigating the reliability of methods over different durations (Ball & Scurr, 2010; Hopkins, 2000; Williams & Wragg, 2004). These included 'reproducibility' referring to testing sessions on the same day, and 'consistency' referring to testing sessions on separate days (Williams & Wragg, 2004). To avoid the confusion of differing terminology, the current study will assess the reliability of all new methods by conducted testing sessions on the same day (daily reliability), seven days later (weekly reliability) and 28 days later (monthly reliability). Daily reliability will indicate the reliability of the marker positioning and participant posture, whereas monthly reliability will also include the reliability of the equipment set up. Weekly reliability is included to consider the potential changes in breast volume throughout the menstrual cycle (Milligan, Drife, & Short, 1975).

Methods to assess reliability are varied, many studies have presented test-retest correlation coefficients due to their versatility, their prevalence means they are useful for comparison between methods, however they have been criticised in recent publications (Ball & Scurr, 2010; Hopkins, 2000). Correlation coefficient values range between -1 and +1, with a value of 1 representing a perfect correlation (Williams & Wragg, 2004). Intraclass correlation coefficients are appropriate to assess the relative consistency of a measure or the extent to which an individual maintains their position in a group, however, the absolute consistency, which shows the variability in the relevant units, can be assessed

using typical error of the measurement (TEM) (sometimes referred to as standard error of measurement – SEM), which is calculated with the equation $TEM = sd_{\text{difference}} / \sqrt{2}$ (Hopkins, 2000; Weir, 2005). Further methods used to assess reliability include coefficient of variation (CV%) which presents standard deviation as a percentage of the mean ($CV\% = (sd/\text{mean}) * 100$) and is advocated because it is dimensionless (Hopkins, 2000). These methods are appropriate for use with test-retest data, which measures the reliability of an individual value obtained on the same piece of equipment by the same operator at different time points. The TEM and CV% are advocated within reliability studies because they are unaffected by the sample size and range (Hopkins, 2000). However, because it is in absolute terms, the use of TEM may lead to difficulties interpreting the results and determining acceptable levels of reliability. Similarly, Bland-Altman's limits of agreement present a reliability statistic in absolute terms, however, it is recommended that a sample of >40 participant is required for this statistic to be used (Atkinson & Nevill, 1998).

The majority of studies on reliability are believed to contain between eight and 30 participants performing two identical trials, the change in mean of test-retest data is therefore easily calculated and should always be presented as a measure of reliability (Hopkins, 2000). Correlations, TEMs, change in mean and CV% have been advised for reliability testing in retest data in numerous publications, and to eliminate the limitations of each method could be used concurrently as a global representation of the reliability obtained in the new methods developed within this study (Atkinson & Nevill, 1998; Ball & Scurr, 2010; Batterham & George, 2003; Currel & Jeukendrup, 2008; Hopkins, 2000).

The challenge when reporting reliability statistics is selecting the most appropriate boundary to deem acceptable reliability. For example, Hopkins (2000) states that a correlation of 0.81 is acceptable to keep error in the measurement low, although others have suggested lower values, such as 0.75 to 0.80 (Shrout & Fleiss, 1979) or higher values >0.9 (Atkinson & Nevill, 1998). However, when coupled with TEMs and change in the mean, research has purported that correlations may be unrepresentative when the absolute values are within a small range (Hopkins, 2000). A CV% of 10% has been arbitrarily selected as the threshold for appropriate reliability in some studies (Hopkins, 2000). TEMs are dependent on

the relevant unit and are therefore subject to change within different methods, a generalised cut off value for acceptable reliability is impossible across different research settings when using TEMs alone. Coefficient of variation avoids this issue by presenting a percentage value that is more easily interpretable, but as with correlation coefficients, these values must also be considered in absolute terms. If the absolute values are small, the CV% will be higher, and a small range of values due to a homogenous sample produces low correlations coefficients (Hopkins, 2000).

Reliability studies should select the level of precision required for the method to be of practical use, and accept or reject the methods based on identified boundaries of reliability (Bruton, Conway, & Holgate, 2000). Thresholds for appropriate reliability would normally be derived from past studies, but due to the lack of literature regarding similar methods for the 11 key bra performance variables, the current study details arbitrary boundaries for each new method within the data analysis section 5.3.4, to the perceived level of precision required to have a practical implication (Bruton et al., 2000), with a greater allowance for CV% where the absolute values are considered small.

Assessing the validity of the key bra performance variables is more subjective than assessing their reliability, indeed, the ability of a protocol to measure what it is designed to measure, without a universally accepted method available for comparison, is difficult (Hopkins, 2000). However, if a method can discriminate between two groups of known difference this indicates its construct validity (Currel & Jeukendrup, 2008; Williams & Wragg, 2004). Therefore, due to a universally accepted method for comparison being unavailable for the 11 key bra performance variables, study B of this chapter includes a comparison of two different bras in an attempt to determine the validity of the new methods.

5.3 Study A Methodology

5.3.1 Ethical Approval

This study received ethical and scientific approval from the BioSciences Research Ethics Committee, in accordance with current University regulations.

5.3.2 Participants

All participants were recruited by contacting suitable respondents from the previous two chapters and by advertising on the University of Portsmouth's staff

newsletter, stating participant requirements. Twelve female participants with physical characteristics (mean \pm SD): age 53.3 ± 5.0 years (range: 45 to 64 years), height 1.60 ± 0.07 m, body mass 77.4 ± 15.8 kg, volunteered to take part in this study. Two participants were pre menopausal, one was peri menopausal and nine were post menopausal. Participants with a range of bra sizes were used as all analyses were within-participant and to assess the reliability of the methods across the sizes (band size 34 to 40, cup size C to F). Exclusion criteria stipulated that all participants were UK residents within the age range 45 to 65 years, had had no surgical procedures to their breasts, had no muscular or joint injury/problems within the last year, had not been pregnant or breast fed in the past year and were not currently undergoing clinical treatment to their breasts (Scurr et al., 2009, 2010, 2011). All participants gave written informed consent prior to undertaking testing and completed a health history questionnaire to ensure they had no contraindications to the study. To ensure all participants were tested in a correctly fitting bra, bra fittings were conducted by a trained bra fitter according to the best fit criteria outlined by White and Scurr (2012).

5.3.3 Experimental design

5.3.3.1 Equipment

Digital video and optoelectronic cameras were used in this study. The optoelectronic cameras were used to record data for the variables; breast support, bra's ability to stay in place, breast lift and shoulder strap position. However, in order to reduce time constraints for the participants and minimise the invasive nature of kinanthropometric measurements (Godwin et al., 1998; Kim et al., 2007; Hsia & Thomson, 2002), digital video images were used to record data for the variables breast shape and silhouette, which was not possible with the optoelectronic cameras.

Two 50 Hz digital video cameras were used (Sony DV HandycamVision, DCR-TRV900E) with a shutter speed of 150 Hz (low shutter speed is optimal to increase lighting whilst not decreasing clarity as only static images were used) and exposure of F6.8 db. Cameras were positioned on tripods at a height of approximately one meter (adjusted for participant's height so the cameras were equivalent to the participant's breast height); directly in front of, and 90 degrees to the right of the participant, this allowed 2D frontal and sagittal images to be taken simultaneously. Position of the cameras was measured with a tape measure and

protractor. A spirit level was used to ensure cameras were level and a flat, vertical surface was positioned for the participants to stand against. A calibration frame (volume 0.5 x 0.5 x 0.4 m) was used to calibrate the space in which subjects stood (Peak Performance Technologies Inc., calibration objective, Engelwood, Colorado). A two dimensional coordinate system was defined within the computer software used for digitising (SIMI Reality Motion Systems gmbh, version 5.5, build 229), to an accuracy of 1 mm. The lighting was kept constant between trials and participants (Cummins, Bishara, & Jakobsen, 1995; DiBernardo, Adams, Krause, Fiorillo, & Gheradini, 1998). Figure 10 shows the set up of the video cameras in the laboratory.

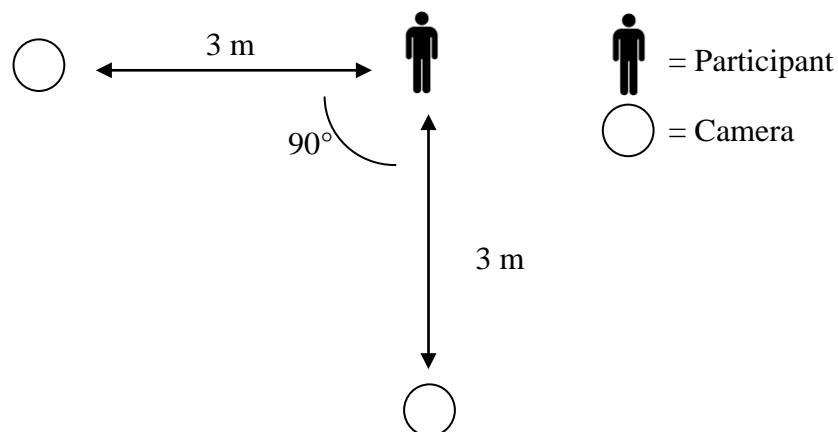


Figure 10. Laboratory set up with two video cameras positioned 3 m away from the participant in a frontal and sagittal plane.

In addition, six Oqus 300 and two Oqus 310 high speed optoelectronic cameras (Qualisys, Sweden) were positioned in an arc around a treadmill (Mercury, H/P/Cosmos Mercury Sport and Medical gmbh, Germany) on which participants walked and static images were taken. The cameras were set at 200 Hz and with a 0.25 mm tracking parameter. The optoelectronic cameras were calibrated using a coordinate frame positioned on the treadmill and a handheld wand containing markers of predefined distances (Qualisys Track Manager; Version 1.10.828, Qualisys Motion Capture Systems, Sweden). SIMI Motion software was used to digitise video images from the Sony Cameras, (SIMI reality motion systems gmbh, version 5.5 build 229) and QTM was used to digitise images from the Oqus optoelectronic cameras.

The reliability of the methods was assessed in both bare breasted and bra conditions. The bra used within the reliability trials was the Playtex Affinity Rose Beauty Cross bra (style 6879, white, underwired, non-padded full cup, RRP

£20.50; made from 78% cotton, 13% nylon, 7% elastane and 2% polyester) (figure 11). This bra was selected as it matched the criteria determined in chapter four of this thesis of the most common bra style worn by women aged 45 to 65 years, in that it was a non-padded, white, underwire bra. This bra was also readily available to the researcher in a full range of sizes. Information sewn into the bra that identified the brand or details of the bra was removed (Moutinho & Evans, 1992; Proctor, 2003).



Figure 11. Playtex Affinity Rose Beauty Cross bra (style 6879) selected for reliability testing.

5.3.3.2 Procedures

Prior to testing, resting blood pressure was measured to ensure it met with the Ethics Committee's guidelines for testing (Omron, HEM705; Hoofddorp, the Netherlands). Participants were asked to remove all jewellery due to the potential to reflect light (Dibernado et al., 1998), retroreflective markers (5 mm radius) were then attached with hypoallergenic tape. In the bare breasted condition, figure 12 shows the position of retroreflective markers on the participant's suprasternal notch (A), nipples (H and G), left foot and both anterior inferior ribs (K and L) (Scurr et al., 2009), totalling six markers. Additional markers were added in the bra condition to the centre gore (F), back strap directly over the spine (M), acromion processes (E and C), most superior point of the shoulder straps (D and B) and most inferior point of the underwire (I and J), totalling 14 markers (see figure 12). All markers were removed and reattached between the test and retest trials when assessing daily reliability, this was to ensure that marker reapplication was included in the reported test-retest reliability. However, markers were not

removed between the different tasks, to avoid potential influences on measurement error within trials.

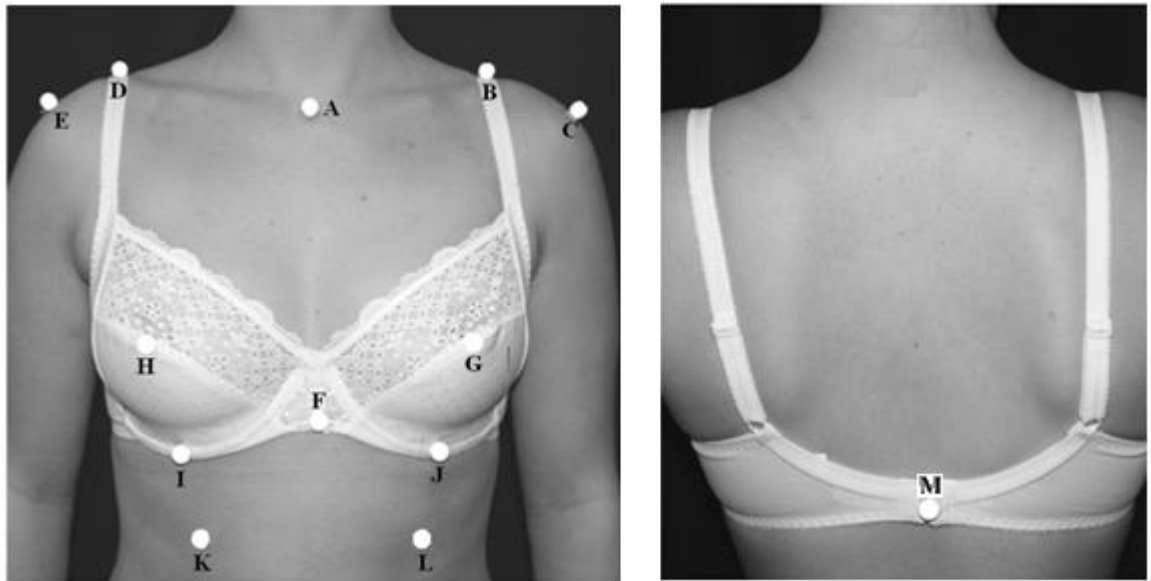


Figure 12a and 12b. Marker set used to assess all objective key bra performance variables simultaneously. Foot marker is also attached to left heel.

A demonstration of the activities was carried out by the researcher, each participant was then offered a familiarisation period. The time taken for the familiarisation ranged from five minutes to approximately 30 minutes to become accustomed to the treadmill and the four other selected activities (figures 13 to 17). As previous experience has been found to influence subsequent perceptions and ratings (Robinson & Wise, 2004), the bare breasted condition was conducted first in all testing sessions to act as a base line measure from which bra data could be compared. A static image was taken initially in each breast support condition using the optoelectronic camera system, to record data for the variables; shoulder strap position, breast lift, and the initial position of the bra for the variable bra's ability to stay in place. Participants were required to stand in the anatomical reference position whilst a two second static image was taken (Scurr et al., 2011). Chapter four revealed that respondents believed breast support was most important during brisk walking and housework. Therefore, activities were selected from a variety of 'everyday' activities in order to assess bra slippage and breast support throughout the day. These activities mimicked dressing, moving about, transferring objects, cleaning, social activities and work, deemed 'everyday' activities in many publications (Legg et al., 2009; Bendstrup et al., 1997). To minimise embarrassment for participants, only the treadmill walk was conducted in the bare breasted condition, as breast support is typically assessed during

treadmill activity alone (Zhou et al., 2011). In the bra condition, all five everyday activities were carried out in a random order, determined by use of a random number generator. Participants were asked not to adjust their bra once they had begun the activities. The following figures provide an illustration of these everyday activities:



Figure 13. Shoulder exercise video (<http://www.youtube.com/watch?v=UBepBsKjfO8&feature=channel>). Participants copied the exercise video, this ensured standardisation of movement across bra conditions and between participants. The video elicited arm positions similar to those for brushing hair or applying makeup.



Figure 14. Removing and replacing shoes. Sitting down, removing shoes and putting them back on. Participants sat down and bent forwards towards their feet rather than lifting their feet up toward them. The left shoe was removed and put on first each time, in order to standardise the activity as much as possible.



Figure 15. Sweeping. Participants were asked to sweep a 1 m² area of floor for one minute. Participants were required to reach to the edge of the marked area with each sweep. Determining a 1 m² floor area ensured participants reached the same distance (Jacobs, 2008; Mackinnon, 1999).



Figure 16. Treadmill walk. Participants walked on a treadmill for two minutes (Scurr et al., 2010; Zhou et al., 2009). A speed of 6 kph was selected based on the average brisk walking speed indicated in previous research (Murtagh, Boreham, & Murphy, 2002).



Figure 17. Reach. Participants reached as high as they could with both left and right arms in turn. This procedure was standardised by ensuring the participants assumed the same position each time. Prior to testing, participants stood with their feet shoulder width apart, on tip toes, and attach a left and right arm marker to their maximum reach height. Participants were given the same instructions and asked to reach and touch their marker in each subsequent breast support condition.

Immediately following these activities, a second static image was taken using the optoelectronic camera system when wearing the bra, to determine the position of the bra and thus the bra's ability to stay in place. After which frontal and sagittal static images were taken using the digital video cameras, to record data for breast shape and silhouette. Although photogrammetry is often used to reduce time constraints of the participant and its minimal invasive nature (Godwin et al., 1998; Kim et al., 2007; Hsia & Thomson, 2002) there are some disadvantages to its use that may influence the measurement error, standardisation of participant posture and position can be problematic. Participant position was standardised by providing a solid, flat, vertical surface and instructing them to stand with their shoulders flat against it, floor foot markers were also used. In order to standardise head position, reduce postural sway and maintain an upright posture during every trial, participants were asked to look directly at the camera lens and hold their breath at the end of their natural inspiration whilst the images were taken (Ashizawa et al., 1990; Christie et al., 1996; Kleinberg, 2007; McGhee & Steele,

comments regarding the bra, in addition to what they liked, disliked and what suggestions they could make to improve the bra.

5.3.3.3 Pilot testing

Pilot testing was conducted to assess the time needed for each participant in the laboratory. Bra fit was estimated to take approximately 20 minutes, familiarisation with the treadmill, if required, to take a further 20 minutes, and approximately 20 minutes for each bra condition. The initial laboratory testing session was therefore estimated to take approximately 80 minutes, with subsequent sessions taking approximately 30 minutes to complete.

5.3.3.4 Schedule of testing

Using the aforementioned methods, the following schedule of testing was conducted during reliability testing.

Testing session one (daily reliability); after an initial bra fit, the tests detailed above were undertaken in a bare breasted condition, and then in the bra condition (trial one). Both the bare breasted and bra condition were then repeated approximately one hour later (trial two). Statistical comparisons between these two trials provided 'daily' reliability data in both a bare breasted and bra condition. Pre menopausal participants were tested at approximately day 21 of their menstrual cycle.

Testing session two (weekly reliability); this session was conducted one week after testing session one. Pre menopausal women were therefore approximately at day one of their menstrual cycle, when the steepest decrease in breast volume has occurred (Milligan, Drife, & Short, 1975). The same tests were again undertaken in a bare breasted condition, and then in the same bra condition (trial three). Statistical comparisons between trial one and trial three provided 'weekly' reliability data.

Testing session three (monthly reliability); this session was conducted four weeks after testing session one. The same tests were undertaken in a bare breasted condition, and then in the same bra condition (trial four). Statistical comparisons between trial one and trial four provided 'monthly' reliability data.

5.3.4 Data Analysis

Subjecting ratings for all of the 11 key bra performance variables are presented as mean and mode values. Acceptable reliability for these measures is defined as a change in the mean of less than one rating, a change in mode of less than two ratings, a TEM of less than two ratings, CV% of less than 20%, and a correlation of above 0.8. For the objective key bra performance variables (stays in place, support, shoulder straps, silhouette, breast shape, lift) data are presented in the most appropriate format for each method's application, and to enable comparisons to previous literature. Breast shape and silhouette are therefore presented in absolute values (mm) (Brown et al., 1999; Qiao et al., 1997; Smith et al., 1986; Westreich, 1997), breast support data are presented in absolute values (mm and $\text{m}\cdot\text{s}^{-1}$) (Scurr et al., 2010, 2011) and breast lift is presented in an absolute values (mm) (Brown et al., 1999) and relative (%) value, as the lift provided by a bra may be normalised to the bare breasted position of the breast. The method to assess the position of the shoulder strap is presented as a percentage value, to normalise for the varying widths of individual's shoulders (previously reported between 16.0 and 21.5 cm, Westreich, 1997). Data for the variable bra's ability to stay in place are presented in millimetres of movement of the bra, as normalisation to the individual's body size is irrelevant.

5.3.4.1 Stays in place

To assess the ability of the bra to stay in place, two 2 second static images were taken using the optoelectronic cameras pre and post the five everyday activities. The change in relative position pre and post indicated the movement of the bra over the skin. Markers were positioned on the anterior inferior ribs and suprasternal notch (Scurr et al., 2010, 2011). Markers were identified using QTM and raw position-time data were exported as a TSV file and opened in a transformation matrix in excel (Microsoft Office 2003, Microsoft, Redmond, WA, USA) (Scurr et al., 2010). The global laboratory coordinate system used z as the vertical axis, y as mediolateral and x as anteroposterior (figure 19) (Scurr et al., 2009). The transformation matrix creates an orthogonal coordinate system which identifies the suprasternal notch as the origin, with left and right anterior inferior rib markers creating the u axis (mediolateral), an n axis was perpendicular to this (anteroposterior) and a v axis perpendicular to both n and u (vertical) (Scurr et al., 2010). Transformation of the coordinate data was conducted in order to account

for the position and orientation of the torso in six degrees of freedom, thus establishing marker positions relative to the torso.

An average positional coordinate for each marker within the two second static capture was calculated. The following distances were recorded in three dimensions (vertical, mediolateral and anteroposterior) relative to the torso; superior most point of shoulder straps (both left and right) to the suprasternal notch, centre gore to suprasternal notch, centre back to suprasternal notch, and suprasternal notch to inferior most point of underwire (both left and right) (figure 19). No statistical difference was seen between left and right measurements, the average movement of the left and right shoulder strap and left and right underwire was therefore calculated. Results are reported as millimetre difference between the markers in pre and post activity images. Acceptable reliability values were defined as a change in mean of less than 3 mm, TEM of less than 5 mm, a CV% of less than 20% and a correlation coefficient of above 0.8.

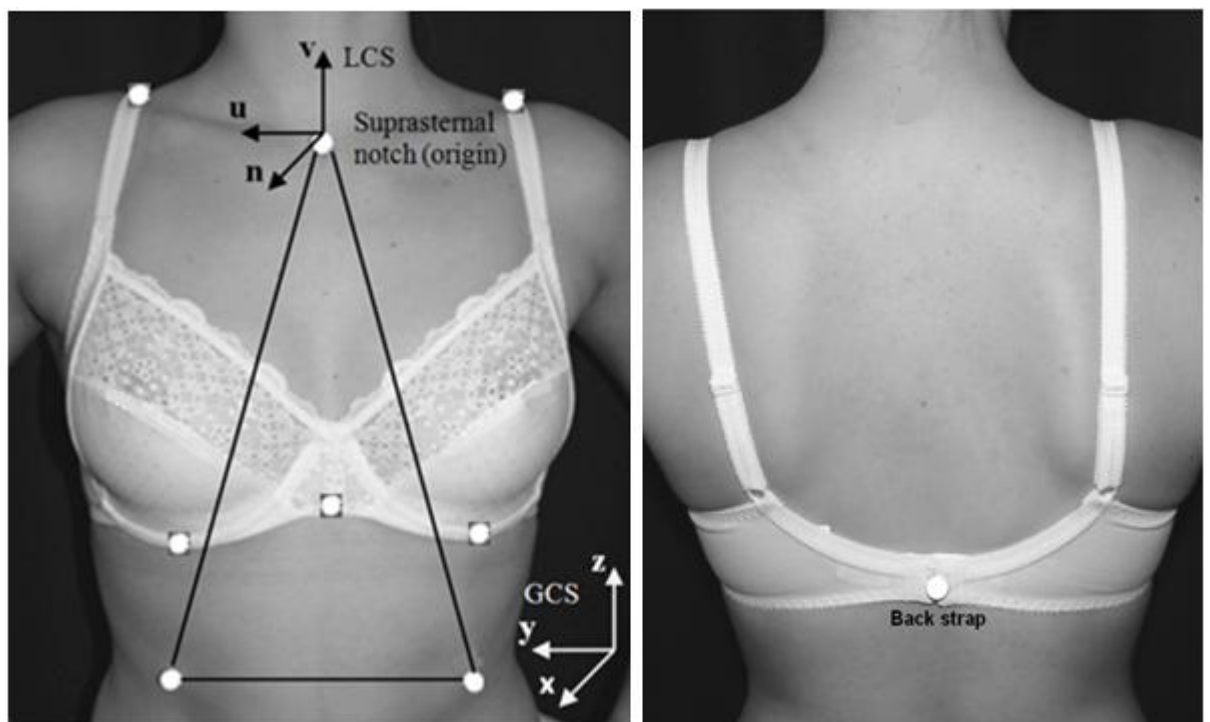


Figure 19a and 19b. Anterior (19a) and posterior (19b) measurements to assess multiplanar bra movement over the skin for the key bra performance variable 'bras ability to stay in place'. The origin of the local coordinate system (LCS) was the suprasternal notch. GCS = global coordinate system (Scurr et al., 2009).

5.3.4.2 Support

Participants were asked to walk on a treadmill for 2 minutes (Scurr et al., 2009) whilst bare breasted and then in the bra. A marker was placed on the left heel in

order to track gait cycles (Scurr et al., 2010). Using the local coordinate system defined in section 5.3.4.1, relative breast kinematics were calculated from the right breast. The right breast was used to represent the movement of both breasts as previous literature has shown no difference between left and right breast (Scurr et al., 2011). Gait cycles were determined using the foot marker velocity along the x axis (Scurr et al., 2010); the anteroposterior coordinates of the foot marker were used to derive foot velocity. The change of this marker from a positive to negative velocity indicated heel strike (Scurr et al., 2010).

As the marker coordinates in this test were recorded during dynamic rather than static trials, a Fast Fourier Transformation was conducted on the coordinate data using MATLAB in order to determine the most appropriate cut off frequency for which to filter the dynamic coordinate data. A selection of four participant's data were analysed in both bare breasted and bra conditions, using a range of 4 Hz to 14 Hz low pass cut off frequencies, after 11 Hz the difference in calculated breast displacement was reduced to less than 0.5 mm for all trials, therefore 11 Hz was selected as the cut off frequency with which to filter the coordinate data. Data were filtered using a second order low pass Butterworth filter (Scurr et al., 2010, 2011; Winter, 1990). During treadmill walking the filtered three dimensional relative nipple coordinate data were calculated for each sample (0.005 s) using MATLAB and velocity was calculated. Relative breast displacement was subsequently calculated as the maximum minus the minimum displacement of the breast within one gait cycle (Scurr et al., 2011). Five gait cycles were averaged (Scurr et al., 2009) and displacement was reported in millimetres (mm) and velocity in meters per second ($\text{m}\cdot\text{s}^{-1}$). Acceptable reliability values for breast kinematics were defined as; a change in mean of less than 3 mm for breast displacement and $0.03 \text{ m}\cdot\text{s}^{-1}$ for breast velocity, TEMs of less than 5 mm for breast displacement and $0.05 \text{ m}\cdot\text{s}^{-1}$ for breast velocity, CV% of less than 20% and a correlation of 0.8 or above.

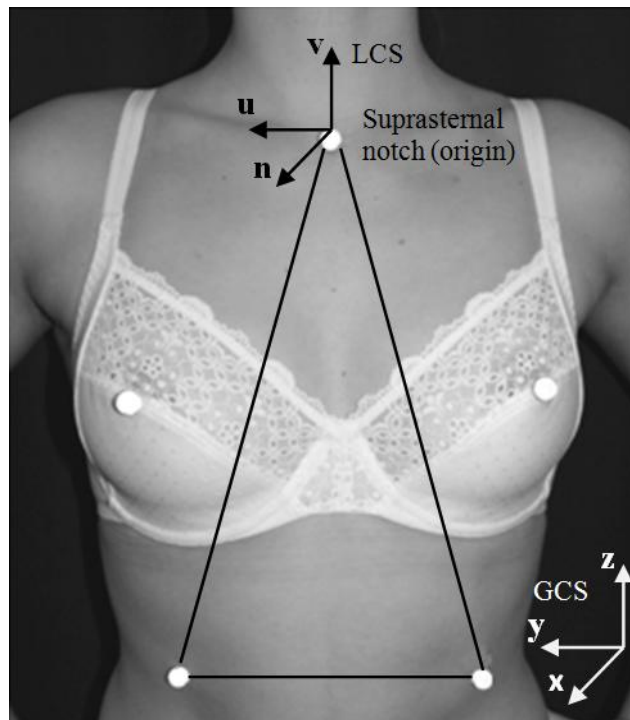


Figure 20. Marker set used to measure breast motion. The origin of the local coordinate system (LCS) was the suprasternal notch. GCS = global coordinate system (Scurr et al., 2009).

5.3.4.3 Shoulder straps

The acromion, shoulder strap and suprasternal notch markers were identified in QTM and exported into the excel transformation matrix (detailed in section 5.3.4.1) where data were transformed into the local coordinate system (as detailed in section 5.3.3.2), this provided horizontal shoulder strap measurements relative to the torso. No statistical difference was seen between left and right measurements; the average position of the left and right strap was therefore calculated.

To account for individual differences in shoulder width, distances are reported as a percentage from suprasternal notch to acromion process (see figure 21). The relative horizontal distance between the suprasternal notch and acromion was measured and defined as 100% of the distance. The relative horizontal distance between the suprasternal notch and the shoulder strap marker was then measured, and calculated as a percentage of the distance between acromion and suprasternal notch: $\text{shoulder strap position} = 100 * (\text{shoulder strap to suprasternal notch distance} / \text{acromion to suprasternal notch distance})$. Acceptable reliability

values were defined as a change in the mean of less than 3%, a TEM of less than 5%, a CV% of less than 10% and a correlation of 0.8 or above.

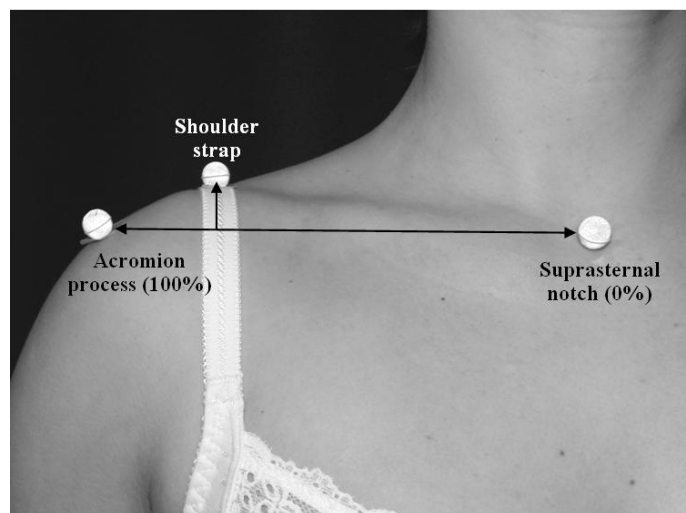


Figure 21. Shoulder strap position calculated as a percentage.

5.3.4.4 Silhouette

Video images were manually digitised in 2D using SIMI. Silhouette was assessed by measuring the width of the participant's upper torso from a frontal and sagittal image (see figures 22a and 22b). Changes in posture were controlled experimentally as detailed in section 5.3.3.2. In the frontal image (figure 22a), the anatomical landmarks identified were the left and right underarm (A: defined as the point at which the armpit begins), both nipples (B: where markers were attached), and the under bust points (C: defined as the inferior most point of the underwire or inferior most point of the breast tissue). Horizontal widths under the arms (A), across the nipples (B) and under the bust (C) were measured in the frontal plane (figure 22a). These measurements are in line with those proposed by Cha (2012) to assess the influence of a bra on a woman's upper torso; however the current method evolves Cha's procedures by using digital analysis rather than kinanthropometry.

Only the right side was assessed in the sagittal plane (22b), and the under arm, nipple and under bust points were identified based on the same definitions used in the frontal plane. Horizontal widths were then measured along these landmarks, with the extremities of the breast/bra used as the anterior border and the back of the arm or back (depending on the natural arm position of the participants) used as the posterior border. Results are reported in millimetres. Acceptable reliability values for all measurements were defined as a change in the mean of less than 5 mm, a TEM of less than 7 mm, a CV% of less than 10% and a correlation of 0.8.

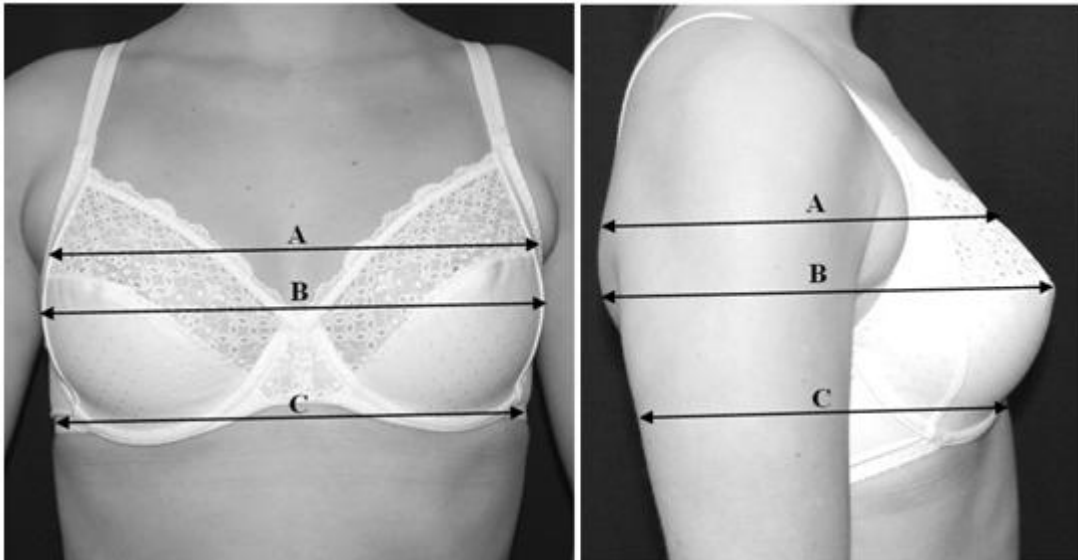


Figure 22a and 22b. Measurements to assess silhouette in the frontal (22a) and sagittal (22b) plane. A: Under the arms, B: across the nipples, C: under bust.

5.3.4.5 Breast shape

Breast shape was measured using the same frontal and sagittal images in SIMI. Due to the difficulty in identifying the true extremities of breast tissue, the top of the breast was defined as the vertical position half-way between the base of the breast and the suprasternal notch (base of the breast was defined as the lower extreme of breast tissue in a bare breasted condition, or to the lower extreme of the bra). This breast shape method attempts to account for individual breast size by defining the top of the breast relative to an individual's measurement, rather than a fixed value. The distance between the top of the breast and the base of the breast was measured and divided into equal vertical thirds. Width of the breast was measured as the distance between the medial and lateral extent of the breast at each third (lines A, B and C in figure 23a). The projection of the breast (figure 23b) was calculated using the horizontal distance from the edge of the breast/bra to a vertical line from the suprasternal notch. Results are reported in millimetres. Acceptable reliability values were defined as a change in mean of less than 5 mm, a TEM of less than 7 mm, a CV% of less than 10% and a correlation of 0.8 or above.

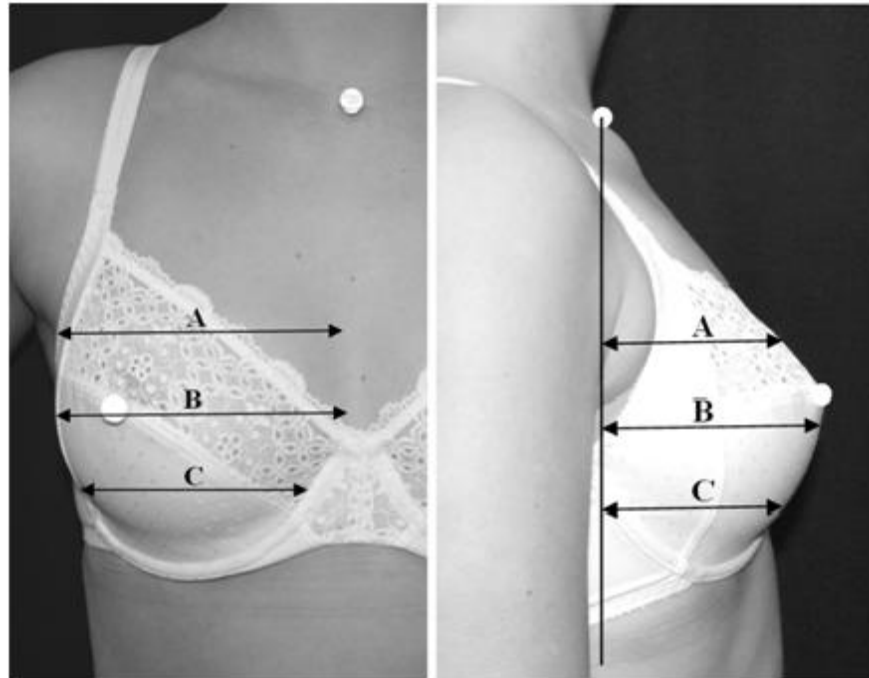


Figure 23a and 23b. Measurements to assess breast shape in the frontal (23a) and sagittal (23b) plane. Vertical position of A is defined as the top of the breast, determined as half way between the base of the breast and the suprasternal notch. Measurements B and C divide the breast into equal thirds.

5.3.4.6 Breast lift

Using the two second static image recorded with the optoelectronic cameras, the vertical distance between the suprasternal notch and nipples was calculated relative to the torso's local coordinate system (Scurr et al., 2010). No statistical difference was seen between left and right measurements, an average was therefore calculated (figure 24). The bare breasted condition minus the bra condition value was used to indicate breast lift. Results are reported in millimetres in addition to a percentage difference between the bra and bare breasted condition. Calculating a percentage value may account for variance in the starting position of the breast, as well as providing an absolute value for each individual, and is calculated as: $\% \text{ lift} = 100 * (\text{position in bra} / \text{bare breasted position})$. Acceptable reliability values were defined as a change in the mean of less than 5 mm, a TEM of less than 7 mm, a CV% of less than 10% and a correlation of 0.8 or above.

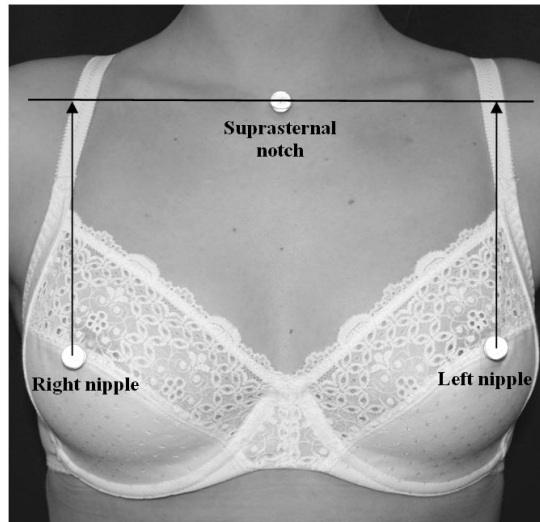


Figure 24. Vertical position of the breast using vertical distance between nipple and suprasternal notch. Breast lift was subsequently calculated as the difference between the bare breasted and the bra condition.

5.3.4.7 Statistical analysis

Daily, weekly, and monthly reliability was assessed by reporting the change in the mean, TEMs ($TEM = \text{sd}_{\text{difference}} / \sqrt{2}$), CV% ($CV\% = (\text{sd}/\text{mean}) * 100$), and a two way random consistency intraclass correlation coefficients between the relevant trials. The reliability statistics for subjective data also include a change in the mode value.

5.4 Study A Results

5.4.1 Subjective Reliability

The means presented for subjective ratings of each key bra performance variable range between 4.5 (silhouette) and 8.3 (bra fit), and mean values do not differ by more than 1.0 rating across daily, weekly and monthly trials within each key bra performance variable. All subjective ratings for the key bra performance variables have significant correlations for daily, weekly and monthly retest trials. Mean values differ by no more than 0.7, 0.9 and 1.1 ratings for daily, weekly and monthly reliability respectively (table 5).

Table 5. *Reliability statistics of subjective ratings of the 11 key bra performance variables for daily, weekly and monthly test-retest trials. Data is combined for the bare breasted and bra condition for variables where both are assessed (n=12).*

Bra Variable	Trial	Mean	Mode	TEMs	CV%	ICC
Comfort	Initial	7.1	10			
	Daily	6.8	9	1.0	11	.92**
	Weekly	6.2	8	1.4	20	.84**
	Monthly	6.8	9	1.3	20	.87**
Stays in place	Initial	8.0	10			
	Daily	7.4	8	2.0	12	.66**
	Weekly	7.4	7	1.7	13	.51**
	Monthly	7.8	8	1.7	8	.74**
Bra fit	Initial	7.8	9			
	Daily	7.8	8	1.0	5	.94**
	Weekly	8.1	8	1.5	8	.89**
	Monthly	8.3	9	1.3	7	.90**
Appearance under clothes	Initial	4.8	5			
	Daily	4.7	6	1.5	20	.78**
	Weekly	4.9	5	1.0	17	.87**
	Monthly	4.9	6	1.2	19	.81**
Support	Initial	4.9	5			
	Daily	5.6	7	1.9	20	.82**
	Weekly	5.8	7	1.5	17	.88**
	Monthly	5.9	9	1.8	16	.81**
Discreetness	Initial	6.7	9			
	Daily	6.0	5	1.4	7	.96**
	Weekly	5.8	4	2.2	11	.86**
	Monthly	5.7	5	2.0	13	.83**
Shoulder strap	Initial	7.3	8			
	Daily	6.7	5	1.2	12	.72**
	Weekly	6.7	5	1.0	10	.81**
	Monthly	6.8	7	1.0	10	.82**
Silhouette	Initial	4.5	6			
	Daily	4.6	5	1.1	20	.88**
	Weekly	4.5	5	1.0	13	.92**
	Monthly	4.8	5	1.1	18	.91**
Breast shape	Initial	4.8	7			
	Daily	4.8	6	1.1	12	.95**
	Weekly	4.6	4	0.7	10	.95**
	Monthly	4.7	6	0.9	10	.93**
Fabric	Initial	6.8	5			
	Daily	6.6	5	1.5	5	.92**
	Weekly	6.6	5	1.5	9	.93**
	Monthly	6.1	5	1.5	9	.92**
Breast lift	Initial	4.9	8			
	Daily	5.3	8	0.8	6	.85**
	Weekly	5.2	5	1.0	8	.77**
	Monthly	5.3	5	0.9	8	.76**

Note: Rating of 10 = positive opinion, rating of 0 = negative opinion. *p<.05, **p<.01

5.4.2 Objective Reliability

5.4.2.1 Stays in place

Bra slippage measurements ranged between 1 mm and 4 mm at the front gore of the bra, between 4 mm and 9 mm at the back strap, between 2 mm and 5 mm at the underwire and between 5 mm and 9 mm at the shoulder straps. Across all areas of measurement and directions of bra slippage, the reliability of the method to assess a bra's ability to stay in place following everyday activities reports changes in the mean of between 0 mm to 3 mm, TEMs of between 1 mm and 5 mm, and CV% of between 12% to 81% across test-retest trials (table 7).

5.4.2.2 Support

Mean values of breast displacement and breast velocity in the bare breasted condition were higher than those in the bra condition. Changes in the mean were up to 2 mm for breast displacement and up to 0.09 m s^{-1} for breast velocity across test-retest trials, regardless of breast support condition. With the exception of correlations of weekly anteroposterior breast velocity, all breast support measurements produced significant correlations between test-retest trials (table 8).

5.4.2.3 Shoulder straps

Mean objective measurements to assess shoulder strap position differed by less than one percent across all trials. The reliability statistics for daily trials appears better than those in weekly or monthly trials, with stronger correlations, lower TEMs and lower CV% (table 6).

Table 6. *Reliability statistics for the objective measurement of shoulder strap position across daily, weekly and monthly test-retest trials (n=12).*

Trial	Mean (%)	TEMs (%)	CV%	ICC
Initial	69			
Daily	69	1	1	.97**
Weekly	69	2	4	.77*
Monthly	70	1	2	.92**
Overall	69	2	2	.80**

Note: * $p < .05$, ** $p < .01$

Table 7. *Reliability statistics for objective measurements of bra's ability to stay in place during daily, weekly and monthly test-retest trials (n=12).*

		Trial	Mean (mm)	TEMs (mm)	CV%	ICC
Front Gore	Anterioposterior	Initial	1			
		Daily	2	1	42	.68*
		Weekly	2	2	81	.67
		Monthly	2	2	80	.36
	Mediolateral	Initial	3			
		Daily	4	2	38	.84**
		Weekly	4	2	36	.81**
		Monthly	3	2	39	.81**
	Vertical	Initial	3			
		Daily	3	2	53	.52
		Weekly	4	3	63	.29
		Monthly	2	2	71	.47
Back strap	Anterioposterior	Initial	6			
		Daily	6	2	29	.81*
		Weekly	6	3	41	.31
		Monthly	7	3	27	.63
	Mediolateral	Initial	5			
		Daily	5	3	55	.66
		Weekly	5	3	46	.75*
		Monthly	4	2	41	.86**
	Vertical	Initial	8			
		Daily	9	2	23	.94**
		Weekly	8	4	34	.91**
		Monthly	9	4	32	.86**
Underwire	Anterioposterior	Initial	3			
		Daily	3	1	33	.53
		Weekly	2	1	36	.55
		Monthly	3	2	46	.19
	Mediolateral	Initial	5			
		Daily	4	2	45	.43
		Weekly	3	2	48	.18
		Monthly	3	2	40	.61
	Vertical	Initial	4			
		Daily	4	2	33	.66
		Weekly	4	2	45	.32
		Monthly	3	1	34	.53
Shoulder strap	Anterioposterior	Initial	6			
		Daily	6	2	12	.98**
		Weekly	7	3	40	.86**
		Monthly	8	4	47	.78*
	Mediolateral	Initial	8			
		Daily	9	2	15	.98**
		Weekly	9	5	45	.81**
		Monthly	8	4	33	.89**
	Vertical	Initial	7			
		Daily	6	4	31	.80*
		Weekly	6	4	51	.55
		Monthly	5	3	42	.79*
Overall		5	4	52	.48**	

Note: * $p < .05$, ** $p < .01$

Table 8. Reliability statistics for objective measurements of breast support during treadmill walking for daily, weekly and monthly test-retest trials (n=12).

		Trial	Mean (mm)	TEMs (mm)	CV%	ICC
Displacement Bare breasted	Anterioposterior	Initial	13			
		Daily	14	4	19	.93**
		Weekly	15	2	10	.98**
		Monthly	14	3	14	.95**
	Mediolateral	Initial	16			
		Daily	15	3	16	.79**
		Weekly	18	5	20	.93**
		Monthly	16	5	20	.93**
	Vertical	Initial	10			
		Daily	9	2	17	.89**
		Weekly	10	2	16	.92**
		Monthly	10	3	17	.88**
Displacement Bra	Anterioposterior	Initial	8			
		Daily	8	2	19	.87**
		Weekly	10	2	24	.85**
		Monthly	9	3	21	.81**
	Mediolateral	Initial	10			
		Daily	10	1	11	.98**
		Weekly	10	2	17	.92**
		Monthly	9	2	16	.95**
	Vertical	Initial	9			
		Daily	9	3	18	.91**
		Weekly	9	1	11	.98**
		Monthly	8	1	10	.97**
			(m·s ⁻¹)	(m·s ⁻¹)		
Velocity Bare breasted	Anterioposterior	Initial	.16			
		Daily	.15	.06	19	.93**
		Weekly	.17	.03	10	.98**
		Monthly	.13	.09	31	.86**
	Mediolateral	Initial	.18			
		Daily	.16	.06	13	.93**
		Weekly	.19	.06	12	.93**
		Monthly	.20	.07	9	.88**
	Vertical	Initial	.14			
		Daily	.12	.04	22	.95**
		Weekly	.14	.04	13	.95**
		Monthly	.14	.05	20	.85**
Velocity Bra	Anterioposterior	Initial	.07			
		Daily	.07	.02	19	.82**
		Weekly	.08	.02	21	.63
		Monthly	.09	.03	26	.90**
	Mediolateral	Initial	.10			
		Daily	.10	.02	12	.96**
		Weekly	.10	.03	20	.90**
		Monthly	.10	.02	15	.96**
	Vertical	Initial	.12			
		Daily	.13	.03	15	.97**
		Weekly	.13	.02	10	.99**
		Monthly	.12	.02	12	.98**
Overall	Displacement		11	2	17	.89**
	Velocity		.13	.05	17	.78**

Note: * $p < .05$, ** $p < .01$

5.4.2.4 Silhouette

Across all measurement points, mean values did not differ between all trials by more than 3 mm for frontal measurements when bare breasted, by more than 8 mm for frontal measurements in the bra condition and by more than 5 mm for sagittal measurements in the bare breasted and bra condition. Reliability statistics for all silhouette measurements vary by up to 6 mm for change in the mean, between 2 mm and 14 mm for TEMs, and 1% and 4% for CV% across trials. For the majority of measurements, daily reliability statistics were better than weekly or monthly (table 10).

5.4.2.5 Breast shape

Across all measurement points, mean values did not differ between trials by more than 4 mm for frontal measurements when bare breasted, by more than 5 mm for frontal measurements in the bra condition and by more than 4 mm for sagittal measurements in the bare breasted and bra condition. For the majority of breast shape measurements, daily reliability was better than weekly or monthly reliability, with lower CV%, lower TEMs and the strongest correlations between trials. All TEMs varied between 2 mm and 7 mm, with CV% varying between 1% and 7% across trials (table 11).

5.4.2.6 Breast lift

Mean values of suprasternal notch to nipple distance vary between 41 mm and 44 mm, and percentage lift values range between 18% and 21% across test-retest trials. With the lowest TEM, CV% and highest ICC, breast lift measurements indicate that this method is more reliable on the same day, compared to weekly or monthly trials. However, daily measurements did produce the greatest change in the mean (3 mm) across all test-retest reliability statistics (table 9).

Table 9. *Reliability statistics for objective measurements of suprasternal notch to nipple distance for daily, weekly and monthly test-retest trials (n=12).*

	Trial	Mean	TEMs	CV%	ICC
Absolute lift (mm)	Initial	44			
	Daily	41	3	10	.97**
	Weekly	43	10	14	.75*
	Monthly	45	8	14	.94**
	Overall	43	7	13	.83**
Percentage lift (%)	Initial	20			
	Daily	18	2	10	.96**
	Weekly	21	6	21	.62
	Monthly	21	3	13	.92**
	Overall	20	4	15	.85**

Note: * $p < .05$, ** $p < .01$

Table 10. *Reliability statistics for objective measurements of silhouette across daily, weekly and monthly test-retest trials (n=12)*

		Trial	Mean (mm)	TEMs (mm)	CV%	ICC
Frontal Measurements- Bare breasted	A	Initial	309			
		Daily	309	4	1	.98**
		Weekly	308	5	1	.98**
		Monthly	307	9	3	.91**
	B	Initial	318			
		Daily	316	3	1	.99**
		Weekly	316	6	2	.98**
		Monthly	315	9	3	.95**
	C	Initial	288			
		Daily	290	3	1	.99**
		Weekly	290	4	1	.98**
		Monthly	288	7	2	.95**
Frontal Measurements- Bra	A	Initial	314			
		Daily	307	6	2	.98**
		Weekly	306	8	3	.95**
		Monthly	309	11	3	.92**
	B	Initial	316			
		Daily	316	2	1	.99**
		Weekly	317	5	2	.98**
		Monthly	317	9	2	.96**
	C	Initial	281			
		Daily	278	4	1	.99**
		Weekly	278	5	2	.97**
		Monthly	276	8	3	.93**
Sagittal measurements- Bare breasted	A	Initial	212			
		Daily	217	4	2	.98**
		Weekly	215	7	3	.94**
		Monthly	214	7	3	.93**
	B	Initial	271			
		Daily	272	5	1	.99**
		Weekly	270	8	2	.97**
		Monthly	273	7	2	.97**
	C	Initial	247			
		Daily	248	9	3	.97**
		Weekly	245	11	4	.94**
		Monthly	243	14	4	.90**
Sagittal measurements- Bra	A	Initial	210			
		Daily	215	6	3	.96**
		Weekly	213	6	3	.95**
		Monthly	213	9	3	.86**
	B	Initial	274			
		Daily	276	4	1	.99**
		Weekly	273	9	3	.96**
		Monthly	275	9	3	.96**
	C	Initial	244			
		Daily	244	6	2	.98**
		Weekly	241	7	2	.97**
		Monthly	240	10	3	.94**
Overall				7	2	.97**

Note: * $p < .05$, ** $p < .01$

Table 11. *Reliability statistics for objective measurements of breast shape across daily, weekly and monthly test-retest trials (n=12).*

		Trial	Mean (mm)	TEMs (mm)	CV%	ICC
Frontal measurements – Bare breasted	A	Initial	141			
		Daily	142	4	3	.95**
		Weekly	142	5	3	.92**
		Monthly	142	7	4	.86**
	B	Initial	141			
		Daily	145	1	2	.99**
		Weekly	145	4	3	.95**
		Monthly	144	4	3	.94**
	C	Initial	126			
		Daily	126	3	2	.95**
		Weekly	128	4	3	.93**
		Monthly	126	4	3	.84**
Frontal measurements – Bra	A	Initial	142			
		Daily	139	3	2	.97**
		Weekly	139	4	3	.95**
		Monthly	137	6	3	.89**
	B	Initial	150			
		Daily	151	2	1	.98**
		Weekly	151	4	2	.96**
		Monthly	151	3	2	.97**
	C	Initial	135			
		Daily	134	3	2	.96**
		Weekly	134	5	3	.93**
		Monthly	135	5	3	.91**
Sagittal measurements- Bare breasted	A	Initial	65			
		Daily	66	4	6	.96**
		Weekly	65	4	5	.96**
		Monthly	65	6	8	.90**
	B	Initial	101			
		Daily	103	4	4	.99**
		Weekly	99	5	4	.98**
		Monthly	100	5	5	.97**
	C	Initial	117			
		Daily	118	4	3	.99**
		Weekly	115	4	4	.98**
		Monthly	115	6	5	.97**
Sagittal measurements- Bra	A	Initial	55			
		Daily	56	3	5	.96**
		Weekly	56	4	7	.93**
		Monthly	57	3	5	.96**
	B	Initial	106			
		Daily	106	4	3	.98**
		Weekly	104	3	3	.98**
		Monthly	106	3	2	.99**
	C	Initial	105			
		Daily	107	3	3	.99**
		Weekly	103	4	3	.99**
		Monthly	106	5	5	.97**
Overall				5	3	.98**

Note: * $p < .05$, ** $p < .01$

5.5 Study A Discussion

In order to determine the test-retest reliability of methods established to assess the 11 key bra performance variables within both a bra and a bare breasted condition, participants were recruited to conduct test-retest trials over a daily, weekly and monthly period. Based on the boundaries of acceptable reliability defined in section 5.3.4, the results suggest that the methods to assess the 11 key bra performance variables have satisfactory reliability and the hypothesis for study A is accepted.

5.5.1 Subjective reliability

The 11 key bra performance variables were subjectively rated using numerical analogue scales. All variables showed changes in the mean of up to 1.1 of a rating, TEMs between 0.7 and 2.2 rating, CV% between 5% and 20%, and correlations between 0.51 and 0.96. Although the majority of correlation coefficients were above the required 0.8 boundary, the emphasis placed on these coefficients is small with regard to the reliability of subjective ratings, due to the small range of values expressed by participants (Hopkins, 2000). The key reliability statistics for subjective measures are therefore the change in the mean and TEM, of which all daily and monthly test-retests were below the required one rating and two ratings respectively.

Measures of comfort within this study reproduced those originally reported by Mason et al. (1999), which were also adopted by subsequent researchers (Scurr et al., 2009; White et al., 2009). Using scales to assess participant's rating of a bra's discreetness and fabric constitution is also concurrent with previous literature (Winslow & Jacobson, 1997; Yoo & Barker, 2005). However, the literature had not indicated the reliability of these methods. Therefore, the results of this study support the use of this scale format for these bra performance variables by suggesting it provides appropriate reliability. For all 11 variables, across daily, weekly and monthly trials, just three reliability values were outside of the required boundaries (weekly CV% comfort rating of 20%, daily CV% appearance under clothes ratings of 20% and weekly TEM discreetness rating of 2.2). The results of this study therefore advise that testing requiring ratings of bra performance be conducted on the same day or four weeks apart, as the weekly reliability accounted for two of the three values outside of the boundary level. It is postulated that monthly fluctuations in the female cycle may influence the

perception of bra performance; further research is required to identify the cause of subjective differences over a monthly cycle. It would appear that these scales are an appropriately reliable method to assess subjective opinion of the key bra performance variables within a cohort of women aged 45 to 65 years.

5.5.2 Objective reliability

To assess the bra's ability to stay in place, bra slippage following five everyday activities on four key areas of the bra was measured (shoulder straps, underwire, front gore and back strap). All measurements met the change in mean and TEM criteria, however, the overall CV% was 52% and the correlation, although significant, was low (0.48). Given the small absolute values of bra slippage (i.e., 1 mm to 9 mm) and subsequently the small range of values, the emphasis for determining the reliability of this method is placed on the TEM and change in mean (Hopkins, 2000), as these represent a more suitable level of precision for this method (Bruton et al., 2000). For example, CV% of up to 81% were reported (anterioposterior movement of the front gore between weekly trials) which relate to only a 1 mm change in the mean and 2 mm TEM. Therefore, the method for a bras ability to stay in place is deemed acceptable, despite correlations and CV% below the determined values.

Shoulder strap position was assessed as a percentage of the relative horizontal distance between the acromion process and the suprasternal notch. This method also showed acceptable reliability, with changes in the mean of less than 1%, TEMs of less than 2%, CV% of less than 4% and a correlation of 0.80 and is, therefore, considered reliable for use within this population of women.

The reliability of three-dimensional analysis of breast kinematics during treadmill activity has been reported by Scurr et al. (2007) as a test-retest of 17% CV%, with a between stride reliability of 10% CV%. However, Scurr et al. did not report the reliability of this method across testing sessions or differences between bra and bare breasted conditions. The current study found a similar overall CV% of 17% for breast displacement and 17% for breast velocity, with equivalent TEMs of 3 mm and $0.05 \text{ m}\cdot\text{s}^{-1}$. In accordance with the findings of previous literature and based on the criteria established in this study, the results confirm the reliability of this method to assess breast support. With typically higher TEMs seen in the bare breasted condition, the current findings indicate that this method is less reliable

during bare breasted trials compared to bra trials, but that little difference is seen whether tested on the same day, one week or one month later. Differences in the reliability of the measurement of breast kinematics in a bra condition or when bare breasted have few implications for research design, as studies utilising this methodological approach primarily determine the influence of a breast support intervention in comparison to a bare breasted condition (e.g., Scurr et al., 2010, 2011; White et al., 2009).

The method designed to assess silhouette was the first objective method of its kind to report reliability, therefore, no comparisons can be made to the reliability of previous methods. However, based on the criteria defined in section 5.3.4.5, the overall results indicate acceptable reliability, with a CV% of 2%, a TEM of 7 mm and a correlation of 0.97. The overall CV% appears low due to relatively large absolute values, and as such should be interpreted as an over-estimation of the reliability of this method (Hopkins, 2000). The greatest change in the mean of 8 mm (frontal measurement A for weekly reliability) is above the defined limit of 5 mm, however all other measurements fell within 4 mm, therefore overall reliability is deemed appropriate. Due to the unacceptable change in mean of 8 mm occurring during a weekly test retest trial, it is postulated that fluctuations due to the monthly cycle may be causing this change (Milligan, Drife, & Short, 1975). The monthly cycle may therefore be an important consideration when assessing female silhouette.

In previous methods to assess breast shape, Smith et al. (1986) showed CV% of up to 168%, Brown et al. (1999) reported TEMs of up to 4 mm during the same testing session, whereas Westreich (1997) and Qiao et al. (1997) did not discuss the reliability of the methods used. The current study found peak CV% of 8%, TEMs of up to 4 mm for daily reliability, and TEMs of up to 7 mm for monthly reliability. It is therefore recommended that breast shape measurements are conducted on the same day if possible, in order to minimise differences in camera set up and breast shape fluctuations. It appears that breast shape measurements are more reliable in a bra than a bare breasted condition, with peak TEMs of 7 mm when bare breasted and 6 mm in a bra condition. Based on the reliability boundaries defined in section 5.3.4.6, the breast shape measurement method developed within this study was deemed to be reliable.

The current findings indicate that assessing breast lift by measuring the vertical suprasternal notch to nipple distance within the LCS of the torso is reliable according to the criteria defined in section 5.3.4.7, with a daily TEM of 4 mm (8 mm over all testing sessions), a daily CV% of 10% (15% over all testing sessions) and correlations above 0.8. It is therefore recommended that assessment between different breast support conditions is conducted on the same day, as this provides the best reliability for this method. Daily reliability showed the lowest CV% and TEMs, but the greatest change in mean of all test-retest trials (3 mm). This may be due to the CV% and TEM being calculated as a factor of the standard deviation of the difference values. Therefore, if all values differed by the same amount between the test and retest trials, the CV% and TEM would appear relatively low compared to the change in mean. Brown et al. (1999) similarly reported TEMs of between 3.5 and 3.7 mm when calculating the vertical suprasternal notch to nipple distance using a ruler or tape measure. The current method therefore shows similar TEMs to previous kinanthropometric methods, despite the additional complexities of the LCS and optoelectronic tracking. However, it is recommended that the current method of optoelectronic analysis to assess breast lift be used where possible, to eliminate the more time consuming and invasive nature of kinanthropometric measurements on participants.

Due to the lack of agreement in the literature as to the most appropriate statistical procedures with which to indicate reliability, this study utilised a range of approaches to create an overview of each method's reliability within the context tested. By identifying the measurement error and variation in the protocols, the reliability of each protocol has been determined and accepted as suitable for use (Atkinson & Nevill, 1998). Although this study identified the reliability of the methods, the validity of the methods to distinguish differences between testing conditions remains unclear. Study B therefore aimed to assess the validity of these methods by assessing two bras of known structural difference, in order to determine if the same 11 key bra performance methods were able to identify differences between the two bras.

5.6 Study B Methodology

5.6.1 Ethical Approval

This study received ethical and scientific approval from the BioSciences Research Ethics Committee, in accordance with current University regulations.

5.6.2 Participants

Twelve female participants with physical characteristics (mean \pm SD): age 58.1 ± 5.4 years, height 1.62 ± 0.1 m, body mass 67.3 ± 9.0 kg, volunteered to take part in this study. Two of the participants were pre menopausal, one was peri menopausal and nine were post menopausal. Different to the reliability testing (study A), which was a within-participant design, in this study, all participants were required to have the same bra size, as the bras may have a different effect on different breast sizes. For example, bras have been found to provide different levels of support to different breast sizes, therefore it has been advised that studies include participants of the same bra size when comparing different breast support garments (Lawson & Lorentzen, 1990). Therefore, the mode bra size found in chapter four of this thesis (36C) \pm one size on the cross grading bra scale was selected for study B, resulting in five 34D participants, four 36C participants and three 38B participants.














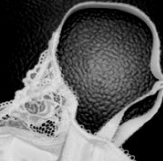


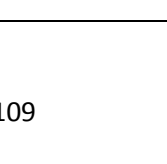

5.6.3 Experimental Design

5.6.3.1 Equipment

The equipment details and set up used in this study were the same as study A (see section 5.3.3.1), with the exception of the bras tested. For study B, the two everyday bras selected were based on their structural differences. The reason for this was to elicit differences within the 11 key bra performance variables, which, in addition to a comparison with a bare breasted condition, will inform the validity of the methods (Currel & Jeukendrup, 2008; Williams & Wragg, 2004). The structural differences detailed in table 12 were assumed to lead to differences within all 11 key bra performance variables.

Participants were blinded to the bra brand and labels identifying the brand were removed prior to testing (Moutinho & Evans, 1992; Proctor, 2003). Both bras were fitted according to White and Scurr's (2012) fitting criteria; this meant that some participants were not the same bra size in both bras. The participant's band size remained consistent between bras; however, the cup size differed by up to two sizes in order to meet White and Scurr's recommendations in each bra.

Table 12. Structural differences between bra A and bra B for validity testing

	Bra A	Bra B
		
Brand and style	Playtex Cross Your Heart bra (style 152)	M&S Jacquard lace bra (style T33/2781)
Price	£22.50	£12.00
Fabric	62% nylon, 22% cotton and 16% elastane	89% polyamide and 11% elastane
Under wire	No	Yes
Padding	Half padded sling 	Non-padded 
Hook and Eye	4 x 3 (73 mm) 	2 x 3 (38 mm) 
Underband width	30 mm 	12 mm 
Centre Gore	149 mm 	71 mm 
Side wing length	135 mm 	81 mm 
Strap width	21 mm 	12 mm 
Strap apex	Ring	Fabric
Strap adjusters	Front 	Back 
Cup height	201 mm 	168 mm 
Cup seam	Horizontal	T shape

5.6.3.2 Procedures

The procedures in study B were the same as study A (see section 5.3.3.2), with the exception that a bare breasted condition followed by two bras were tested (table 12), rather than just one bra (figure 11). Where possible in this study, retroreflective markers were not removed between tests to avoid potential influences on measurement error.

5.6.4 Data analysis

The data analysis methods for all 11 key bra performance variables were the same as in study A (see section 5.3.5). Statistical tests were conducted to assess differences between the two bras of structural difference (table 12) within all 11 key bra performance variables. All subjective data was treated non-parametrically due to the level of data. Parametric assumptions of objective data were checked using Kolmogorov-Smirnov, Shapiro-Wilk and Levenes tests ($p < 0.05$). Those data that violated the parametric assumptions were also analysed using non-parametric tests. Therefore, all subjective measures and objective measures of breast lift and bra's ability to stay in place for each bra were assessed using Friedman tests for differences and/or Wilcoxon signed rank tests for differences. Objective measures of shoulder strap position of the two bras were compared using a paired samples t-test, whereas breast shape, silhouette and breast support included a comparison to the bare breasted condition and were therefore assessed using mixed design ANOVAs. Where Mauchly's test of sphericity was violated, a Greenhouse-Geisser correction was used in replacement of the sphericity assumed F values (Hinton, Brownlow, McMurray, & Cozens, 2004). All statistical significance values were set at $p < 0.05$ and Bonferroni correction factors were used for post hoc analysis for the subjective variables; appearance under clothes, breast shape, silhouette, breast support and breast lift, and the objective measures; breast support, silhouette, breast shape and breast lift.

5.7 Study B Results

5.7.1 Subjective Results

Figure 25 shows the participant's average subjective ratings, following the everyday activity tasks for each of the 11 key bra performance variables, within each bra. Participants rated bra A as significantly less discreet ($Z = -2.25$, $p = .021$), worse fitting ($Z = -2.51$, $p = .012$), and as having worse fabric ($Z = -2.68$, $p = .007$) than bra B. Bra B was rated as appearing better underneath clothing than the bare breasted condition ($\chi^2_{(2)} = 10.98$, $p = .004$), whereas bra A was not rated

significantly differently from either bra B or the bare breasted condition ($p>.017$). No differences were found between bra A, bra B and the bare breasted condition with regard to comfort ($X^2_{(2)}=3.35, p=.191$). The bare breasted condition was rated as providing a less attractive breast shape ($X^2_{(2)}=10.30, p=.011$) and silhouette ($X^2_{(2)}=12.05, p=.002$), less breast support ($X^2_{(2)}=10.60, p=.011$) and less breast lift ($X^2_{(2)}=18.67, p=.001$) than both bras, however no difference was seen between ratings of bra A or bra B for these variables ($p>.017$). Ratings of the two bras ability to stay in place and the shoulder strap positions were similar ($Z=-.48, p=.631$ and $Z=-.41, p=.682$ respectively).

5.7.2 Validity of objective results to distinguish between bras of known structural difference

5.7.2.1 Bra's ability to stay in place

The mean magnitudes of bra movement over the skin (mm) for bra A and bra B were similar ($Z=-1.25, p=.211$), with bra movements of between 8 mm (bra A vertical movement of the centre gore) and 2 mm (bra B mediolateral movement of the shoulder strap) (figure 26).

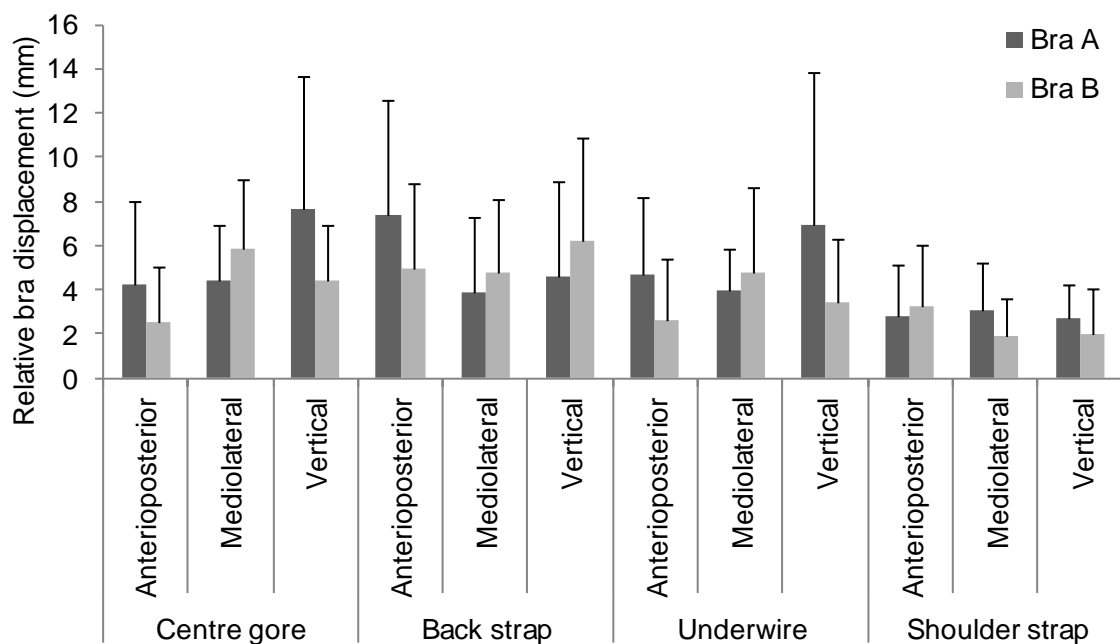


Figure 25. Mean multiplanar movement (mm) of four areas of the bras following everyday activities in bra A and bra A. Error bars represent the standard deviation (n=12)

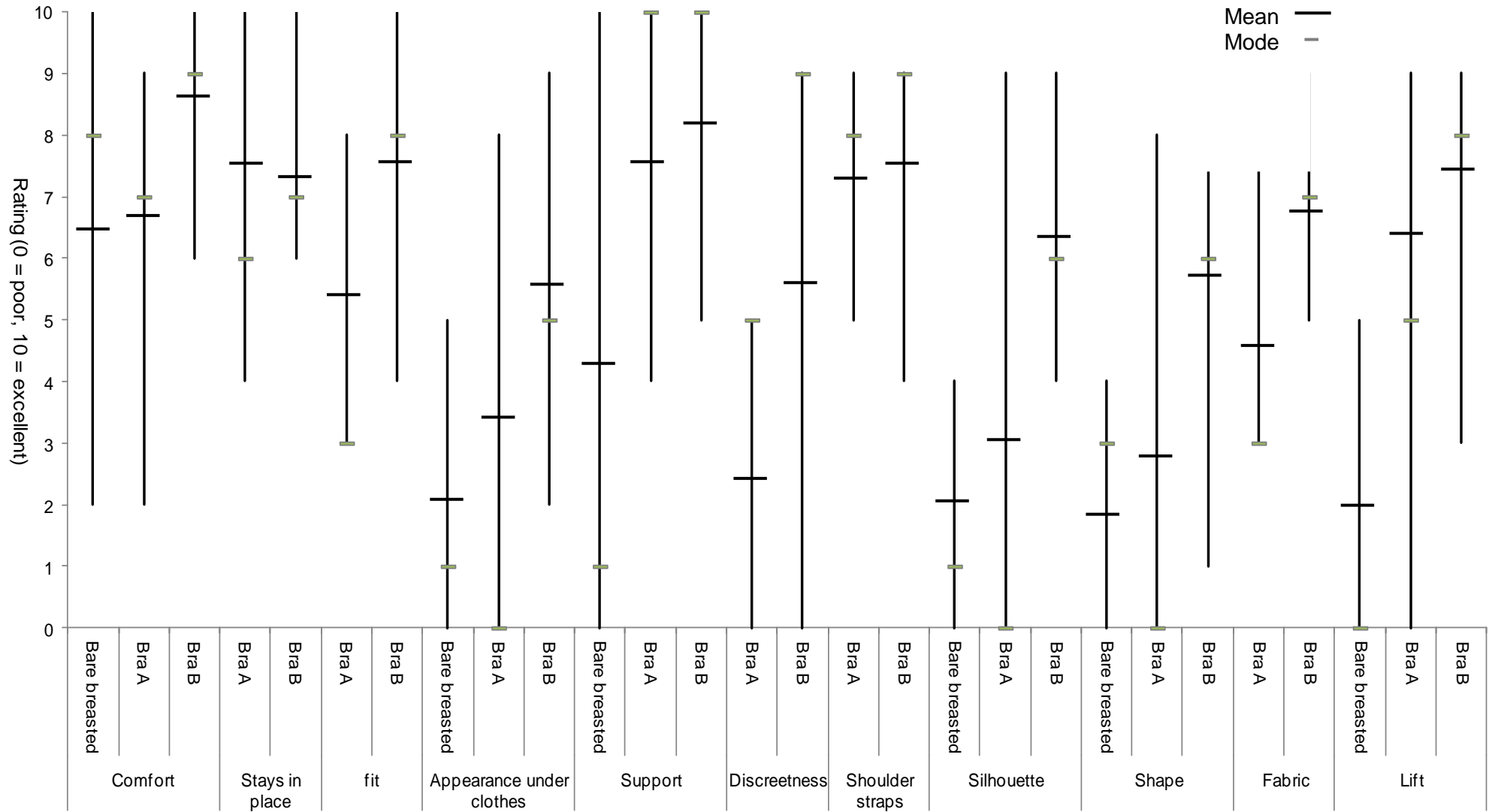


Figure 26. Range of subjective ratings for the 11 key bra performance variables following the everyday activity tasks in the two bras of structural difference and (where applicable) in a bare breasted condition. The mean (black) and mode (grey) values are shown as horizontal lines (n=12)

5.7.2.2 Support

There was significantly more breast movement in the bare breasted condition than in bra A or B ($F_{(1,34)}=25.93$; $p=.001$), but no difference between the two bras ($p>.003$) (figure 27). Interaction effects identified differences in mediolateral breast velocity between the bare breasted condition and bra B ($p<.003$), but not bra A (figure 28).

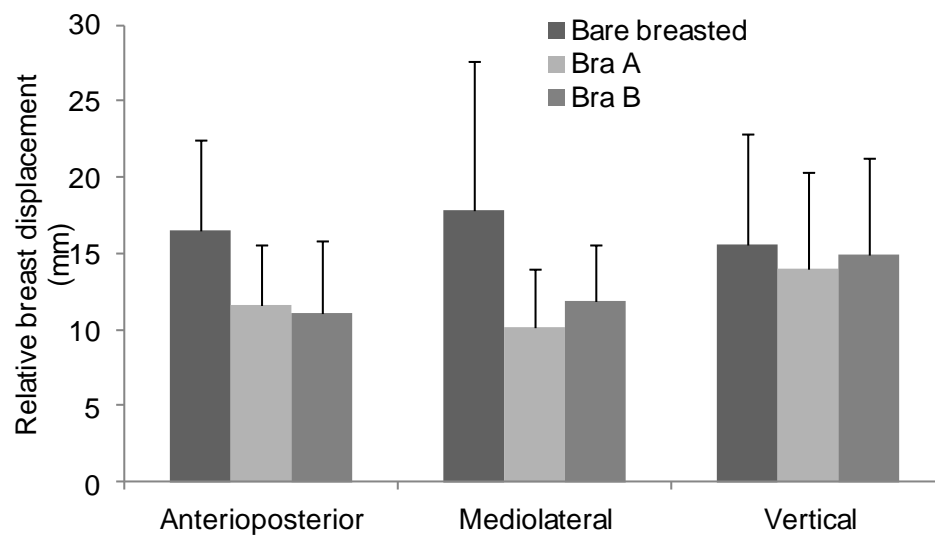


Figure 27. Mean relative breast displacement (mm) in anteroposterior, mediolateral and vertical directions in a bare breasted condition, bra A and bra B during treadmill walking. Error bars represent the standard deviation (n=12)

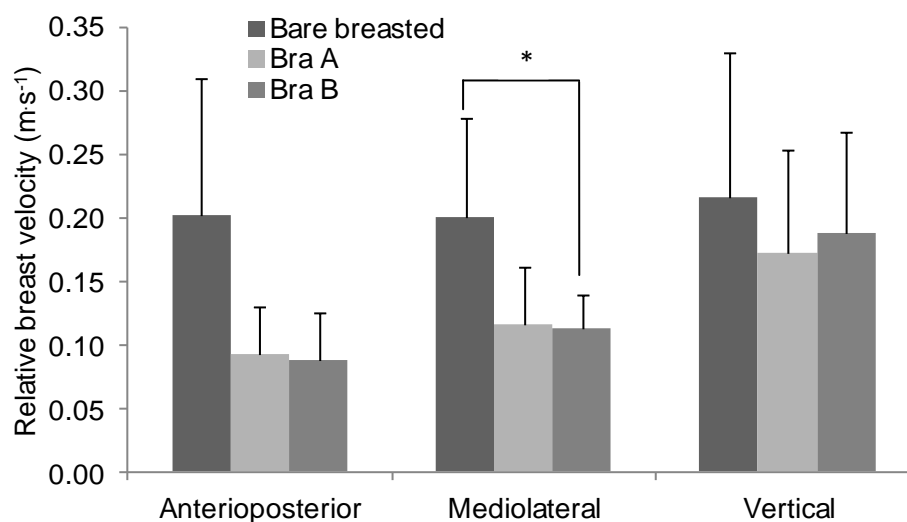


Figure 28. Mean relative breast velocity ($\text{m}\cdot\text{s}^{-1}$) in anteroposterior, mediolateral and vertical directions in a bare breasted condition, bra A and bra B during treadmill walking. Error bars represent the standard deviation (n=12). * $p<0.05$.

5.7.2.3 Shoulder Strap position

Bra A and bra B were positioned 70% and 71% of the distance between the suprasternal notch (0%) and the acromion process (100%), no difference was found between the two bras ($t_{(11)}=-1.37, p=.202$) (figure 29).

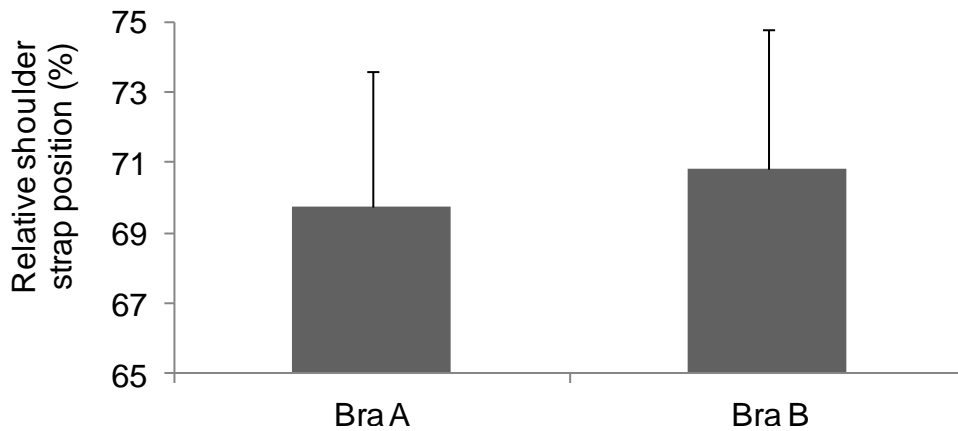


Figure 29. Mean horizontal shoulder strap position (%) in bra A and B. Error bars represent the standard deviation (n=12).

5.7.2.4 Torso Silhouette

The breast support condition had an influence on silhouette ($F_{(2)}=8.13; p=.001$), with significant interaction effects ($F_{(10)}=9.03; p=.001$) seen only in the frontal plane between the bare breasted condition and bra A across the under bust (271 ± 20 mm and 255 ± 17 mm, respectively), and between the bare breasted condition and bra B across the nipple (290 ± 17 and 278 ± 14 mm, respectively) and under bust (271 ± 20 and 256 ± 18 mm, respectively) (figure 30).

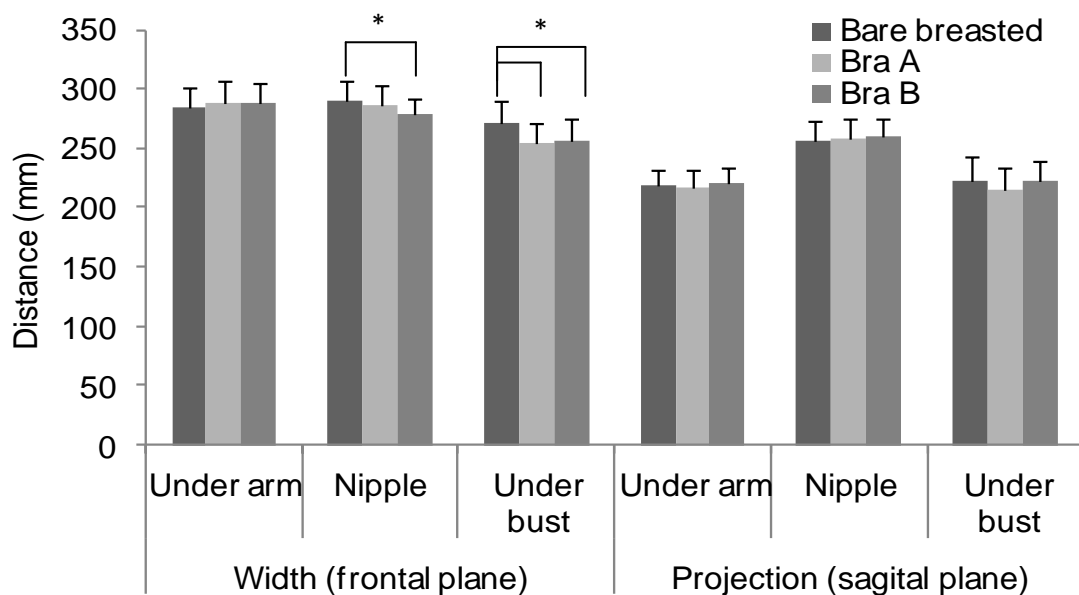


Figure 30. Width (frontal plane) and projection (sagittal plane) measurements of silhouette in three breast support conditions. Error bars represent the standard deviation (n=12). * $p<0.05$.

5.7.2.5 Breast shape

Breast shape was influenced by the breast support condition ($F_{(1,69)}=4.88$; $p=.011$). Interaction effects indicated differences between support conditions for individual measurement areas ($F_{(8,43)}=12.26$; $p=.001$). Bra A provided a narrower top measurement in the frontal plane (112 ± 8 mm) than either the bare breasted condition (131 ± 6 mm) or bra B (128 ± 6 mm). In the sagittal plane however, the bare breasted condition provided greater breast projection (53 ± 6 mm) than either bra A (46 ± 8 mm) or bra B (46 ± 6 mm) across the top (figure 31).

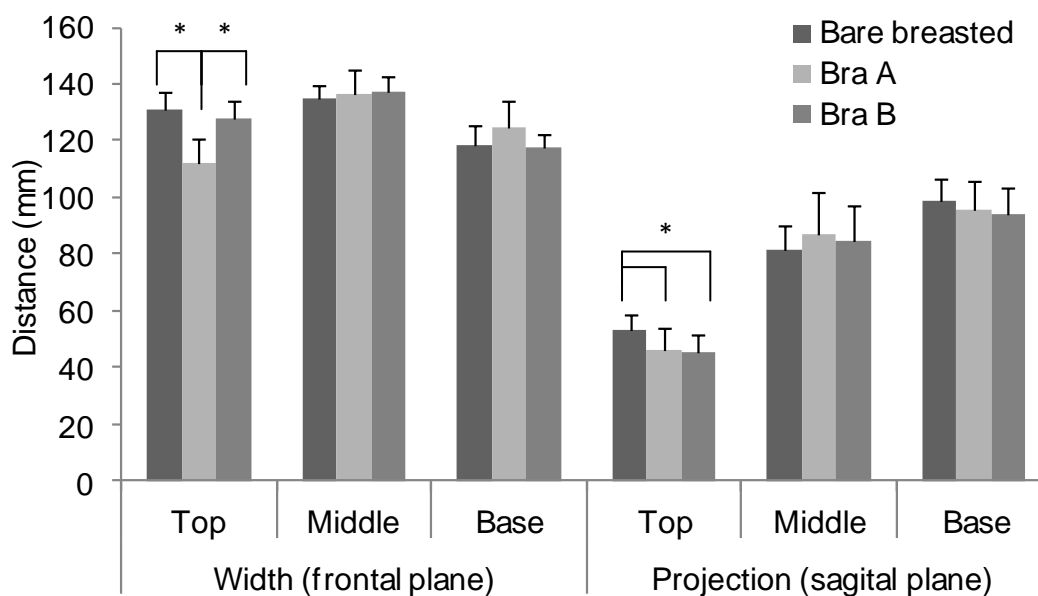


Figure 31. Width (frontal plane) and projection (sagittal plane) measurements of breast shape in three breast support conditions. Error bars represent the standard deviation ($n=12$). $*p<0.05$.

5.7.2.6 Breast lift

The breast lift data showed that the vertical position of the breast was altered by bra use ($\chi^2_{(2)}=18.67$, $p=.001$), with a significantly higher position in both bra A and bra B when compared to the bare breasted condition ($p<.017$), but no difference seen between the two bras (figure 32).

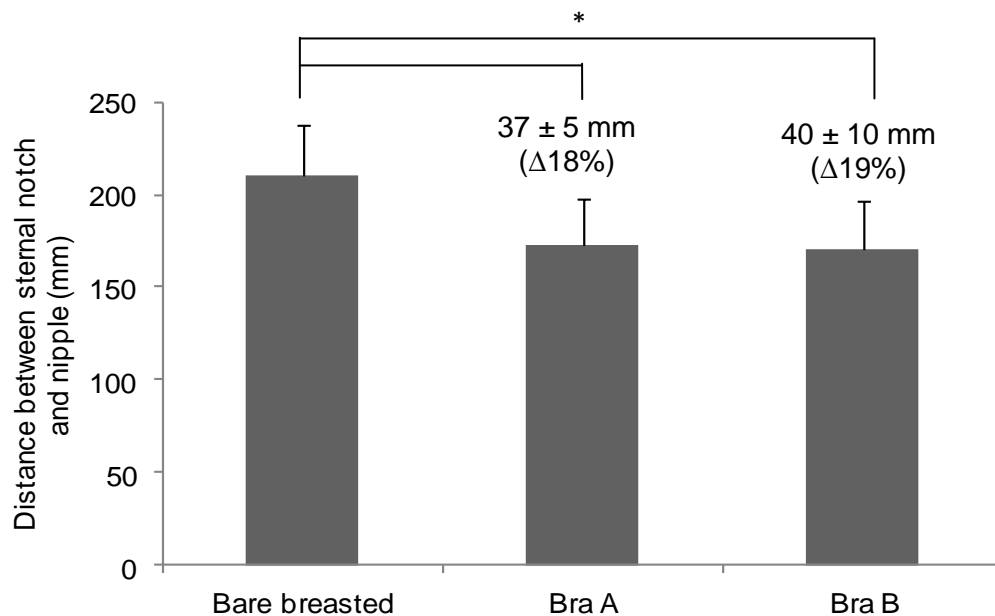


Figure 32. Mean vertical position of the nipple (mm) relative to the suprasternal notch. Breast lift in millimetres and as a percentage of the bare breasted condition is shown above each bra condition. Error bars represent the standard deviation ($n=12$). $*p<0.05$.

5.8 Study B Discussion

Study B aimed to investigate the validity of the methods established to assess the 11 key bra performance variables, by quantifying differences between two bras of a known structural difference (bra A and bra B, table 12) and a bare breasted condition. The results of the validity tests between the two bras and the bare breasted condition show differences for all criteria except comfort, shoulder strap position and bra's ability to stay in place. The bras selected for validity testing were structurally different based on their structure and style. The key bra performance variables; comfort, shoulder strap position and ability to stay in place showed no significant difference between these support conditions. This may not indicate that the tests are invalid, but may reflect that these bras were not specifically selected based on differences within those variables.

The question format for subjective rating scales were similar to past publication (Godwin et al., 1998; Mason et al., 1999; Winslow & Jacobson, 1997) and were also influenced by the qualitative results from chapter three. This increased the validity of this study by ensuring the terminology used in the survey was similar to that used by participants in chapter three (Hinkin, 1995). Despite bra fitting participants according to the recommendations in the literature (White & Scurr,

2012) differences were found in subjective ratings of bra fit between the bras of known difference, suggesting that this method is valid and may be used to signify a woman's perception of a bra's fit. The results suggest that some bras are not perceived to fit well due to their design, regardless of a bra fitter's selection of the best possible fit. Therefore, it is recommended that bra-related studies adhere to White and Scurr's (2012) best fit criteria to ensure subsequent data are affected minimally by poor bra fit.

Designing new methods on previous related protocols can aid validity. For example, the method to assess the bra's ability to stay in place was based on previous protocols to measure helmet slippage (Smith & Smith, 2006). This improves the likelihood that the measurements taken are an accurate representation of the garments ability to stay in place (Hopkins, 2000). The amount of bra slippage recorded varied between 2 mm and 8 mm, with the least amount of movement occurring at the shoulder straps in either bra. This seems contradictory to previous literature that suggests women often experience shoulder strap slippage in everyday bras (Bowles et al., 2011; Chen, LaBat, & Bye, 2011; Yu, Wang, He, & Zhang, 2011). However, the limitations of this methodology may have influenced the current findings, it is possible that bra movement occurred during the activities, but the bras settled back to the same position prior to the post activity static image. Due to the limitations of optoelectronic tracking, it was not possible to record bra slippage during the activities, as the participant's body position during sweeping and shoe removal would have blocked markers. Bra slippage during the remaining three tasks (treadmill walking, reach task and shoulder exercise video) were not recorded individually because the aim of this method was to investigate a holistic view of bra slippage throughout the day, rather than bra slippage during or following specific activities.

Although the present study found no difference between the two bras of structural difference for the variable breast lift, differences were seen between the bare breasted and the two bra conditions. The similar level of breast lift provided by the two bras is unsurprising as the bras were not selected based on the level of lift provided. A push-up bra could have been used to elicit greater differences between bra conditions. However, the validity of this method is supported by

numerous breast surgeons that use this measurement following mastopexy surgery (<http://www.baaps.org.uk> and <http://www.cosmeticsurg.com>). Similarly, no difference was found between the two bras for the variable shoulder strap position. This was surprising given the different strap widths and strap apex of the two bras. However, an indication of validity may be gleaned based on the suprasternal notch to acromion process values found in this study, which ranged between 18.3 to 20.9 cm, similar to those reported in previous literature of 16.0 to 21.5 cm (Westreich, 1997). This range of values supports the use of relative percentage values for shoulder strap position due to the 2.6 cm difference in suprasternal notch to acromion process size.

The methods were able to discern differences in breast shape between the breast support conditions, and may therefore have an application wider than bra performance assessment. For example, pre and post breast surgery differences could be assessed in a clinical environment using this method. The method to assess breast shape presents a limitation due to the defined position of 'top of the breast'. Figure 33 indicates that greater breast projection was seen at the top of the breast in the bare breasted condition than in either bra, which seems counterintuitive due to the volume shift in breast tissue caused by the lift of the bra (figure 32). However, due to the nature of the soft tissue of the breast, the defined superior and inferior breast boundaries were moveable in the breast shape method, rather than rigid landmarks. Due to the position of the defined superior breast boundary, landmarks in the bare breasted condition presented a lower 'top' than in either bra. This meant that the projection measured when in a bra was from a higher position on the torso than when in the bare breasted condition, explaining this result. Figure 33 indicates the difference in breast shape measurement that would be caused by assuming the same 'top of the breast' position in both the bare breasted and bra condition using rigid landmarks. With the breast tissue lifted, measurements must be taken from a more superior position. The values should therefore be considered with regard to the vertical position of the breast in each support condition.

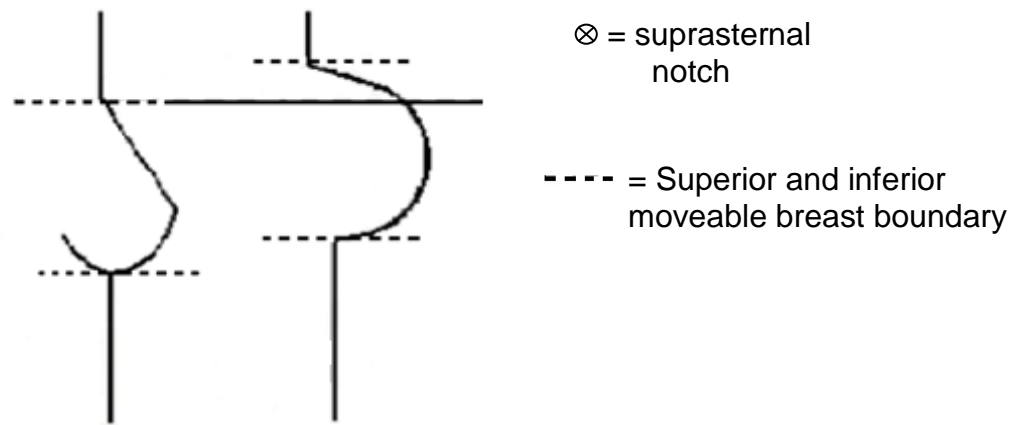


Figure 33. The superior and inferior breast boundary positions. The left image indicates a bare breasted condition, and the right image shows the lifting effects of a bra, thus the true ‘top of the breast’ would be excluded from measurement if the same distance from the suprasternal notch were used as in the bare breasted condition, indicated by the extension of the horizontal line from the superior bare breasted boundary.

Due to the variable dispersion of breast tissue in the superior portion of the breast, it is not possible to define an exact boundary of the breast. Determining the ‘top of the breast’ as half way between the suprasternal notch and inferior most point of the breast/underwire is important, as it ensures that the measurements taken report the shape of the soft tissue of the breast, rather than the breasts relative position on the body, as previous methods have purported to represent breast shape (Brown et al., 1999; Qiao, Zhou, & Ling, 1997; Smith, Palin, Katch, & Bennett, 1986; Westreich, 1997). By not assuming an arbitrary fixed distance from the suprasternal notch to be the superior boundary of the breast tissue, this approach also ensures that measurements are normalised to the individual participant.

Where a universally accepted method was not available for comparison, the most appropriate format of validity testing was implemented within study B, incorporating tests of difference between two products that were thought to differ (Currel & Jeukendrup, 2008; Hopkins, 2000; Williams & Wragg, 2004). The results show differences between bra A, bra B and the bare breasted condition for all but three of the key bra performance variables. However, when assessed collectively, the results indicate that the methods developed to assess the performance of a

bra for women aged 45 to 65 years are appropriately discernable to distinguish differences between two products, where differences exist.

5.9 Summary

This chapter aimed to develop methods to assess the 11 key bra performance variables determined in chapter four, and to assess their reliability and validity. These new procedures were required to assess the key bra performance variables for women aged 45 to 65 years to assess the appropriateness of products for this population. These methods may provide information that can be used by manufacturers to optimise bras for this population. Study A identified reliability statistics for the 11 key bra performance variables in both a bra and bare breasted condition and determined acceptable reliability based on a combination of change in the mean, TEMs, CV% and correlation coefficients. Study B provided justification that the methods are valid to distinguish differences between two bras of structural difference and a bare breasted condition, with differences found for eight of the 11 variables (Currel & Jeukendrup, 2008; Williams & Wragg, 2004).

The application of these methods is both fundamental and applicable to a clinical setting. For example, in addition to studies investigating the performance of bras, methods regarding breast lift, breast shape and silhouette may be appropriate for post operative assessment. Additionally, methods to assess bra slippage may be used to assess slippage of other garments. This chapter identified methods to quantify; comfort, bra's ability to stay in place, bra fit, appearance under clothes, breast support, bra discreetness, shoulder strap position, silhouette, breast shape, fabric and breast lift. With consideration of the influence of ageing on the female breast, future research should implement the methods developed in this study in order to assess the performance of everyday bras for women aged 45 to 65 years. This may provide information on the appropriateness of current bras for older women and identify any shortcomings in their design.

Chapter 6.

Investigating key bra performance variables: Comparisons of a popular and unpopular bra brand

6.1 Introduction

It has been suggested that the bra market is predominantly influenced by modern fashion culture rather than women's needs (Greenbaum et al., 2003). With regard to the anatomical and physiological changes to the breast with increasing age, the ability of bras to meet the needs of older women is unknown. Having determined the key variables of a bra for women aged 45 to 65 years and established methods to assess them in previous chapters, the aim of this chapter is to quantify the performance of two different bras on the market, investigate their appropriateness in meeting the needs of an older woman and identify any shortcomings in their design. The selection of the two bras for performance testing is therefore important.

6.1.1 Selection of bras

Swan and Combs (1976) previously proposed that; if the outcome of a product is equal to or exceeding the consumer's expectations, it is judged as a satisfactory product and repeat purchase may occur. The popularity of a product or brand may therefore lie within its ability to perform to the expectations of the consumer; expectations that are formed based on the preferences and physical requirements of the consumer (Hart & Dewsnap, 2001). Brand choices are linked to numerous factors, such as the presence and associated image of co-consumers, the image a brand projects and the attitudes derived from beliefs about the product attributes (Bass, Pessimier, & Lahmann, 1972; Birtwistle & Tsim, 2005; Hart & Dewsnap, 2001; Ross & Harradine, 2010). However, brand switching from consumers' favourite brand may occur if an alternative product is deemed more appropriate at that time (Bass et al., 1972); therefore, the choice of product or brand may ultimately come back to the performance of the product itself. Moreover, Birtwistle and Tsim (2005) suggested that the preferences and requirements of products differ among age groups, with consumers typically drawn toward brands they feel represent their own self image. Hence, it would appear that the popularity of a product/brand is influenced by the product performance among individual populations, and by assessing products of different popularities it is possible to gauge their appropriateness for individual populations. However, it should be

considered that a bra's price, marketing strategy and positioning in store will all influence a bra's dominance within the bra market, in addition to the quality of the bra (Cooper, 1996; Malhotra & Birks, 2003; Ross & Harradine, 2010; Vink & Hallbeck, 2011).

In order to select the bras used within the current study, information gathered from the survey implemented in chapter four was used. The results showed that Marks and Spencer (M&S) was the most commonly worn bra brand, and that Playtex was the least commonly worn brand (figure 8, chapter four). Based on the aforementioned literature regarding the popularity of brands, the current study is conducted under the premise that the commonality of a bra brand is influenced by its popularity. Further, it is proposed that the popularity of a brand is influenced by the products appropriateness for the consumer (Bass et al., 1972; Swan & Combs, 1976). Therefore, the bras tested in this chapter will subsequently be referred to as the 'popular bra' (M&S) and the 'unpopular bra' (Playtex). However, it is unknown whether M&S is more popular among women aged 45 to 65 years than Playtex due to the superior performance of the bras, or due to extraneous factors relating to brand popularity (Proctor, 2003; Ross & Harradine, 2010). By selecting the best-selling bras from both M&S and Playtex for comparison within the current study, the appropriateness and performance of each bra brand can be assessed for women aged 45 to 65 years.

6.1.2 Determining a bras appropriateness

In order to investigate whether bras are appropriate for the needs of women aged 45 to 65 years, a criterion must be determined for each bra performance variable. However, due to the lack of published literature on the objective key bra performance variables for this population, criterion must be based on subjective ratings and gleaned from related research. For example, pain literature provides clinically relevant boundaries for analogue scales, identifying when further medication is required for patients. Past literature has determined the optimum cut off ratings on a numerical analogue scale for mild, moderate and severe pain, with a score of seven or above indicating severe pain (Serlin, Mendoza, Nakamura, Edwards, & Cleeland, 1995).

More recent research by Boogaerts, Vanacker, Seidel, Albert, and Bardiau (2000) conducted a regression analysis between visual analogue scale data and a four

point verbal descriptive scale for nausea in postoperative patients. The results indicated that a score of below four implied mild nausea, between four and seven implied moderate nausea, and seven or above implied severe nausea. Different boundary levels were defined for pain ratings by Bodian, Freedman, Hossain, Eisenkraft and Beilin (2001), with pain defined in postoperative patients as mild (below three), moderate (between three and seven) and severe (seven and above). Similarly, when the aim of the study was to assess acceptable levels of comfort in women in labour, the level of medication was deemed appropriate when pain ratings were three or lower on a ten point scale (Roelants, Rizzo, & Lavand'homme, 2003). These studies indicate that a difference from the maximum scale value of 30% is defined as the cut off value for applied relevance. The current study will therefore deem each key bra performance variable appropriate for women aged 45 to 65 years if the subjective rating has an average score of seven or greater on the numerical analogue scale.

6.1.3 Relationship between objective and subjective data

Previous literature contains no information regarding the performance of bras within key performance variables of women aged 45 to 65 years. However, some bra performance variables have been researched within other populations. A study by Kim et al. (2004) followed a quantification process similar to that within the current thesis; by identifying the bra needs of a younger cohort of Korean women, developing objective measures for key bra variables where appropriate, and subjectively assessed the remaining 'primary' variables. However, unlike the methods developed in chapter five of this thesis, Kim et al.'s study does not specify how each variable was quantified in sufficient detail to replicate the methods. The findings from Kim et al.'s study were suggested to have been used in the engineering design process of bras. It is hoped that by using similar research approaches the results from the current study may be relevant for optimising bra designs for women aged 45 to 65 years.

For bra variables with an objective and subjective measure, Kim et al. (2004) also correlated the two, resulting in design recommendations to improve overall wearer comfort, although these were not detailed in the article. The relationship between objective and subjective measures can therefore enhance the applications of the results within research studies. Prior research by Constantakos and Watkins (1982) correlated objective measures of pressure exerted by bras on the skin of

nursing mothers with their subjective ratings of bra comfort, with the aim to identifying bra design features that would increase wearer comfort. Increased bra-skin pressure was found to negatively correlate with bra comfort in particular areas of the bra, identifying the bra areas that required adjustment to improve wearer comfort. Subjective ratings of breast comfort and support have previously been shown to correlate with vertical breast displacement during treadmill running (Lawson & Lorentzen, 1990). This relationship was investigated among females in order to show that the evaluation of bra performance is multidimensional (Lawson & Lorentzen, 1990). More recent research by Heil et al. (2011) compared a computer based, semi-automatic objective measure of breast symmetry with the results of a questionnaire completed by post-operative female breast cancer patients. Based on correlations, Heil et al. (2011) concluded that it was necessary to apply both objective and subjective approaches to gain a comprehensive knowledge of breast aesthetics.

The advantages of understanding the relationship between objective and subjective measures are evident in previous literature. Among the 11 key bra performance variables identified within the previous chapters of this thesis, the relationship between subjective and objective measures may reveal design recommendations for women aged 45 to 65 years (Constantakos & Watkins, 1982; Kim et al., 2004), if significant correlations are found, it may provide an indication of an optimum value range for objective measurement. For example, if subjective ratings of breast shape have a positive correlation with breast width, it may be deduced that wider breasts are perceived as having a more attractive shape.

It is unknown how current bras on the market are performing with regard to the key bra performance variables for women aged 45 to 65 years. Therefore, this study had multiple aims regarding the assessment of bra performance. The first aim of this study was to assess whether differences in the key bra performance variables exist between a bra from a popular brand (M&S, subsequently referred to as the 'popular' bra) and a bra from an unpopular brand (Playtex, subsequent referred to as the 'unpopular' bra), giving insight into whether these bra performance variables determine the popularity of a bra, or whether extraneous variables related to the brand influence its popularity. The second aim of this

study was to observe any correlations between objective and subjective measurements. By investigating these variables, the performance of the popular and unpopular bra for women aged 45 to 65 years may be ascertained. Those variables that are rated by participants as below seven on the subjective scale will be highlighted in order to indicate which key bra performance variables may need improving to optimise them for women aged 45 to 65 years.

H₁. There will be a significant difference between the popular and unpopular bra among the 11 key performance variables (appearance under clothes, discreetness, fabric, breast lift, bra shoulder straps, silhouette, bra's ability to stay in place, breast shape, comfort, bra fit, and breast support).

H₂. There will be a correlation between objective and subjective measures of the six key performance variables that were objectively quantified (breast lift, bra shoulder straps, silhouette, bras ability to stay in place, breast shape and breast support).

6.2 Methodology

6.2.1 Ethical approval

This study received ethical and scientific approval from the BioSciences Research Ethics Committee, in accordance with current University regulations.

6.2.2 Participants

Participants were recruited by an advertisement on the University of Portsmouth's newsletter, stating participant requirements. Fourteen females participated in this study, with physical characteristics (mean \pm standard deviation): age 57.5 ± 5.2 years, height 1.61 ± 0.1 m, body mass 67.6 ± 8.7 kg. Two of the participants were pre menopausal, two were peri menopausal and ten were post menopausal. The findings from the study reported in the fourth chapter of this thesis suggested that the mode bra size for this sample was 36C. In order to provide the most representative results for this population, the mode bra size and those \pm one size on the cross grading system were selected, resulting in seven 34D, four 36C and three 38B participants. Participants were bra fitted according to the best fit criteria as stated in the previous chapter of this thesis (White & Scurr, 2012), with participants measuring a 34D, 36C or 38B in the popular bra, and then provided with the size that was most suitable for them in the unpopular bra. Based on the exclusion criteria, participants were all UK residents aged 45 to 65 years, had not had muscular or joint injury/problems within the last year, were not currently

pregnant, had not given birth or breast fed within the last year and had no history of surgery of any kind to the breasts (Scurr et al., 2009, 2010, 2011).

6.2.3 Experimental procedure

To investigate the 11 key bra performance variables for women aged 45 to 65 years (comfort, stays in place, fit, appearance under clothes, support, discreetness, shoulder straps, silhouette, shape, fabric and lift), this study followed the procedures developed and assessed in chapter five (section 5.3.3). Descriptions of these methods are summarised in 13.

Table 13. *Summary of the methodological approaches to assess each key bra performance variable.*

Performance Variable	Methodology
Comfort	Subjective (NAS)
Stays in place	Subjective (NAS), objective measure of displacement after daily activities (mm)
Bra fit	Subjective (NAS)
Appearance under clothes	Subjective (NAS)
Support	Subjective (NAS), objective measure of displacement (mm) and velocity ($m \cdot s^{-1}$) during treadmill activity
Discreetness	Subjective (NAS)
Shoulder Straps	Subjective (NAS), objective measure of shoulder strap position (%)
Silhouette	Subjective (NAS), objective measure of torso width frontal and sagittal (mm)
Breast shape	Subjective (NAS), objective measure of breast width frontal and sagittal (mm)
Fabric	Subjective (NAS)
Breast lift	Subjective (NAS), objective measure of vertical distance (mm) and percentage difference between bare breasted and bra (%)

Note: NAS: Numerical Analogue scale. As detailed in chapter five, all NAS were ten point, with zero indicating a low/bad rating of the variable, and ten indicating a high/good rating of the variable.

Two bras and a bare breasted condition were tested, resulting in three breast support conditions. The bras used were the best selling bras from the most and least popular brands as determined in chapter four. The most popular brand was Marks and Spencer. To identify the most popular bra within Marks and Spencer, their website was searched for 'best sellers' and identified the Jacquard lace underwired bra (table 12) as the best seller (style T233/2781, white, underwired, non-padded, full cup with lace and non-slip straps, available for £12; made from 89% polyamide and 11% elastane). To confirm this bra was the most popular, shop assistants in three different Marks and Spencer's stores across South East England were asked which bra sold best for older women, each identified the Jacquard lace underwire bra as the most popular. As determined by the survey implemented in chapter four, the least popular brand was Playtex, communication with the company identified the best selling bra as the Affinity-rose Beauty Cross bra (Style 6879, white, underwired, non-padded full cup, available for £20.50; made from 78% cotton, 13% nylon, 7% elastane and 2% polyester) (figure 11). Where branding is not important, it is recommended that blind trials are conducted to allow feedback on the product alone, which may be biased by preconceptions about the brand or style (Moutinho & Evans, 1992; Proctor, 2003). Information sewn into bras that identified the brand or style of the bra was therefore removed.

The survey used in chapter four determined the most popular and least popular bra brand by asking participants which brands they had worn in the past five years, in the past six months and which brand they wore most often. Due to the terminology of these questions, it was a concern that the results may have represented availability of the brands, rather than the popularity. Therefore, the number of outlets in which these brands were available was calculated. At the time this study was conducted, both Marks and Spencer's (703 stores) and Playtex (at least 500 known: exact number unknown due to distribution within numerous smaller outlets) had over 500 individual outlets in the UK in which their bras could be purchased. Due to the wide availability of both brands, it was determined that the difference found in wearer use between the brands was not influenced by availability.

6.2.4 Schedule of testing

Pilot tests were not conducted as methodological details were already defined in the previous chapter. Participants were required to attend one laboratory testing

session lasting approximately 1.5 hours. The session included a bare breasted condition, and both the popular and unpopular bra conditions. The session followed the procedures outlined in chapter five: participants had six retroreflective markers attached in the bare breasted condition, and 15 attached in each bra condition, a static image was taken using the optoelectronic camera system, followed by five everyday activities (bare breasted and bra conditions: treadmill walk, bra conditions only: reaching, sweeping, removing and replacing shoes, shoulder exercise video), after which a second static image was taken, then a sagittal and frontal image was taken using digital video cameras. The bare breasted condition was conducted first in all cases, and the popular and unpopular bra alternated in testing order. Participants were asked to complete a questionnaire following each support condition to provide subjective ratings for each of the key bra performance variables.

6.2.5 Data analysis

All data were analysed according to the protocol developed in chapter five of this thesis (section 5.3.5), with the exception of the statistical tests performed. Subjective ratings of each bra variable were compared between breast support conditions using Wilcoxon signed rank tests or Friedman tests, dependent on the number of breast support conditions of interest (two or three). Parametric assumptions for all objective variables were assessed using Kolmogorov-Smirnov, Shapiro-Wilk and Levenes tests ($p > 0.05$) and a mixed design ANOVA was conducted to assess differences between the bare breasted condition, the popular bra and unpopular bra for the variables: bra's ability to stay in place, breast support, silhouette, breast shape and breast lift. Paired samples t-tests with a Bonferroni correction factor were used for post hoc analysis where appropriate. Where Mauchly's test of sphericity was violated a Greenhouse-Geisser correction was used in replacement of sphericity assumed F values (Hinton et al., 2004). Comparisons of shoulder strap position between the popular and unpopular bra were assessed using a paired samples t-test. In order to distinguish the relationship between subjective and objective measurements, Spearman's rho correlation coefficients were conducted. With a strong correlation defined as > 0.5 , a medium strength correlation defined as between 0.3 and 0.5, and a weak correlation defined as < 0.3 (Cohen, 1988; Fields, 2009). A Bonferroni correction factor was used where multiple correlations were required for each variable (breast support, breast shape, silhouette and ability to stay in place) (Fields, 2009). A

summary table is provided of the key bra performance variables, their appropriateness for women aged 45 to 65 years, and recommendations for bra design and future bra studies regarding objective values for appropriateness.

6.3 Results

6.3.1 Subjective results

Figure 34 shows the participant's average subjective ratings, following the everyday activity tasks, regarding each of the 11 key bra performance variables within each breast support condition. No subjective differences were seen between the popular and unpopular bra, with similar ratings of bra fit (7.7 ± 1.7 and 7.2 ± 2.0 , respectively), bra's ability to stay in place (7.5 ± 2.3 and 7.7 ± 1.3 , respectively), shoulder strap position (7.4 ± 1.3 and 7.2 ± 1.8 , respectively), bra fabric (6.9 ± 1.3 and 7.2 ± 2.0 , respectively) and bra discreetness (5.8 ± 2.3 and 5.6 ± 2.8 , respectively) (all $p < .05$). All breast support conditions were rated as comfortable ($\chi^2_{(2)} = 3.11$, $p = .211$), with average ratings of 6.6 ± 2.9 (bare breasted condition), 8.4 ± 1.2 (popular bra) and 7.9 ± 2.1 (unpopular bra). The remaining variables that include a comparison to the bare breasted condition showed improved ratings in both bras when compared to the bare breasted condition. Subjective ratings of breast support were higher in the popular bra (8.6 ± 1.3) and unpopular bra (8.6 ± 1.9) than the bare breasted condition (4.4 ± 3.4), as were ratings of breast shape (bare breasted 2.4 ± 1.9 , popular bra 5.9 ± 2.1 and unpopular bra 5.6 ± 2.2), breast lift (bare breasted 2.1 ± 2.0 , popular bra 7.1 ± 1.6 and unpopular bra 6.6 ± 2.5), appearance under clothes bare breasted 2.3 ± 1.6 , popular bra 5.7 ± 2.0 and unpopular bra 5.3 ± 1.5) and silhouette (bare breasted 2.3 ± 1.6 , popular bra 5.7 ± 2.0 and unpopular bra 5.3 ± 1.5) (all $p < .05$). A Bonferroni correction was applied ($p < .0167$) and for these five variables, significant differences lay between the bare breasted condition and both bras, but not between the popular and unpopular bras.

6.3.2 Additional subjective comments

Participants were asked about their likes/dislikes of the popular and unpopular bra, all 14 participants provided additional feedback on both of the bras. No comments were excluded and all comments are presented in table 14; number of participants is given in brackets where multiple participants provided the same response. No subsequent analysis of these comments was conducted due to the brief nature of the comments provided by participants.

Table 14. *Participant's likes, dislikes and alterations of the popular and unpopular bra following everyday activity trials. Bracketed numbers show the number of participants, where multiple participants provided the same comment (n=14).*

Popular bra	Likes	The support. Pretty fabric. The fabric felt nice (2). It feels lovely to wear. It looks good underneath t-shirt (3). Very stable. Comfortable. Appearance (3). Straps (2). Neat seaming. Not obvious under t-shirt. Fit very well. Part lace part fabric.
	Dislikes	Under wire dug in (2). Flattened the top of my breasts. There is nothing to dislike about this bra. I haven't worn the bra long enough to work out what I don't like. Top edge of cup too tight (3). Noticeable seam line across cup and visible through t-shirt (3). Lace irritated skin. Cup material. Material looked cheap.
	Alterations	None. Make a plain version for under t-shirts. Would prefer cotton or high cotton content. Take out elastic on top of cup (3). Prefer slightly wider straps. Remove seam on cup (2).
Unpopular bra	Likes	The support. Good for every day wear. Material is nice (4). Looked ok under t-shirt (2). A comfortable bra (3). General style and design (4). Comfortable underwire. Appearance (2). Good shape. Thick straps. Pretty material. Looked nice under clothing (2) but not in the flesh.
	Dislikes	Wiring very low on chest. Straps a little too far out (wide) on shoulders. The look of it was too pointy. Visible seams under clothes (2). Felt uncomfortable around ribs (2). Seemed to move a little (2). Nothing to dislike at all. Top edge of cup too tight (4). Rubbed at shoulder strap attachments. Lacy upper cup showed shape of nipple. Combination of fabrics is unattractive (2).
	Alterations	Different type of material for the cup. Better seaming on cup (2). Different design to the top of the cup (2).

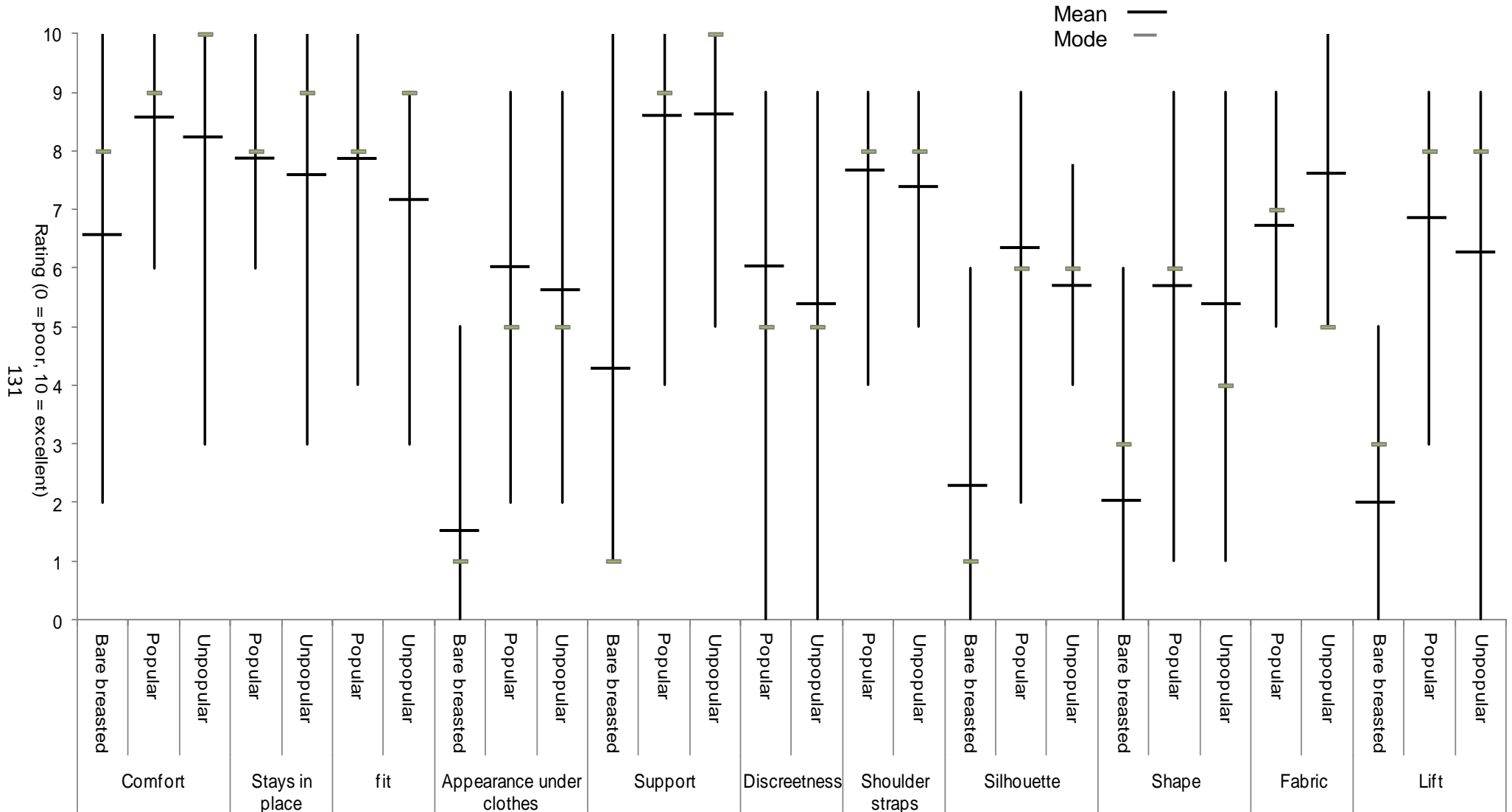


Figure 34. Range of subjective ratings for the 11 key bra performance variables following everyday activity tasks, in the popular bra, unpopular bra, and (where applicable) the bare breasted condition. The mean (black) and mode (grey) values are shown as horizontal lines (n=14).

6.3.3 Objective results

6.3.3.1 Bra's ability to stay in place

The mean magnitudes of multiplanar bra movement (mm) in the popular and unpopular bra following the five everyday activities can be seen in figure 35. The greatest bra movement was observed in the vertical movement of the back strap, with an average of 6 ± 4 mm; the least bra movement was seen in the anteroposterior movement of the centre gore (2 ± 2 mm). The popular and unpopular bra showed no difference in their ability to stay in place ($F_{(1)}=.63$; $p=.432$), with both bras moving an average of 2 mm to 6 mm over the skin across all areas of the bra. There was no interaction effect of bra and area of movement of the bra ($F_{(11)}= 1.14$; $p=.331$), and similar amounts of movement were reported at each area of the bra ($F_{(11)}=1.46$; $p=.152$). No relationship was found between the participant's rating of bra's ability to stay in place and measured bra movement over the skin in any area of the bra (centre gore, $r_s =.00$, $p=.971$; back strap, $r_s =-.13$, $p=.240$; underwire, $r_s =-.07$, $p=.550$ or shoulder straps, $r_s =-.05$, $p=.651$).

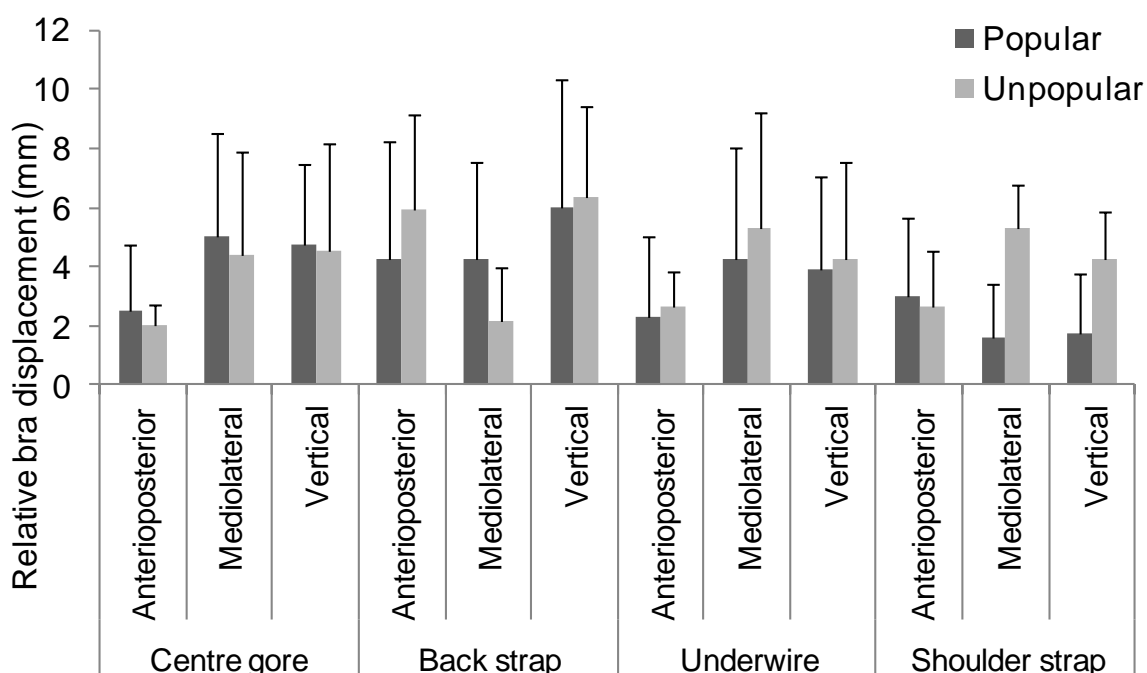


Figure 35. Mean multiplanar movement (mm) of four different areas of the bra following everyday activities in the popular and unpopular bras. Error bars represent the standard deviation (n=14).

6.3.3.2 Breast support

Figures 36 and 37 show the significant differences in average relative breast displacement and velocity during treadmill walking at 6 kph different across the

breast support conditions ($F_{(1,16)}=28.49$, $p=.001$). Post hoc analysis ($p<.0167$) revealed greater levels of breast displacement and velocity in the bare breasted condition when compared to both the popular and unpopular bra conditions; however, the two bra conditions provided similar levels of breast support during treadmill walking. A difference was also observed with regard to individual displacements and velocities in each direction of movement ($F_{(5,79)}=6.18$, $p=.001$), with greater breast movement seen in all directions in the bare breasted condition than in either bra. Post hoc analysis revealed that the only individual difference was between mediolateral velocity in the bare breasted ($.18 \pm .08 \text{ m}\cdot\text{s}^{-1}$) and popular bra ($.10 \pm .04 \text{ m}\cdot\text{s}^{-1}$) conditions.

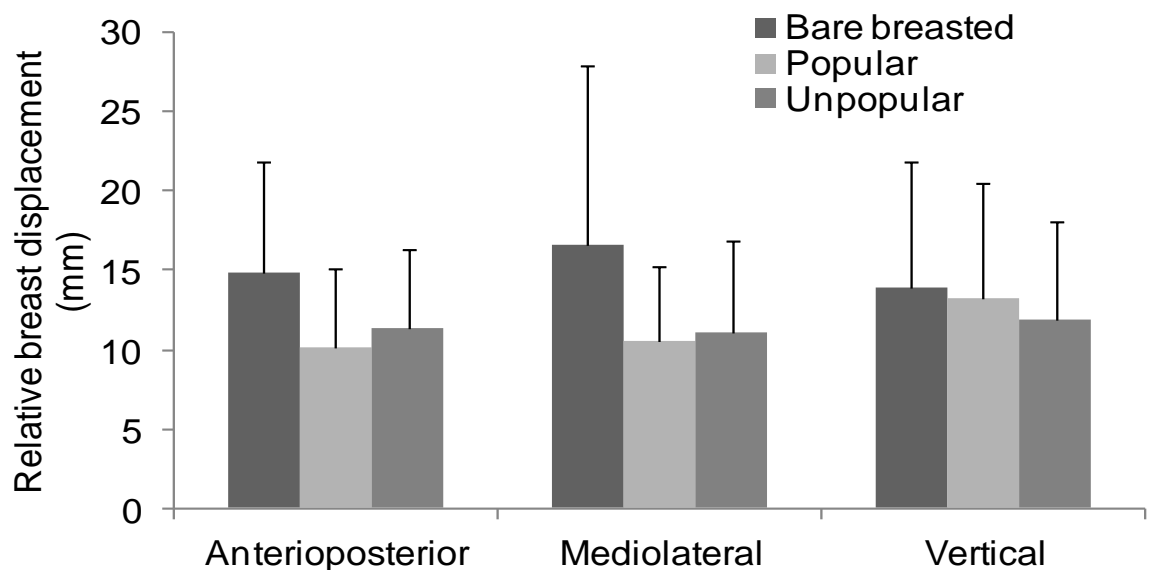


Figure 36. Mean relative breast displacement (mm) in anterioposterior, mediolateral and vertical directions in the bare breasted condition, the popular bra and the unpopular bra during treadmill walking. Error bars represent the standard deviation ($n=14$).

Irrespective of breast support condition, a relationship was seen between subjective ratings of breast support and some kinematic data. Rating of breast support demonstrated a medium relationship ($p<.008$) with anterioposterior displacement, ($r_s = -.42$, $p=.011$), anterioposterior velocity ($r_s = -.47$, $p=.001$) and mediolateral velocity ($r_s = -.44$, $p=.010$), while other breast kinematics did not show a correlation with subjective rating of breast support.

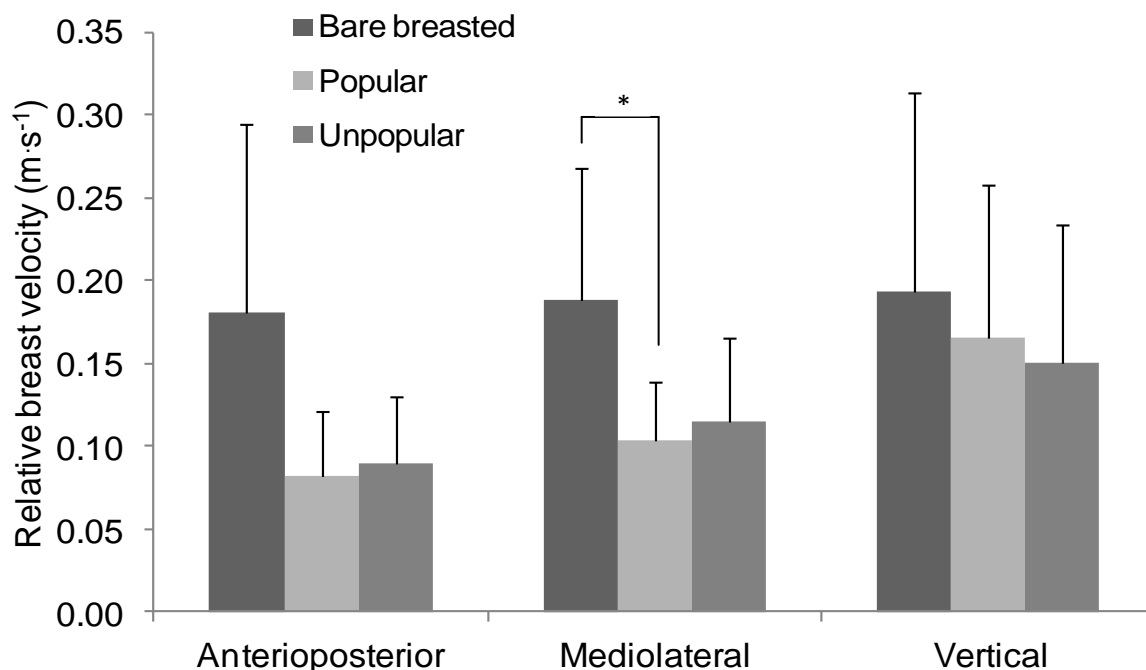


Figure 37. Mean relative breast velocity ($\text{m}\cdot\text{s}^{-1}$) in anterioposterior, mediolateral and vertical directions in the bare breasted condition, the popular bra and the unpopular bra during treadmill walking. Error bars represent the standard deviation ($n=14$). $*p<0.05$.

6.3.3.3 Shoulder strap position

Both the popular and unpopular bra's shoulder straps were positioned at average of 71% of the distance between the suprasternal notch (0%) and the acromion process (100%) (figure 38). No difference was found between the shoulder strap position of the two bras ($t_{(13)} = -1.17$, $p = .260$). Participants subjectively rated the position of the shoulder straps of the two bras similarly (figure 34) and no relationship was found between the objective and subjective measures ($r_s = -.12$, $p = .551$).

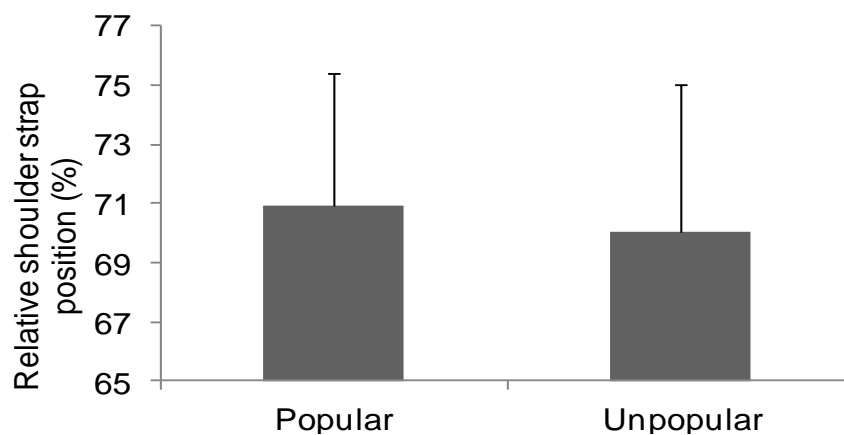


Figure 38. Mean shoulder strap position (%) in the popular and unpopular bra. Error bars represent the standard deviation ($n=14$).

6.3.3.4 Torso silhouette

Silhouette measurements differed between the bare breasted, popular bra and unpopular bra ($F_{(1,82)}=4.25$, $p=.021$) (figure 39). Interaction effects ($F_{(9,09)}=9.87$, $p=.001$) between the breast support conditions and each measurement point showed that the popular bra provided a narrower frontal width across the nipple (278 ± 13 mm) than both the bare breasted (289 ± 16 mm) and unpopular bra (286 ± 14 mm), and the bare breasted condition (270 ± 19 mm) had a wider under bust frontal width than either bra (popular 256 ± 17 mm, unpopular 259 ± 15 mm).

No relationships were found between subjective and objective measures of silhouette, for either frontal width or sagittal projection (under arm width $r_s = -.03$, $p=.850$; over nipple width $r_s = -.15$, $p=.352$; under bust width $r_s = -.17$, $p=.281$; under arm projection $r_s = -.24$, $p=.131$; over nipple projection $r_s = -.04$, $p=.821$; under bust projection $r_s = -.01$, $p=.943$).

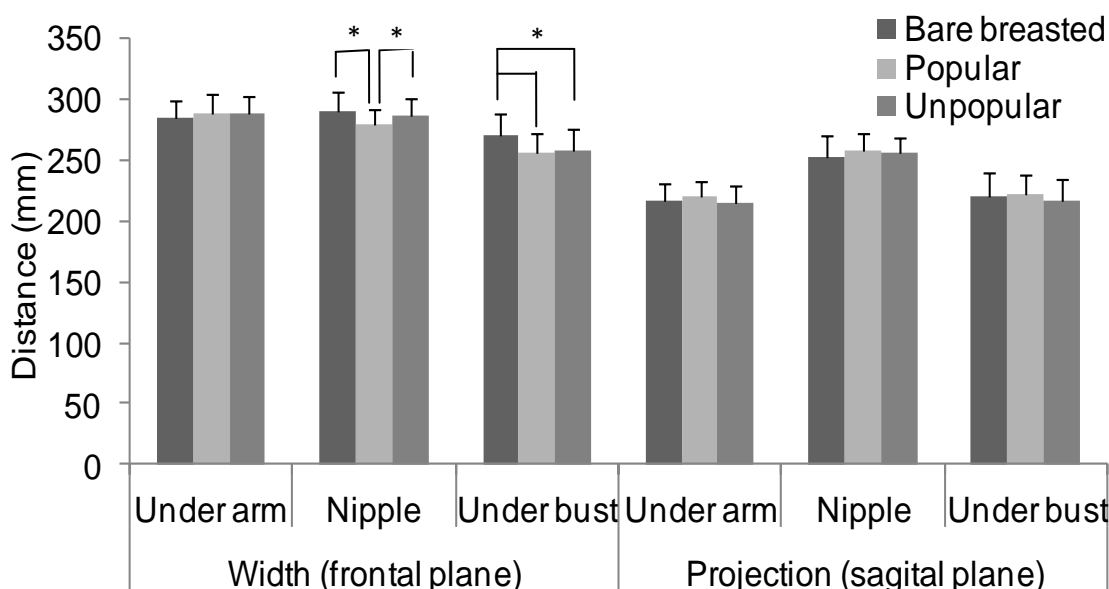


Figure 39. Width (frontal plane) and projection (sagittal plane) measurements of silhouette in three breast support conditions. Error bars represent the standard deviation ($n=14$). $*p<0.05$.

6.3.3.5 Breast shape

Interaction effects were observed between breast support condition and measurement point ($F_{(10)}=9.10$, $p=.001$). The bare breasted condition and unpopular bra provided different magnitudes of breast projection, with the bare breasted condition providing greater projection at the top (52 ± 6 mm vs. 44 ± 5 mm), less projection in the middle (81 ± 8 mm vs. 89 ± 10 mm) and greater

projection again at the base measurement (98 ± 8 mm vs. 91 ± 10 mm). No differences were seen between the bare breasted condition and popular bra, or between the two bra conditions.

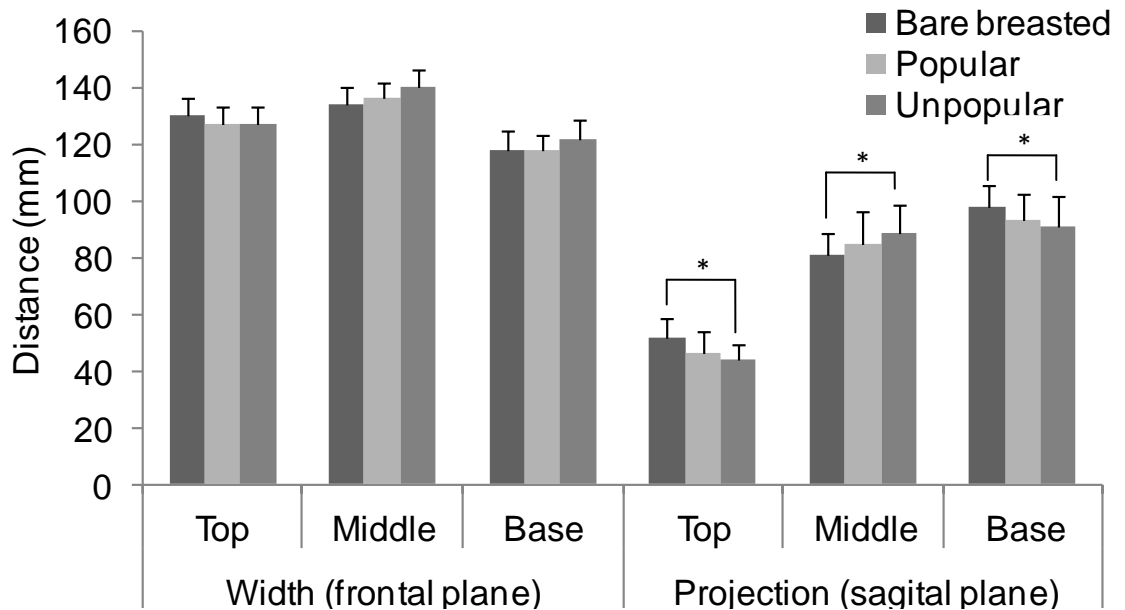


Figure 40. Width (frontal plane) and projection (sagittal plane) measurements of breast shape in three breast support conditions. Error bars represent the standard deviation ($n=14$). $*=p<0.05$.

Irrespective of the breast support condition, a relationship was observed between the subjective ratings of breast shape and the middle measurement of breast projection ($r_s = .48$, $p=.001$), with participants preferring a shape with greater projection in the middle of the breast. Other objective breast shape measurement did not indicate a relationship with subjective breast shape ratings.

6.3.3.6 Lift

Differences in vertical position of the nipple were seen between the bare breasted, popular and unpopular bras ($F_{(2)} = 67.91$, $p=.001$), a lower vertical position of the breast was seen in the bare breasted condition (210 ± 28 mm) compared to the popular bra (174 ± 24 mm) and the unpopular bra (170 ± 27 mm), however, the two bras provided similar levels of breast lift ($p>.017$). Irrespective of breast support condition, a relationship was seen between vertical position of the breast and subjective ratings of breast lift ($r_s = -.62$, $p=.001$).

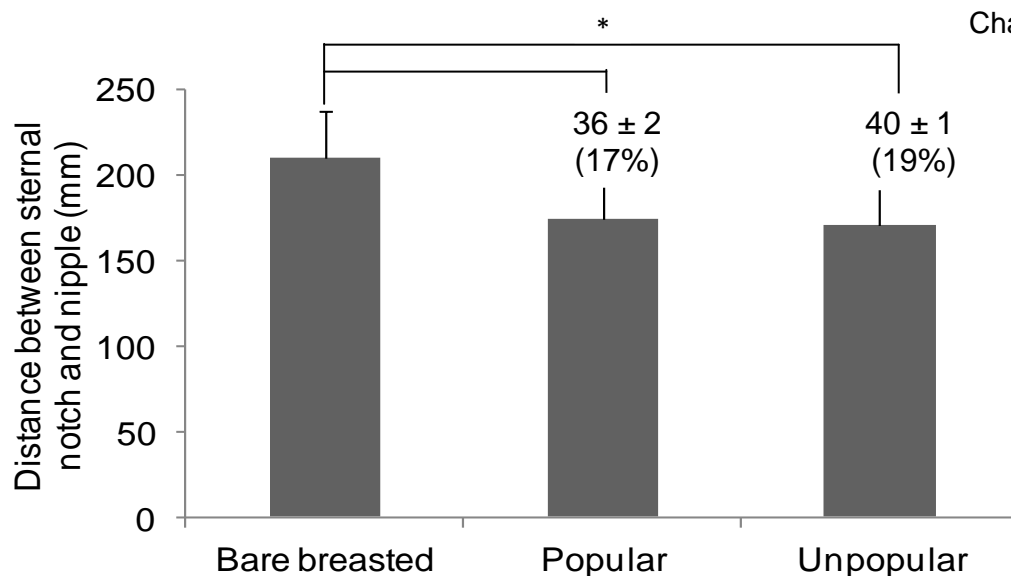


Figure 41. Mean vertical position of the nipple (mm) relative to the suprasternal notch. Breast lift in millimetres and as a percentage of the bare breasted condition is shown above each bra condition. Error bars represent the standard deviation (n=14). * $p < 0.05$.

6.3.4 Summary table

Table 15 summarises the appropriateness of key bra performance variables for women aged 45 to 65 years, based on the assessment of the bras from the popular and unpopular bra brand. Where possible, recommendations are made for bra design and comparison for future bra assessment studies.

Table 15. *Summary of bra appropriateness with regard to the key bra performance variables for women aged 45 to 65 years*

Key performance Variable	Deemed appropriate	Recommendations
Comfort	Yes	n/a
Stays in Place	Yes	Between 2 mm to 6 mm of bra slippage during everyday tasks is acceptable
Fit	Yes	Bra fit according to White and Scurr's (2012) procedure
Appearance under clothes	No	n/a
Support	Yes	Three dimensional breast displacement less than 13 mm and velocity less than $.165 \text{ m s}^{-1}$ during treadmill walking
Discreetness	No	n/a
Shoulder straps	Yes	Shoulder straps should sit 71% of the distance between the suprasternal notch and acromion process
Silhouette	No	None made
Shape	No	Greater breast projection across the middle of the breast may be required
Fabric	Yes	n/a
Breast lift	Popular Yes Unpopular No	Approximately 17 % to 19% breast lift is acceptable

6.4 Discussion

This study aimed to quantify the performance of a popular and unpopular bra, investigate their appropriateness in meeting the needs of an older woman and identify any shortcomings in their design. Secondly, the study aimed to determine the correlation between objective and subjective measures of the key bra performance variables, with the hope of indicating an optimum range of values for objective measurements.

Following everyday activity trials, participants did not perceive a difference in comfort level between the bare breasted condition, popular bra or unpopular bra, thus hypothesis one is rejected for the variable comfort. Both bras also received subjective ratings above seven out of ten, hence, the bras are deemed appropriately comfortable for women aged 45 to 65 years (table 15). However, the popular bra received negative feedback suggesting that the underwire dug into the skin and other participants commented that the bra felt uncomfortable around the ribs. This supports Lee and Hong's (2007) findings on optimum bra wires, which acknowledged that wireless bras are often preferred for improved wearer comfort among Korean women. Although there may be cultural differences between Lee and Hong's study and the current study, it may be that British women aged 45 to 65 years also require adjustment to the underwire design in order to maximise comfort.

Although between 2 mm and 6 mm of bra movement over the skin was identified, both the popular and unpopular bra were deemed appropriately able to stay in place, with an average subjective rating of 7.7 ± 1.3 and 7.5 ± 2.3 out of ten respectively. The results indicate that no subjective or objective difference was found between the popular and unpopular bra in their ability to stay in place, hypothesis one was therefore rejected for bras ability to stay in place. Despite this finding, subjective comments described the popular bra as 'very stable' and that the unpopular bra 'seemed to move a little'. This appears contradictory to previous research by Yu, Wang, He and Zhang (2011), which found that 68% of Chinese women reported straps slipping off their shoulders. Similarly, Chen, LaBat and Bye (2011) found 91% of American women were dissatisfied with the amount of movement within their bra shoulder straps and 57% of women are reported to experience shoulder strap slippage in sports bras (Bowles et al., 2011). Despite

these previous reports, the current study found an average of just 3 mm movement of the shoulder straps in both the popular and unpopular bra following everyday activities. The popular bra had a non-slip rubber lining underneath the shoulder straps, which was advertised as reducing shoulder strap slippage, however, the unpopular bra did not include this design feature and had 3 mm more mediolateral movement of the shoulder straps (2 mm compared to 5 mm). It is therefore recommended that bras for women aged 45 to 65 years of age include non-slip straps in order to reduce any movement in the shoulder straps. In addition, it is unknown whether the bras used in Yu et al.'s and Chen et al.'s studies were fitted appropriately as in the current study, this may have impacted upon the percentage of women experiencing bra slippage in previous studies. With approximately 85% of women wearing the wrong sized bra (McGhee & Steele, 2010), it is unknown how the fit of a bra may impact upon its ability to stay in place.

The popular and unpopular bras demonstrated similar subjective ratings and objective measures of shoulder strap positioning, sitting approximately 71% of the distance between suprasternal notch and acromion process (figure 38), thus hypothesis one was rejected for this variable. Despite the shoulder strap position of these bras being deemed appropriate, additional comments from two participants suggested that the unpopular bra's shoulder straps sat too wide on the shoulders and rubbed at the shoulder strap attachment points. Further investigation is required to identify the optimum position and design of bra shoulder straps in order to improve women's perception of the bra shoulder straps.

McGhee and Steele (2010) suggest that breast shape may inhibit the correct fit of some bra styles. The current study found these bras were perceived to fit appropriately, despite possible differences in breast shape and ptosis that may occur during the ageing process. However, negative comments regarding bra fit included the underwire sitting too low on the chest. This links to previous findings which showed that 45% of women were wearing the wrong underwire shape for their breasts (McGhee & Steele, 2010). Interestingly, both bras received feedback indicating that the top edge of the cup was too tight despite the bra size having been selected for optimum fit. This feedback can be used as a design

recommendation for bra manufacturers, it is suggested that the elastic outlining the cup of a bra may need to be loosened to provide optimum fit for women aged 45 to 65 years. Research has suggested that the majority of women are dissatisfied with their bra fit (Chen et al., 2011; Hart & Dewsnap, 2001); however, ratings of fit within this study were high (7.7 ± 1.7 and 7.2 ± 2.0 for the popular bra and unpopular bra respectively). It is speculated that a professional fitting according to White and Scurr's (2012) best fit criteria has elicited appropriate subjective ratings of bra fit.

Interestingly, the results identify no differences in vertical breast kinematics between the bare breasted condition and either bra, as is commonly seen in previous research (Mason et al., 1999; Scurr et al., 2010, 2011), although the highest breast velocities were consistently seen in the vertical direction. Research by Scurr et al. (2009) has shown relative displacement of the breast during walking at 5 kph of approximately 11 to 15 mm in the vertical, mediolateral and anteroposterior directions (Scurr et al., 2009). The current study found greater breast displacement in comparison, with between 14 and 17 mm across all directions. Scurr et al.'s study was conducted on 15 D cup participants aged 24 ± 4.8 years, which may indicate less breast displacement occurs in younger women during walking. However, these results may be affected by the difference in treadmill speed (1 kph difference) and the different marker sets used. Scurr et al. positioned torso reference markers on the clavicle, and ASIS, therefore the local coordinate system created is different to the current study, which may cause a difference in displacement calculations. Scurr et al.'s (2009) marker set was not implemented in the current study as the clavicle and ASIS were not deemed to be on the same rigid structure for the calculation of breast kinematics relative to this segment, instead, the improved marker set using anterior-inferior ribs and the suprasternal notch was employed (Scurr et al., 2010, 2011).

Despite both the unpopular and popular bra being rated well for practical concerns, both bras were criticised for having seam lines that were too prominent underneath clothing and were thus not deemed appropriately discreet for women aged 45 to 65 years based on their subjective ratings. Similarly, neither bra was deemed appropriate with regard to their appearance under clothing (table 15). Research has previously found that products rated highly for practical concerns,

such as confidence and dryness, were rated lowest for product discreetness (Winslow & Jacobson, 1997). This may indicate that more discreet products are designed based on aesthetics, rather than functionality. As no difference was found between the popular and unpopular bra for the variable discreetness, hypothesis one was rejected for bra's appearance underneath clothes and discreetness. Suggestions from participants to alter both bras included altered/removed seaming on the cup, and making a plain version for use underneath plain t-shirts.

Although both bras provided better subjective ratings of silhouette than the bare breasted condition, neither bra was rated as seven or more out of ten, therefore the silhouette provided by these bras is not deemed appropriate for women aged 45 to 65 years (table 15). Objective analysis revealed a difference between the two bras, with the popular bra providing a narrower torso width across the nipples in the frontal plane (by 3% or 7 mm), thus accepting hypothesis one. In a study involving Chinese women of unknown age, relatively smaller silhouette measurements were obtained than in the current study. The current results and Cha's (2012) results showed measurements in the frontal plane of; 284 mm and 284 mm at the under arm, 289 mm and 264 mm at the nipple, and 270 mm and 249 mm at the under bust, respectively. Whilst sagittal plane measurements were; 217 mm and 179 mm at the under arm, 253 mm and 221 mm at the nipple, and 221 mm and 180 mm at the under bust, respectively. These results suggest an intercultural difference in torso silhouette, and thus, a difference in bra design requirements within different countries, in addition to Cha's (2012) postulation that different ages may require different bra designs.

Westreich (1997) previously assessed silhouette within the frontal plane, describing a single measurement from the inframammary crease as 'chest width'. Westreich found an average chest width of 253 ± 15 mm, within a sample of women aged 20 ± 4 years with perfect breasts, whereas the current study found an under bust width of 270 mm. In the current study the measurement of under bust width was taken from the most inferior point of the breast, although it is unknown whether this measurement point is similar to that within Westreich's study, it appears that the cohort of women aged 45 to 65 years had a similar frontal chest width to the younger cohort of women with 'perfect breasts'.

Westreich also assessed 'chest depth' from a sagittal view, reporting 171 ± 12 mm in comparison to the current studies finding of 221 mm. This comparison suggests that an older cohort of women had a larger chest depth compared to participants in Westreich's (1997) study, which has also been found by Ashdown and Na (2008). This may be expected, as larger proportions of body fat are stored on the anterior abdomen in older women, whereas younger women have higher percentages of gynoid fat (Ley, Lees, & Stevenson, 1992). This indicates that older women may require a different under band or underwire design in order to accommodate the differences in sagittal silhouette compared to younger women.

As seen in the key performance variable silhouette, breast shape was not deemed appropriate for women aged 45 to 65 years (table 15). No subjective differences were seen between the popular and unpopular bra and hypothesis one was rejected for the performance variable breast shape. Breast projection in the sagittal plane was altered by bra use, but differences were only seen between the bare breasted condition and the unpopular bra. Therefore, although a direct difference between the popular and unpopular bra was not seen, it is concluded that the unpopular bra altered the breast shape of the participants to a greater extent than the popular bra (figure 40). Subjective feedback suggested that the unpopular bra provided a 'good shape', whereas the popular bra 'flattened the top of the breast'. As discussed in the previous chapter (section 5.8), the results of this study also indicate that the bare breasted condition provided the greatest breast projection at the top of the breast compared to either bra ($52 \text{ mm} \pm 6 \text{ mm}$ for bare breasted, and $46 \text{ mm} \pm 8 \text{ mm}$ and $44 \text{ mm} \pm 5 \text{ mm}$ for the popular and unpopular bra respectively), possibly due to the lower defined position of the 'top of the breast' caused by up to 19% breast lift when in the bra (figure 41). In addition, due to the tight elastic edge of the cup reported by participants when wearing both the popular and unpopular bra, the projection at the 'top of the breast' may have been decrease. Indeed, one participant commented that the popular bra 'flattened the top' of her breasts, and cited this as a dislike of the bra.

The current study reported breast projections in the sagittal plane of between 52 mm and 98 mm. These values support previous literature that assessed breast projection using a similar method to the current study by measuring projection perpendicular to a vertical line from the suprasternal notch, and found average

breast projections at the nipple of 40 ± 12 mm (Brown et al., 1999). Swanson (2008) reported upper pole projections of 47 to 50 mm, and lower pole projections of 101 to 103 mm. However, Swanson's method creates individual differences caused by the varying heights of upper and lower poles on women, whereas the current method develops this by taking measurements at each third on the breast. Breast projection has also previously been assessed by Qiao et al. (1997), who found an average projection of 30 to 40 mm. Similarly, Westreich (1997) calculated breast projection at 90° to the chest wall 'just beneath the breast' and reported an average value of 49 ± 10 mm for women aged 17 to 38 years. Unfortunately, limited information was provided on how breast projection was calculated in both of these studies, therefore comparisons to the current studies finding of 81 mm are difficult.

As expected, both bras reduced the distance between nipple and suprasternal notch (up to 19% or 40 mm), indicating breast lift. However, only the popular bra was subjectively rated as above seven out of ten, the unpopular bra received an average rating of just 6.6, and is therefore not deemed appropriately able to lift the breasts of women aged 45 to 65 years. However, differences between the unpopular and popular bra were not identified and hypothesis one was therefore rejected for the key bra performance variable of breast lift. A study by Qiao et al. (1997) included suprasternal notch to nipple distance. The cohort of 125 Chinese females aged 18 to 25 years produced an average value of 190 ± 11 mm compared to 210 ± 2 mm in the current study. Other studies have also measured the vertical distance between nipple and suprasternal notch, reporting distances of between 174 and 231 mm in various cohorts of women (Agbenorku et al., 2011; Brown et al., 1999; Catanuto et al., 2008; Westreich, 1997). Qiao et al.'s study lacks detailed information on the measurement techniques used and therefore reported differences may be due to methodological variations. However, the findings provide some indication that cross-cultural differences in breast ptosis and upper body anthropometry may exist.

Neither bra was rated as having a better fabric, and both were described as having 'pretty fabric' or 'nice material', therefore hypothesis one was rejected for this variable. Subjective ratings indicated that the fabric was appropriate for women aged 45 to 65 years. One participant commented that she liked the 'part

lace, part fabric' appearance on the popular bra, although the same feature on the unpopular bra was described as the 'combination of fabrics is very unattractive'. The perception of a bra's fabric is affected by visual and cognitive cues, in addition to touch (Moody, Morgan, Dillon, Baber, & Wing, 2001). Therefore, similar ratings between the popular and unpopular bra may not indicate identical fabrics, but a similar rating based on a combination of multiple factors. In addition, Paek (1983) suggest that fabric preferences are influenced by what people are familiar with, particularly regarding the weave pattern of the fabric. Individuals may have different preferences for fabric constitution dependent on the location of contact with the body, so assumptions made within one item of clothing should not be directed to different garments (Vink & Hallbeck, 2011). As participant's past experiences and the exact fabric constitution of the current bras was unknown, this may be a limitation of this research design.

To address the aim of indicating an optimum range of values for objective measurements, correlations were conducted between objective and subjective measures where possible. A negative correlation between vertical position of the nipple and ratings of breast lift indicates that the participants were able to discern different levels of breast lift, and that greater levels of breast lift were preferred. With regard to recommendations for optimum breast shape, the results indicate that a bra which provides a greater amount of breast projection around the middle of the breast was rated as providing a better breast shape. Chen et al. (2011) previously found that just 8.2% of the population are happy with the support provided by their bra, a relationship between reduced breast kinematics and improved ratings of support would therefore be expected (Risius et al., 2011). Correlations were found between perceived support and anteroposterior breast displacement and velocity, and mediolateral velocity. Hypothesis two was therefore accepted for the key performance variables; lift, shape and support. However, no relationship was found between subjective and objective measures for the variables silhouette, shoulder strap position and bra's ability to stay in place, thus no assumptions can be made for bra requirements within these variables.

In order to allow unbiased feedback on the bra, participants in the current study were blinded to the bra brand and style (Proctor, 2003). Given the lack of

quantitative differences found between the popular and unpopular bra, subsequent research may wish to reveal the brand and develop a greater understanding as to what causes the popularity differences between bra brands. Possible areas causing the difference in usage/popularity of the bra brands include; the in-store environment, the perception of quality, self image and price (Granot, Greene, & Brashear, 2010; Ross & Harradine, 2010). However, the popularity of a product or brand typically lies within its ability to perform to the expectations and requirements of the consumer (Hart & Dewsnap, 2001). Whereas both bras were adequate with regard to comfort, ability to stay in place, fit, support, shoulder strap position and fabric. Only the popular bra provided adequate lift according to the subjective cut off boundary of seven out of ten, and neither bra performed appropriately for the variables; appearance under clothes, silhouette, breast shape or discreetness. It is these variables that require improvement in order to ensure bras from differing brands are appropriate to meet the needs of women aged 45 to 65 years.

6.5 Summary

This chapter provides an analysis of the 11 key bra performance variables between a popular and unpopular bra for women aged 45 to 65 years. The results indicate that just one of the key bra performance variables significantly differed between the two bras (a frontal width measurement of silhouette). Given the substantial difference in popularity and usage of these two bra brands identified in chapter four, the lack of difference between the two bras suggests that additional factors are influential in the popularity/use of the two brands, as the products themselves do not differ with regard to the 11 key bra performance variables (Proctor, 2003; Ross & Harradine, 2010).

Neither bra performed appropriately for women aged 45 to 65 years with regard to the performance variables; appearance under clothes, discreetness, silhouette and breast shape, indicating that these variables require improvements for this population (table 15). Additional subjective feedback in table 14 suggests improvements are necessary and this study provides rationale for improved bra design in order to optimise bras for women aged 45 to 65 years. Improvements and alterations include: an adjustment to the underwire design to maximise comfort, bras having non-slip shoulder straps, loosened elastic along the top of the bra cup, removing large seams from the front of the cup and providing

sufficient breast projection around the middle of the breast, high levels of breast lift and sufficient breast support.

Hart and Dewsnap (2001) reported that a common approach used by women in bra assessment was to purchase a bra, wear it and wash it at home, then return to buy an identical bra if it were deemed suitable. This is due to the strong perception that a bra cannot be truly judged for suitability until it has been worn and washed (Hart & Dewsnap, 2001). When completing the subjective questionnaire, a number of participants commented that they had not had enough time wearing the bra to consider all of the variables they were required to rate. Several of the 14 participants in this chapter stated that they typically do not develop strong opinions on bras until they have been washed and worn for a longer duration. These comments indicate that future bra related research may require a longer period of participant exposure to the products by means of a wearer trial in order to elicit greater feedback on the bras.

Chapter 7.

Investigation of key bra performance variables: Comparisons of a popular and unpopular bra brand after prolonged use

7.1 Introduction

Recent literature has suggested that the mood and emotions of an individual when trying on garments may influence the clothing style preferences at that time point (Moody, Kinderman, & Sinha, 2010). In line with this, it is possible that results from single laboratory testing sessions may be impacted by the participants' mood on the day of testing or limited exposure to products (Roe, 2004). Therefore, to develop a fuller understanding of the shortcomings of products, research suggests not only assessing the key performance variables during a single testing session, but allowing participants an extended wearer trial period prior to product assessment (Moutinho & Evans, 1992). This rationale was also demonstrated in the previous chapter, which indicated that participants felt a longer duration of wear was required to fully evaluate each bra.

Wearer trials are used to evaluate the performance of a garment over a set period of time, during which consumers rate the bra with regard to certain variables, often by use of an ordinal scale (Hardaker & Fozzard, 1997). In an assessment of ten different bra manufacturers, all were found to include wearer trials of some description to evaluate their products (Hardaker & Fozzard, 1997). However, all of the manufacturers reported using company employees as participants for their trials, which may lead to bias in the data if participants have a personal investment in the product.

It is understood that distinguishing differences between products is complex and may require a longer time period than an individual testing session, as seen in most bra assessment studies (Proctor, 2003; Roe, 2004; Scurr et al., 2010, 2011; White et al., 2009, 2011). By affording an extended period of wear and allowing actual wearer experience of the bras, a more effective evaluation of a bra's strengths and weaknesses may be gained, allowing easier comparisons between difference bras (Proctor, 2003). Irrespective of product comparisons, a single product may possess problems that only manifest themselves after a period of time; a wearer trial period permits the development of such problems (Moutinho &

Evans, 1992). Additionally, market research suggests 'in home' testing is more realistic and may elicit greater product feedback than brief 'in hall' testing (Malhotra & Birks, 2003; Roe, 2004). This format of bra assessment more accurately represents the longer term bra use that leads to brand loyalty and product preferences cited in published articles (Assael, 1981; Hart & Dewsnap, 2001).

Moutinho and Evans (1992) recommend that participants complete a pre- and post- wearer trial survey, maintain a diary of product use, and include an ultimate choice between the products to conclude the study. Typical duration of diary use in previous product evaluation research is between two and four weeks (Keleher & Verrinder, 2003; Milligan, Bingley, & Gatrell, 2005). However, if participants do not drop out initially then the duration of diary use is a small factor in adherence to the trial, although response fatigue has been reported at two months (Keleher & Verrinder, 2003; Milligan et al., 2005). Cooperation rates in wearer trials and diary use are improved by providing participants with an incentive at the end of the period (Sudman & Ferber, 1971). In addition, continued researcher support is vital to increase response quality and compliance in completing wearer trial diaries and regular contact with participants is recommended (Milligan et al., 2005). As when designing any survey instrument, a user friendly design is recommended. This should include; a professional appearance with colour graphics, example pages/answers provided, contact details for the researcher, and instructions for completion (Davis, Stinson, & To, 2002; Milligan et al., 2005).

A common concern regarding wearer trials and diary use for consumer research is poor compliance, resulting in diary entries being omitted, missing, or participants dropping out all together (Shiffman, Hufford, & Paty, 2001). False compliance (also referred to as 'backfilling' or 'hoarding') occurs when participants do not complete the daily diary within the required time period for each day, but return to complete numerous days worth of data at one time (Shiffman et al., 2001). False compliance initiates bias in the data caused by saliency and recency of events, and it is near impossible to detect (Shiffman et al., 2001). Research by Stone et al. (2002) noted the difference between reported compliance of a paper diary and actual compliance of up to 79%, with 75% of participant backfilling diaries to some extent, and 32% of diary days not being opened at all on the

required day. The results of the current study must therefore be interpreted with the understanding that some false compliance may have taken place.

The study presented in this chapter aimed to determine whether a wearer trial period is required to identify any objective and subjective differences in bras by assessing the 11 key bra performance variables within the popular and unpopular brand bras tested in chapter six. This study also aimed to explore any changes that may occur in the bras during the wearer trial period, by use of the subjective feedback provided by participants during the trial period. As detailed in the previous chapter, average subjective ratings of seven out of ten or above will ensure that the key bra performance variable is deemed appropriate for women aged 45 to 65 years (Bodian, et al., 2001; Boogaerts, et al., 2000; Serlin, et al., 1995; Roelants, et al., 2003). By assessing a longer duration of bra use, greater understand may be gained as to the performance of bras on the market for women aged 45 to 65 years with regard to the key performance variables. The results of this chapter may have implications for the duration of exposure to bras within subsequent bra related studies, if a wearer trial period is found to affect either objective or subjective measures. Is it hypothesised that:

H₁. There will be a significant difference between the subjective and objective measures of the 11 key bra performance variables pre and post a four week wearer trial for each support condition (popular and unpopular bras).

H₂. There will be a significant difference between the support conditions (bare breasted, popular and unpopular bras) among the 11 key performance variables post a wearer trial.

7.2 Methodology

7.2.1 Ethical Approval

This study received ethical and scientific approval from the BioSciences Research Ethics Committee, in accordance with current University regulations.

7.2.2 Participants

Participants were recruited in a similar manner to chapters five and six, by use of an announcement promoting the study in a staff newsletter at the University of Portsmouth. In addition, posters were put up in local leisure centres, gyms, universities and hospitals to increase participant recruitment. Eleven women participated in this study, with physical characteristics (mean \pm standard

deviation); age 55 ± 5.7 years, height $1.61 \pm .06$ m, body mass 66.7 ± 5.3 kg. Exclusion criteria and bra fit criteria were identical to that used in previous chapters (White & Scurr, 2012). In order to maintain consistency through the thesis, the bra sizes included were 34D (n=5), 36C (n=4) and 38B (n=2), with participants wearing a 34D, 36C or 38B in the popular bra, and then provided with the size that was most suitable for them in the unpopular bra. Eight participants were post menopausal, one was peri menopausal and two were pre menopausal.

7.2.3 Experimental design

The popular and unpopular bra established in chapter four and used in chapter six (figure 11 and M&S bra in table 12) were selected for investigation within the current study. The study design was based on wearer trial literature (Moutinho & Evans, 1992). An initial testing session using identical methods to those carried out in chapter six was conducted. This involved; a static image being taken, followed by five everyday activities being conducted, then subsequent static images with both optoelectronic and digital cameras, and finally a survey provided to participants. As in previous chapters, tests were conducted in a bare breasted condition first, followed by the two bras in a random order. This laboratory session was followed by a four week wearer trial and completion of appraisal diary (appendix E). An identical laboratory testing session was conducted four weeks later to assess any changes in the bras. The equipment and procedures for laboratory testing sessions were the same as those used in chapters five and six, including methods to assess the 11 key bra performance variables; comfort, bras ability to stay in place, bra fit, appearance under clothes, breast support, discreetness, shoulder straps, silhouette, breast shape, bra fabric and breast lift.

7.2.4 Bra Appraisal Diary (appendix E)

A four week diary period was selected based on typical duration of diary use in previous product evaluation research (Keleher & Verrinder, 2003; Milligan et al., 2005). The bra appraisal diary was designed based on Davis et al.'s (2002) and Milligan et al.'s (2005) user friendly design recommendations, including; coloured graphics, instructions for completion, contact details of the researcher, a variety of question formats, example pages/answers and check boxes. The variety of question formats included; numerical analogue scales for each key bra performance variable (identical format used in chapters five and six), tick boxes and open ended questions.

The bra appraisal diary was provided to participants in order to track their bra usage and number of bra washes, and to identify changes in their ratings of the bra throughout the four week period. Measurements taken within the bra appraisal diary were: a record of bra use (day and time period), number/dates of bra washes during the trial period, and subjective opinion of the 11 key bra performance variables each day that participants wore the bra. Where individual key performance variables of a product are known, it is best to present them separately in wearer trial diaries (Ross & Harradine, 2010), the bra appraisal diary therefore included a question regarding each key bra performance variable individually. Participants were asked to wear the popular and unpopular bras for as many days as possible during the four week period for the duration they would normally wear a bra each day. Participants were asked to alternate the popular and unpopular bra in accordance to their typical bra routine; resulting in some participants alternating the bras each day, and some alternating them each week. Participants were asked to wear each bra for the same number of days to ensure both bras were tested equally, and were asked to wash each bra at least once. A record of bra use was therefore included to track whether the two bras received an equal share of the participant's attention (Roe, 2004).

Information sewn into bras that identified the brand or style of the bra was removed to ensure a blind trial was conducted (Moutinho & Evans, 1992; Proctor, 2003). This resulted in the manufacturers washing instructions also being removed (detailing that the popular bra could be machine washed and tumble dried, but the unpopular bra was hand wash only). Participants were therefore given this information verbally. Following the completion of the second laboratory testing session, the brand and product information was revealed to participants if requested. As an incentive for participation, women were allowed to keep the bras after the study.

Weekly phone contact was made with participants in order to answer any questions they may have had and remind them to complete the bra appraisal diary every day (Milligan et al., 2005). Participants were informed verbally and within the information sheet that, should they experience discomfort/rubbing when wearing either bra, they should discontinue use and seek the advice of the researcher; however, this did not occur.

7.2.5 Data Analysis

All data collected during laboratory sessions were analysed according to the protocol developed in chapter five of this thesis (section 5.3.5) and as used in chapter six. Differences in the 11 key bra performance variables between the pre and post wearer trial period were assessed for both the popular and unpopular bra. Difference between the popular and unpopular bra were assessed pre wearer trial, and, in order to indicate whether one bra had changed to a greater extent than the other during the wearer trial period, the same statistical tests were conducted on the post wearer trial data. Statistics carried out were the same as in chapter six (see section 6.2.5), and thus included Friedman and Wilcoxon signed rank tests for subjective data, and mixed design ANOVAs and paired samples t-tests for objective data, with post hoc analysis with Bonferroni correction where appropriate. Means are presented for bra appraisal diary data per bra per day. Both the popular and unpopular bras were worn for at least 12 days of the wearer trial period by each participant. The additional four days of data for the participants that had worn the bras for the full 14 days each were excluded, as the mean would not have represented the entire sample. The subjective comments written in the bra appraisal diaries were not of sufficient quantity to warrant any further form of analysis; all comments are included in table 16. A table similar to table 15 presented in chapter six is included, with amendments made based on the results of the wearer trial.

7.3 Results

7.3.1 Bra Appraisal Diary

The average duration of bra use per day was 12.7 hours in both the popular and unpopular bra, with an average total usage during the wearer trial period of 159.1 hours and 157.9 hours per participant, respectively. All participants reported washing the bras at least once during the wearer trial period, with the popular bra being washed an average of 3.7 times, and the unpopular bra washed an average of 3.5 times. All participants were asked to rate the 11 key bra performance variables for the bra they wore each day, figure 42 demonstrates the average rating for the popular and unpopular bra for the 12 days in which all participants wore the bras.

Following the four week wearer trial period, participants were asked which bra they preferred, five selected the unpopular bra as their favourite, and six selected

the popular bra. Subjective comments from the bra appraisal diary are reported in table 16, which details all written comments regarding the popular and unpopular bras.

Table 16. *Subjective comments regarding the popular and unpopular bra during the four week wearer trial period (n=11)*

Bra	Noticeable changes
Popular	<p>When I tightened the straps it rubbed under arm pits. Rubber inside straps so stayed in place and didn't move Disliked itchy fabric Felt heavy to wear and more so after washing Needs softer fabric Bra felt very uncomfortable at times. Wires dug in to side of breast Fabric felt scratchy on nipples Very tight on ribs after a long day Left a dent around ribs at the end of the day Underwire seemed to dig in but better after washing</p>
Unpopular	<p>Wire popped out after seven days wear (<i>replaced</i>) Trimmed back fastening with scissors to stop the stitching rubbing Underwire rubs - needs more cushioning Often felt tight and more so after washing Disappointed with the bra and glad to take it off at the end of day Feels good to wear all day Underwire dug in under armpit Itchy back strap – I cut off the itchy bits Fasteners has rough edges which aggravated the skin so I cut the corners off Elastic on the cup was tight across the breast at the start but this loosened after wear, tear and washing, now more comfortable Never slipped once and felt supportive Underwire felt hard by end of day Scratchy material where the hooks are Quite sweaty material</p>

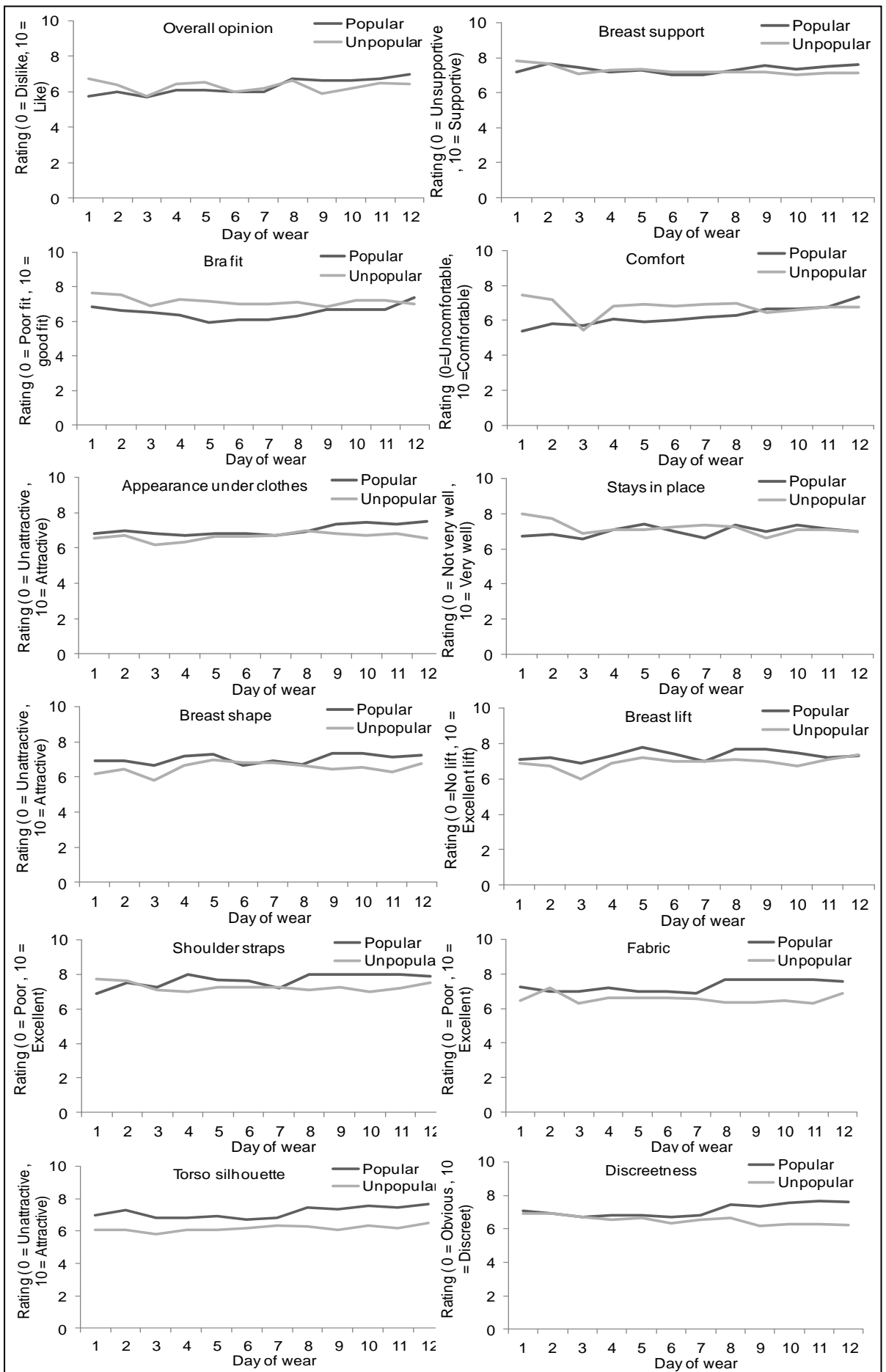


Figure 42. Average rating for the popular and unpopular bras over 12 days, in the 11 key bra performance variables and an overall opinion of the bras (n=11)

7.3.2 Laboratory Testing

7.3.2.1 Subjective results

Figures 43 and 44 show the pre and post wearer trial average subjective rating in the laboratory for the 11 key bra performance variables for the popular and unpopular bra, respectively. All statistical comparisons for subjective data can be seen in table 17. Despite a different cohort, the differences found between the popular and unpopular bra prior to the four week wearer trial were identical to those reported in chapter six, which include: both bras being rated as more supportive than the bare breasted condition, as providing a better breast shape, a better silhouette, greater breast lift, and as appearing better underneath clothes than the bare breasted condition, with no difference found between the popular and unpopular bra for the key performance variables bra discreetness, bra fabric, bra fit, shoulder straps and bra's ability to stay in place, and no difference reported in comfort between the bare breasted, popular and unpopular bra conditions. Following the four week wearer trial, the same subjective differences were found between the breast support conditions. However, for the performance variable breast support, differences were found between the support conditions, post hoc analysis revealed these differences now only lay between the bare breasted condition and the unpopular bra.

No differences were found between the pre and post wearer trial ratings for the variables: appearance under clothes, comfort, breast lift, breast shape, silhouette, breast support, discreetness, fabric, fit, shoulder straps. However, for ratings of bra's ability to stay in place, the unpopular bra was rated significantly worse following the four week wearer trial, whereas the popular bra showed no difference.

Table 17. *Statistical results for subjective ratings of a bare breasted, popular and unpopular bra condition, pre and post a four week wearer trial (n=11)*

Key performance variable	Pre wearer trial comparison of breast support conditions	Comparison of pre and post wearer trial within each breast support condition	Post wearer trial comparison of breast support conditions
Comfort	$X_2=3.63$	Bare breasted $z=.68$ Popular $z=-.48$ Unpopular $z=-.95$	$X^2=6.05$
Stays in place	$z=-1.12$	Popular $z=-2.00^*$ Unpopular $z=-.322$,	$z=-.98$
Bra fit	$z=-.26$	Popular $z=.85$ Unpopular $z=.48$	$z=-.17$
Appearance under clothes	$X_2=14.26^{**}$ (either bra better than bare breasted)	Bare breasted $z=.59$ Popular $z=-.72$, Unpopular $z=-.26$	$X^2=12.15^{**}$ (either bra better than bare breasted)
Support	$X_2=10.24^{**}$ (either bra better than bare breasted)	Bare breasted $z=-1.19$ Popular $z=-1.15$ Unpopular $z=-1.13$	$X^2=7.37^*$ (unpopular bra better than bare breasted)
Discreetness	$z=-.68$	Popular $z=-.74$ Unpopular $z=-.21$	$z=-.11$
Shoulder straps	$z=-.31$	Popular $z=-.43$ Unpopular $z=-.43$	$z=-1.17$
Silhouette	$X_2=17.63^{**}$ (either bra better than bare breasted)	Bare breasted $z=-1.85$ Popular $z=-1.89$ Unpopular $z=-1.35$	$X^2=8.36^*$ (either bra better than bare breasted)
Shape	$X_2=18.82^{**}$ (either bra better than bare breasted)	Bare breasted $z=-1.75$ Popular $z=-.25$, Unpopular $z=-.37$	$X^2=7.00^*$ (either bra better than bare breasted)
Fabric	$z=-.598$	Popular $z=-.78$ Unpopular $z=-1.90$	$z=-1.19$
Lift	$X_2=19.16^{**}$ (either bra better than bare breasted)	Bare breasted $z=-1.19$ Popular $z=-.28$ Unpopular $z=-.72$	$X^2=9.89^{**}$ (either bra better than bare breasted)

* $p<.05$, ** $p<.01$

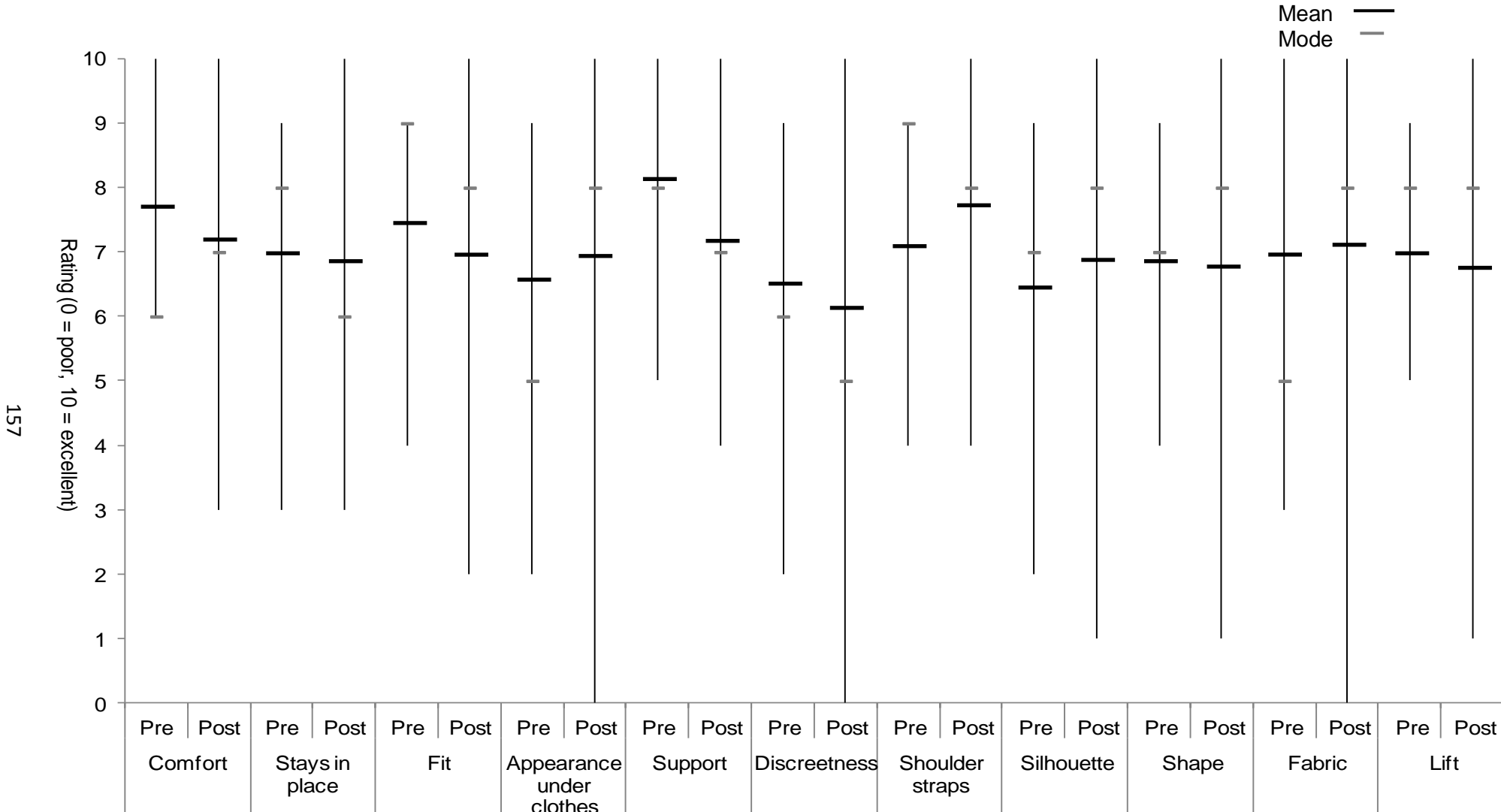


Figure 43. Range of subjective ratings for the 11 key bra performance variables following everyday activity tasks in the popular bra condition, pre and post a four week wearer trial period. The mean (black) and mode (grey) values are shown as horizontal lines (n=11)

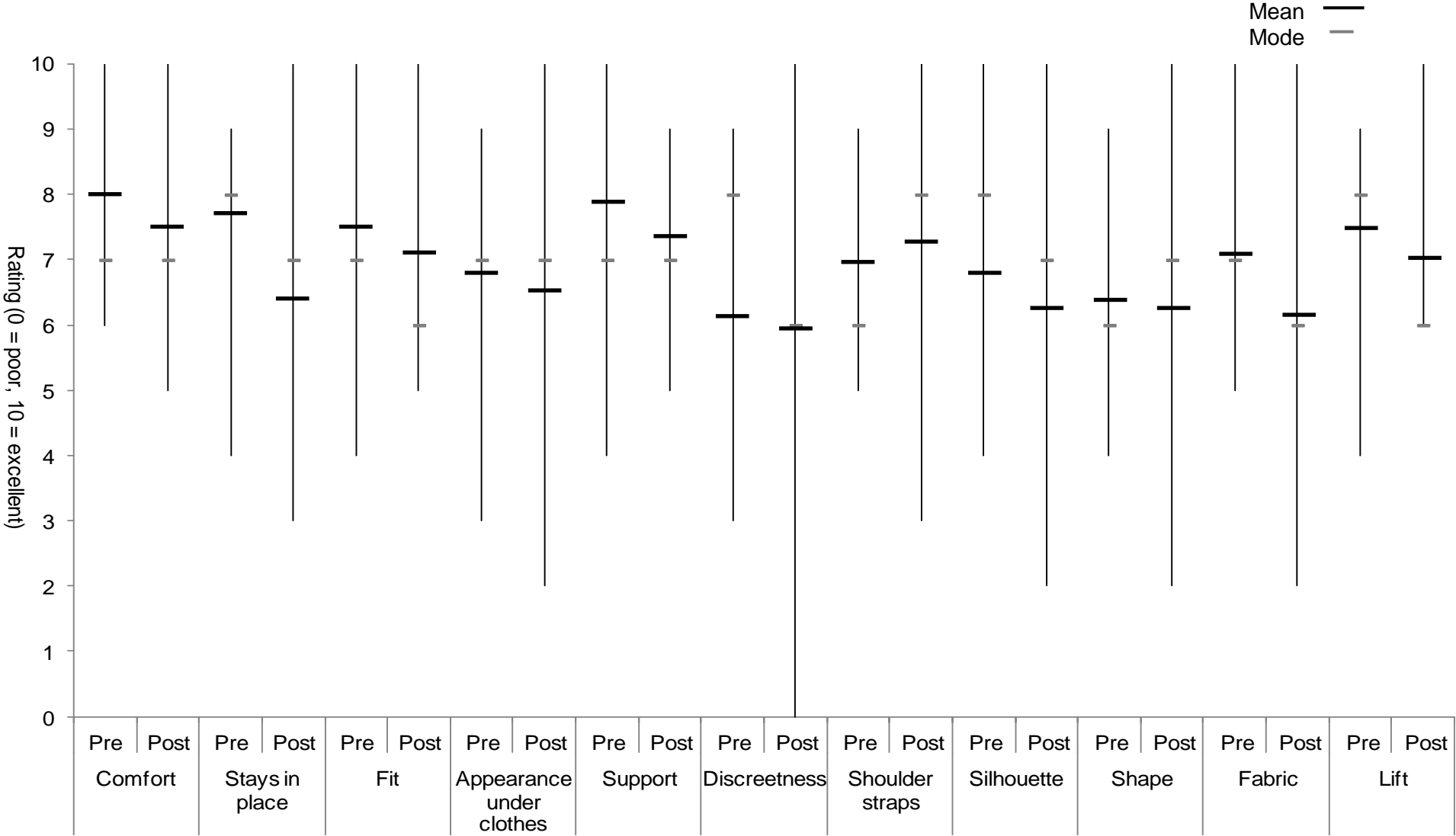


Figure 44. Range of subjective ratings for the 11 key bra performance variables following everyday activity tasks in the unpopular bra condition pre and post a four week wearer trial period. The mean (black) and mode (grey) values are shown as horizontal lines (n=11)

7.3.2.2 Objective results

7.3.2.2.1 Bra's ability to stay in place

Figure 45 shows the results of the popular and unpopular bra's ability to stay in place following everyday activities undertaken in the laboratory, pre and post the wearer trial. Analysis indicates no difference between the popular and unpopular bra in their ability to stay in place ($z=-1.21$, $p=.226$). With no change seen in either the popular ($F_{(11)}=1.07$, $p=.394$) or unpopular bra ($F_{(11)}=1.42$, $p=.175$) following the four week wearer trial, subsequently no differences were found between the two bras following the four week wearer trial ($F_{(5)}=.93$, $p=.513$).

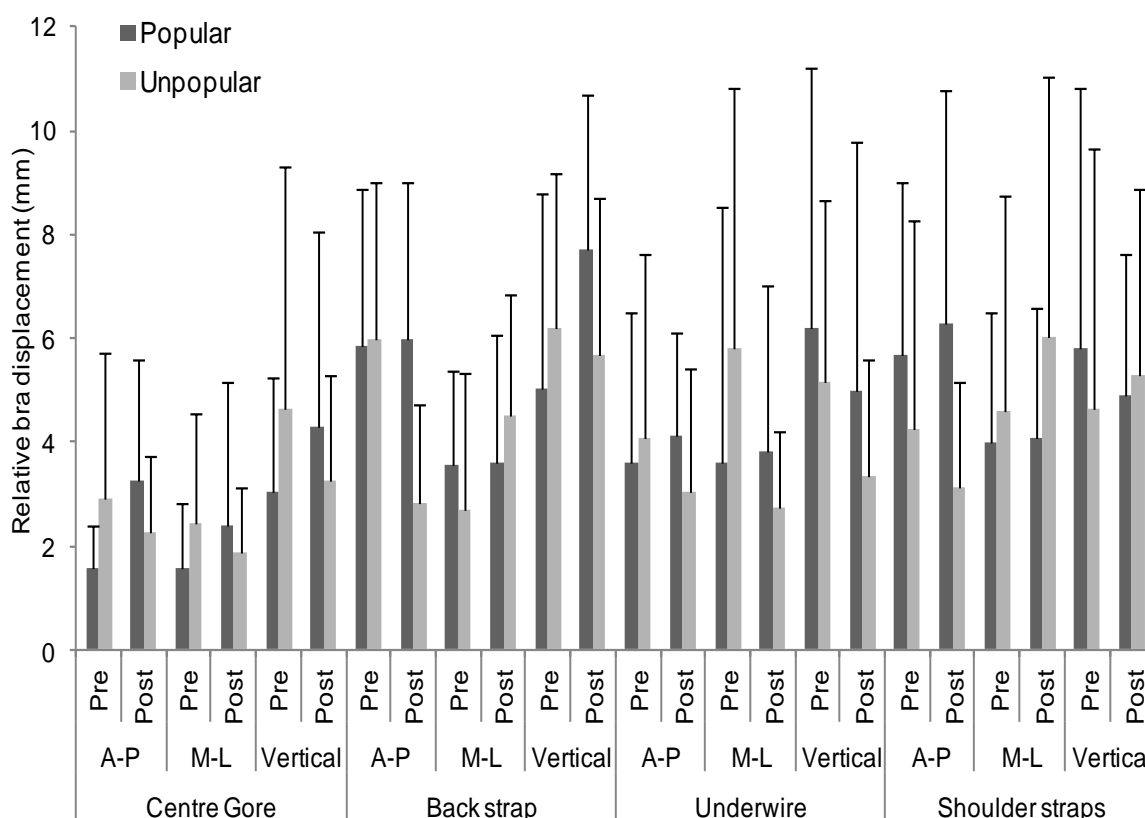


Figure 45. Mean multiplanar movement (mm) of four areas of the bra following everyday activities in the popular and unpopular bras, pre and post a four week wearer trial. Error bars represent the standard deviation ($n=11$).

7.3.2.2.2 Breast support

Figures 46 and 47 show the breast displacement (mm) and velocity ($m\ s^{-1}$) during treadmill walking pre and post the four week wearer trial period. Prior to the four week wearer trial, greater breast movement was seen in the bare breasted condition when compared to both bras ($F_{(1.16)}=28.15$, $p=.001$), with interaction effects detailed in figures 46 and 47. No changes were seen in breast movement

following the four week wearer trial in either the bare breasted ($Z=-1.96$, $p=.06$), popular bra ($z=-1.64$, $p=.101$) or unpopular bra ($z=-.52$, $p=.605$). As found prior to the wearer trial, greater breast movement was observed in the bare breasted condition in comparison to both bras following the wearer trial ($F_{(1,17)}=29.96$, $p=.001$), with specific interactions effects detailed in figures 46 and 47.

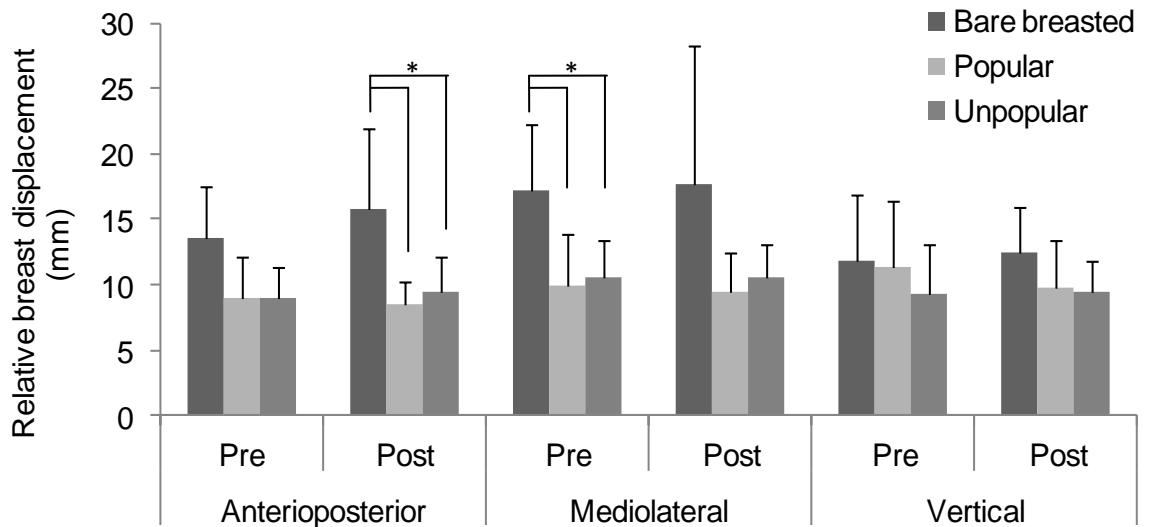


Figure 46. Mean relative breast displacement (mm) in anterioposterior, mediolateral and vertical directions pre and post a four week wearer trial, in a bare breasted condition, a popular and an unpopular bra during treadmill walking. Error bars represent the standard deviation (n=11). * $p<0.05$.

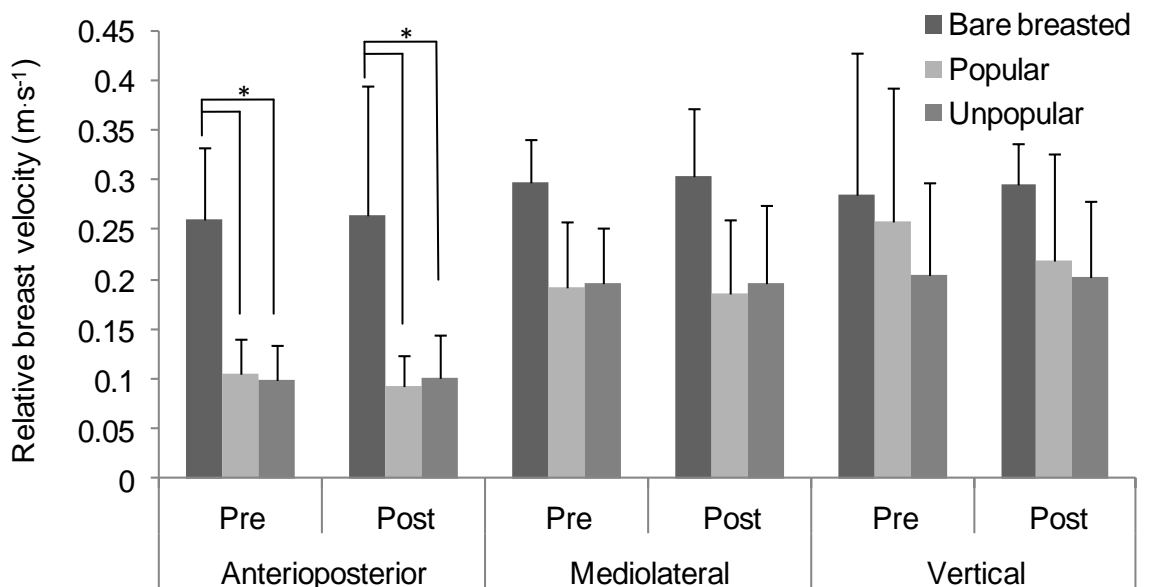


Figure 47. Mean relative breast velocity (m.s⁻¹) in anterioposterior, mediolateral and vertical directions pre and post a four week wearer trial, in a bare breasted condition, a popular and an unpopular bra during treadmill walking. Error bars represent the standard deviation (n=11). * $p<0.05$.

7.3.2.2.3 Shoulder straps

The popular bra's shoulder straps sat at a similar position on the shoulders as the unpopular bra prior to the four week wearer trial ($Z=-.62$, $p=.534$), with no change in the shoulder strap position after the four week wearer trial in either the popular bra ($t_{(10)}=.05$, $p=.960$) or unpopular bra ($t_{(10)}=-.59$, $p=.572$). The two bras were also positioned similarly after the wearer trial period ($t_{(10)}=-1.11$, $p=.296$) (figure 48).

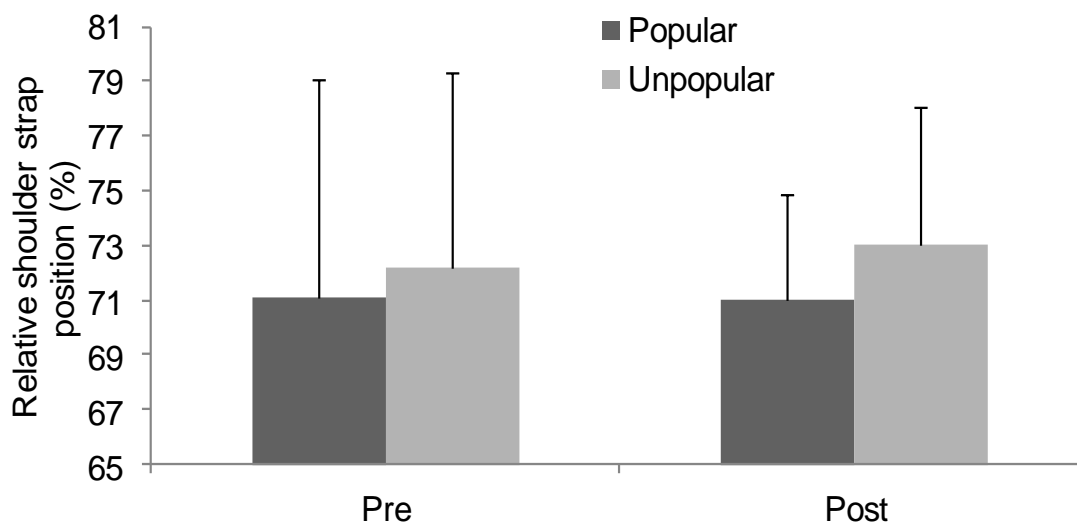


Figure 48. Mean shoulder strap position (%) in the popular and unpopular bra pre and post a four week wearer trial period. Error bars represent the standard deviation (n=11)

7.3.2.2.4 Silhouette

Prior to the four week wearer trial, differences were found in silhouette between the breast support conditions ($F_{(8,01)}=4.98$, $p=.001$), with the bare breasted condition providing a wider frontal under bust measure (272 ± 13 mm) than the popular bra (259 ± 16 mm), and the bare breasted condition providing a narrower sagittal width across the nipple (252 ± 15 mm) than the popular bra (259 ± 13 mm) (figure 49). Following the four week wearer trial, no changes were found between the pre and post measurements of silhouette within the bare breasted condition ($F_{(5)}=.41$, $p=.838$), the popular bra ($F_{(5)}=.98$, $p=.439$) or the unpopular bra ($F_{(5)}=.79$, $p=.564$). As seen prior to the four week wearer trial, interaction effects between the support condition and measures of silhouette were seen following the four week wearer trial ($F_{(10)}=6.23$, $p=.001$). The bare breasted condition (274 ± 14 mm) still provided a wider frontal under bust measurement than the popular bra (264 ± 14 mm), but also a wider frontal under bust

measurement than the unpopular bra (265 ± 13 mm). The difference in sagittal width across the nipple between the bare breasted condition and the popular was no longer present.

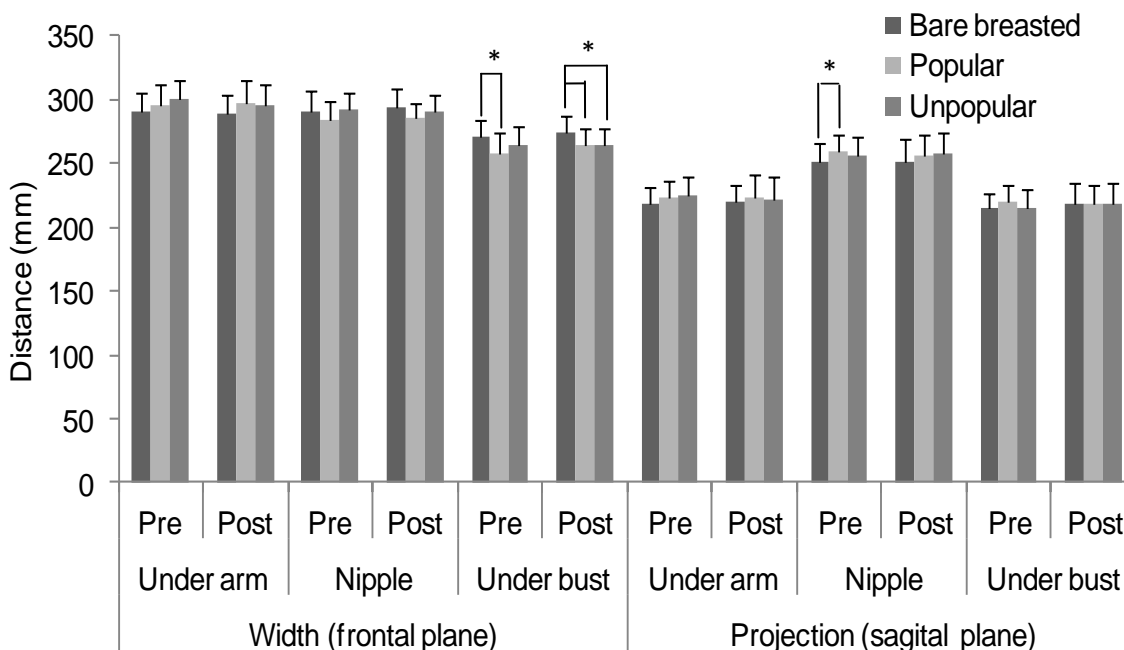


Figure 49. Width (frontal plane) and projection (sagittal plane) measurements of silhouette in the three support conditions, pre and post a four week wearer trial (see figures 22a and 22b for measurement details). Error bars represent the standard deviation ($n=11$). $*p<0.05$.

7.3.2.2.5 Breast shape

Prior to the four week wearer trial, an interaction effect was observed between the breast support condition and objective breast shape measurements ($F_{(8,98)}=6.74$, $p=.001$), post hoc analysis revealed that the only difference was between the measure of breast projection in the bare breasted condition and the unpopular bra at the base of the breast (101 ± 10 mm and 89 ± 12 mm respectively) (figure 50). Neither the bare breasted condition ($F_{(5)}=.14$, $p=.707$), the popular bra ($F_{(5)}=.67$, $p=.648$) or the unpopular bra ($F_{(5)}=2.12$, $p=.076$) showed changes in breast shape following the four week wearer trial. However, differences between the support conditions were seen following the four week wearer trial ($F_{(10)}=6.07$, $p=.001$), with post hoc analysis showing differences between the unpopular bra (139 ± 8 mm) and both the bare breasted (131 ± 6 mm) and popular bra (135 ± 4 mm) at the middle measurement of breast width, and between the bare breasted condition (90 ± 13 mm) and both bras (99 ± 16 mm and 99 ± 14 mm for the popular and

unpopular bra respectively) at the middle measurement of breast projection (figure 51).

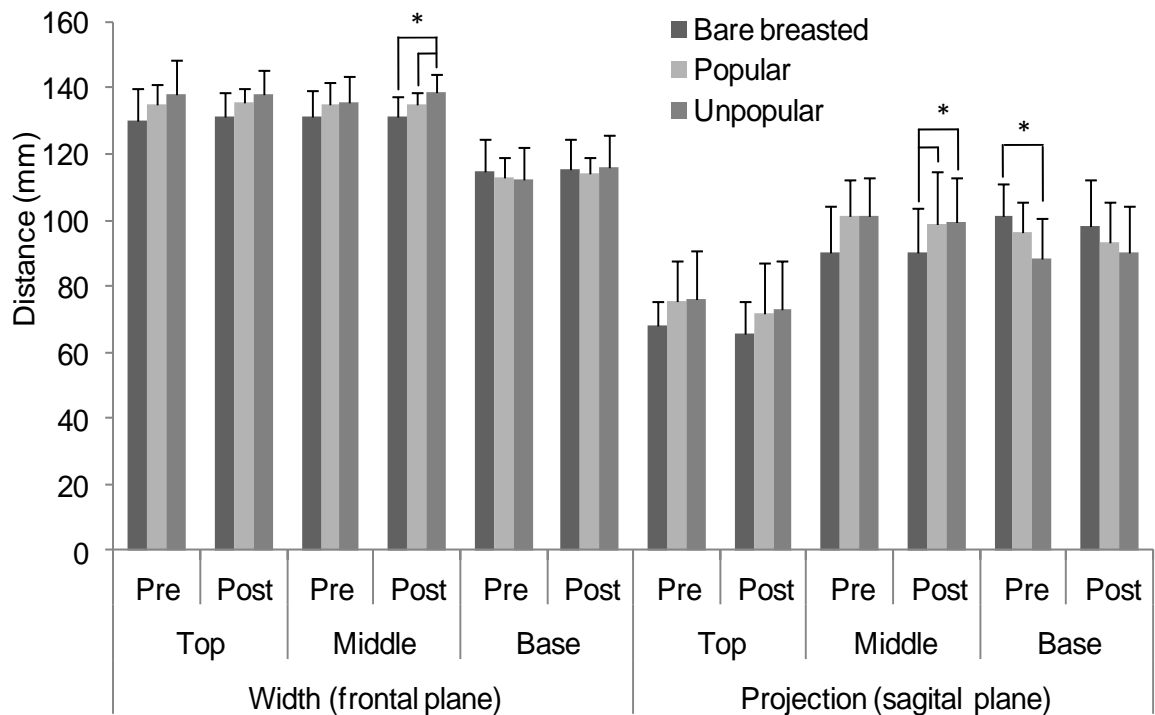


Figure 50. Width (frontal plane) and projection (sagittal plane) measurements of breast shape in the three support conditions, pre and post a four week wearer trial (see figures 23a and 23b for measurement details). Error bars represent the standard deviation (n=11). * $p < 0.05$.

7.3.2.2.6 Lift

Figure 51 shows differences in vertical breast position between the bras and the bare breasted condition during static standing, but not between the popular and unpopular bra ($F_{(2)}=16.23$, $p=.001$). No difference was found between the pre and post wearer trial measurements of bare breasted vertical breast position ($t_{(10)}=-1.03$, $p=.329$), the popular bra ($t_{(10)}=-1.02$, $p=.332$) or the unpopular bra ($t_{(10)}=.44$, $p=.672$). Subsequently, post wearer trial comparisons between the three breast support conditions revealed the same post hoc differences as the pre wearer trial.

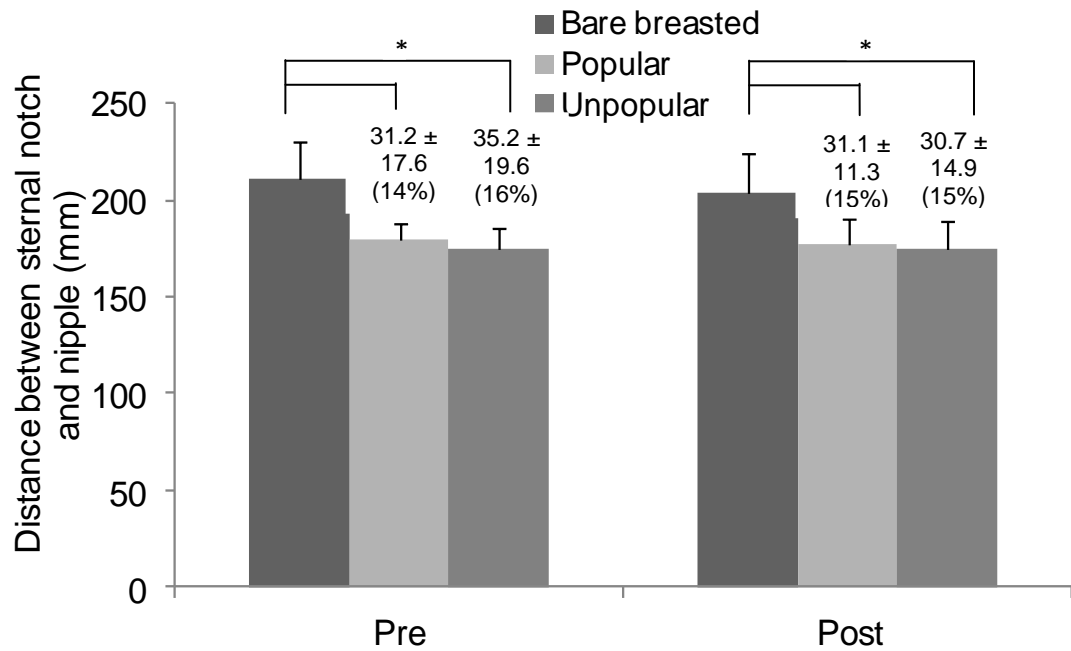


Figure 51. Mean vertical position of the nipple (mm) relative to the suprasternal notch pre and post a four week wearer trial period. Breast lift in millimetres and as a percentage of the bare breasted condition is shown above each bra condition. Error bars represent the standard deviation (n=11). $*=p<0.05$.

7.3.2.3 Summary table

Table 18 summarises the appropriateness of key bra performance variables for women aged 45 to 65 years following a four week wearer trial, based on the assessment of the bras from the popular and unpopular bra brand. Recommendations for bra design and comparison for future bra assessment studies from table 15 (chapter six) are supplemented with the results of the current wearer trial study.

Table 18. *Summary of bra appropriateness with regard to the key bra performance variables for women aged 45 to 65 years following a four week wearer trial.*

Key performance Variable	Deemed appropriate	Recommendations
Comfort	Yes	n/a
Stays in Place	No	Over 6 mm (up to 8 mm measured) not acceptable during everyday tasks
Fit	Yes	Bra fit according to White and Scurr's (2012) procedure
Appearance under clothes	Popular Yes Unpopular No	Assess this variable with a variety of different upper body garments
Support	Yes	Three dimensional breast displacement less than 13 mm and velocity less than $.259 \text{ m}\cdot\text{s}^{-1}$ during treadmill walking
Discreetness	No	n/a
Shoulder straps	Yes	Shoulder straps should sit 71% to 73% of the distance between the suprasternal notch and acromion process
Silhouette	No	None made
Shape	No	Greater breast projection across the middle of the breast may be required
Fabric	Popular Yes Unpopular No	n/a
Breast lift	Popular No Unpopular Yes	Approximately 17 % to 19% breast lift is acceptable, below 15% is not.

7.4 Discussion

This study aimed to determine whether an extended period of time (a four week wearer trial) is required to identify differences in the 11 key bra performance variables between a popular and unpopular bra. Also, to explore any changes that may have occurred in the two bras during the wearer trial period and define how this influences the appropriateness of the bras tested for women aged 45 to 65 years. Following the four week wearer trial, the unpopular bra was perceived as not staying in place to the same extent. Hypothesis one, that a significant difference would be found between pre and post measures of the key bra performance variables within support conditions, is therefore partially accepted. However, as no difference was found between the popular and unpopular bra following a four week wearer trial, the second hypothesis is rejected. The objective data did not reveal any differences within support condition as a result of the wearer trial, however, some small post hoc differences between conditions were found for breast support, breast shape and silhouette.

As expected based on the results of chapter six, no subjective differences were seen between the popular and unpopular bra prior to the four week wearer trial period. Despite fluctuations in ratings throughout the wearer trial period, figure 42 shows that, with the exception of the key bra performance variables breast lift and the bra's ability to stay in place, the popular bra was rated higher than the unpopular bra at the conclusion of 12 days of wear. Following Moutinho and Evans (1992) recommendations to include an ultimate choice at the end of a wearer trial, despite the popular bra appearing better on average than the unpopular bra, five of the 11 participants selected the unpopular bra as their favourite. This would suggest a relatively even distribution of preference between the popular and unpopular bra for the participants of this study.

The participant comments in table 16 indicate a variety of changes within both bras during the four week wearer trial. Three comments refer to the affect that washing had upon the bras and five comments refer to the underwire digging in after use. Interestingly, three comments refer to the fabric of the popular bra being itchy/scratchy, but four participants mentioned scratchy material on the back fastening of the unpopular bra, of which three participants trimmed the area with scissors until it no longer scratched their skin. Indeed, table 18 indicates that the fabric of the unpopular bra was no longer considered appropriate after the wearer trial.

Given that all bra manufacturers reported conducting wearer trials during product development (Hardaker & Fozzard, 1997), the high occurrence (four of 11) of a particular area of the bra being uncomfortable is surprising, as this should have been identified during the design process. One participant contacted the researcher regarding the underwire of the unpopular bra, which had broken through the channelling fabric at the centre gore, a replacement was subsequently sent out by post. Although Hardaker and Fozzard (1997) indicate that manufacturers randomly assess their bulk supplies of bra fabric to test for deviations in specification, it appears some products are not withstanding use. This did not deter the participant from asking for the bra details in order to purchase it at a subsequent date. Indeed, three participants in the current study asked for the details of the two bras so they could purchase them (Ross &

Harradine, 2010), and stated that they would never have previously considered purchasing the brand of the unpopular bra.

Although bra consumers are typically clear about their opinion on competing brands with regard to perceived quality and image (Hart & Dewsnap, 2001), Ross and Harradine (2010) noted an observable difference in opinion between participants who had taken part in a four week wearer trial and those that had not, but stated this did not result in a positive shift towards purchase, whereas the current study appeared to. This was indicated by three participants requesting the product details of the unpopular bra, suggesting that the bra itself may be suitable for women aged 45 to 65 year.

Following the four week wearer trial, the unpopular bra was rated as significantly worse at staying in place than prior to the trial, and this key performance variable was no longer deemed appropriate for women (table 18). This subjective change may be caused by numerous factors, such as washing machine use, fabric deterioration, adjustment of shoulder straps and hook and eye fastening. Indeed, further research is required to further explore this finding. Objective results (see section 7.3.3.1) did not support the participant's subjective ratings, with no differences in the measurement of bra movement over the skin pre and post the wearer trial period. Although subjective differences only occurred in the unpopular bra, this may indicate that the perception of bra movement is gained from activities other than the five assessed with the laboratory testing session (figures 13 to 17), that participants were not good at assessing this variable subjectively, or that the movement occurred during the activities but the bra resumed its original position prior to the post activity static image.

The post wearer trial comparisons between breast support conditions indicate that the popular bra was no longer considered to provide greater support than the bare breasted condition, whereas the unpopular bra was still considered more supportive than the bare breasted condition. Objective tests showed that both the popular and unpopular bras reduced anterioposterior breast displacement following the four week wearer trial, but not before. Based on the negative relationship found between breast support rating and anterioposterior breast displacement in chapter six of this thesis (section 6.3.3.2), it may have been

expected that ratings of breast support would increase in the current study, however this was not the case. Although treadmill activity is typically advocated within biomechanical breast support research (Scurr et al., 2009, 2010; White et al., 2011), a possible explanation for this result is that the perception of breast support is not only gleaned from treadmill activity, but from activities carried out during the four week wearer trial.

Comparisons of silhouette measurements pre- and post- the four week wearer trial indicated no objective change in the bare breasted, popular and unpopular bra conditions, confirming the subjective feedback. However, between support conditions comparisons following the four week wearer trial indicated that both bras provided a narrower frontal under bust measurement than the bare breasted condition, whereas only the popular bra was narrower prior to the wearer trial. This suggests that the under band of the unpopular bra may have altered due to use. Participant comments in table 16 indicate that the unpopular bra 'often felt tight and more so after washing', suggesting that washing may have affected the under band tightness. Sagittal width over the nipple line was also no longer different between the bare breasted and popular bra, indicating that the popular bra flattened the breast to a greater extent following the wearer trial period. These differences indicate that bra wear and washing altered the silhouette a bra creates. Similarly, bra use appears to alter the breast shape created, as the unpopular bra became slightly wider across the middle of the breast. Subsequent studies utilising these methods should therefore report the duration of bra use prior to the measurements being taken, as this may have some influence on the data.

With regard to the performance of bras for women aged 45 to 65 years, average subjective ratings of seven or above out of ten indicates that key bra performance variable is appropriate (Bodian, et al., 2001; Boogaerts, et al., 2000; Serlin, et al., 1995; Roelants, et al., 2003). Following the four week wearer trial period, both bras were deemed appropriate for the variables; comfort, fit, support, and shoulder strap position (table 18). However, neither bra was rated as appropriate for the variables; discreetness, silhouette, stays in place or breast shape. Although no statistical differences were found, the cut off boundary of seven out of ten meant that; neither bra stayed in place appropriately following the wearer trial,

the popular bra was deemed appropriate under clothes only following the wearer trial whereas the unpopular bra appeared inappropriate regardless of the wearer trial, the popular bra no longer provided sufficient lift following the wearer trial, and the fabric of the unpopular bra was no longer appropriate following the wearer trial (table 18). These differences suggest that the use of a bra for 12 days influences its appropriateness, and ability to meet the needs of the wearer.

Previous research implementing a wearer trial period indicated that few feedback comments regarded the product itself, indeed, the themes of feedback centred on; convenience and price, location, perception of quality, retail environment, brand positioning and self image (Ross & Harradine, 2010). These aspects of bra purchasing were seen as key themes in chapter three of this thesis (e.g., practicalities of bra purchasing, psychological aspects) and, although not relevant to the aim of the thesis, may be more influential in bra purchasing than the product itself. It may be gleaned from chapter three that the higher order themes; availability and buying, affordability and shop assistants, will influence the likelihood of bra purchasing, in addition to the performance of the bra itself. Subsequent research may wish to implement branded testing, so that these important aspects of bra popularity can be considered. In addition, Ross and Harradine's (2010) study incorporated the perspective of others, where in participants were asked to record the attitudes and reactions of their peers (Ross & Harradine, 2010). This may also be influential in wearer trials of bras, with the opinion of the romantic partner of particular importance.

7.5 Summary

The aim of this study was to determine whether an extended period of time and wear (a four week wearer trial) was required to identify differences in the 11 key bra performance variables between a popular and unpopular bra and explore any changes that may have occurred in the two bras during the wearer trial period. The results indicate that no major objective difference occurred between the bras as a result of the four week wearer trial; however, subjective ratings of breast support and the bra's ability to stay in place were both influenced by four weeks of bra use. It is therefore recommended that the duration of bra use be reported in future studies in order to allow the consideration of bra changes. The four week wearer trial did not distinguish any significant differences between the popular and unpopular bra, suggesting that the two bras performed similarly, and additional

factors are influencing the popularity of the bra brands, such as, convenience and price, perception of quality and retail environment (Ross & Harradine, 2010).

By assessing a longer duration of bra use, aim three of the thesis was addressed and a greater understanding was gained as to the performance of bras on the market for women aged 45 to 65 years. Only four of the 11 key bra performance variables were deemed appropriate regardless of duration of use (comfort, fit, support, and shoulder strap position). This not only indicates that improvements are required among bras of differing popularity in order to make them more appropriate for women aged 45 to 65 years, but that a four week wearer trial period influences the perceived appropriateness of a bra for older women.

Chapter 8.

General Discussion

8.1 Discussion

Due to the anatomical changes to the breast with increasing age and limited literature on the bra preferences of older women highlighted in chapter 1 and 2 of this thesis, the programme of research presented firstly aimed to provide a better understanding of the bra requirements and preferences of women aged 45 to 65 years. Secondly, to determine the key bra performance variables for older women and develop procedures by which to assess these variables. Finally, the research aimed to use the procedures developed to help gauge the appropriateness of a small sample of bras for women aged 45 to 65 years. This thesis adopted a mixed method design to gain both qualitative and quantitative data to address the research aims (Birtwistle & Tsim, 2005; Kim et al., 2004; Liao & Lee, 2010). The following discussion details the novel contributions of the thesis to the extant literature.

In order to build a knowledge base on the bra preferences and opinions of women aged 45 to 65 years, a qualitative investigation using focus groups and interviews was conducted. The results address the dearth of information in the literature by identifying 109 raw data themes, 23 higher order themes and five general dimensions of conversation. As seen with younger cohorts, the findings suggest bra purchasing is influenced by a variety of variables, relating not only to the bra itself, but to the purchasing environment and previous experience (Hart & Dewsnap, 2001; Liao & Lee, 2010). The results of this study provide the first knowledge base on the bra requirements and preferences of women aged 45 to 65 years.

Study one supports commonly reported issues with bra fitting due to discrepancies in sizing between different manufacturers (Hardaker & Fozzard, 1997; White & Scurr, 2012). The findings suggest that bra fitting services, store assistants and other soft factors may influence the purchasing process of women aged 45 to 65 years. The findings of the first study are synonymous with the results of subsequent laboratory testing. The collective findings from the thesis indicate that brand loyalty and repeat purchasing may be influential for women of this age range, which has implications to the marketing approach of new bra

products that are targeted to women aged 45 to 65 years, regardless of any alterations of current bras on the market. It is suggested that brand choices are linked to numerous factors, in addition to product performance, such as the presence and associated image of co-consumers, the image a brand projects and the attitudes derived from beliefs about the product attributes (Bass, Pessimier, & Lahmann, 1972; Birtwistle & Tsim, 2005; Hart & Dewsnap, 2001; Ross & Harradine, 2010). Although these variables do not influence the performance of a bra and were therefore not relevant within the current thesis, future research should consider these variables when assessing the bra market. It is recommended that the general dimensions reported during the focus groups and interviews in study one (practicalities of purchasing and psychological aspects) are investigated. A study detailing the influence of each of these factors, with regard to models of purchasing, may reveal ways to optimise the bra purchasing process for older women. As suggested in study two (chapter 4) of this thesis, such research might also investigate the influence of pricing within different subgroups, for example, different ages and socioeconomic populations.

Crucially, the findings from study one highlight that women aged 45 to 65 years acknowledge a change in their breasts. The findings from study two show 80% of women reported some change in their breasts since the age of 45 years, and breast sag was the most common response when specifying the type of change. The findings reinforced the rationale for this thesis and the importance of understanding the bra preferences of women aged 45 to 65 years by supporting previous literature that has centred on other items of clothing for older women (Birtwistle & Tsim, 2005). The qualitative comments in study one and the findings in study two indicate that women acknowledge anatomical changes in their breasts and have adapted their bra requirements to suit these changes (Rosen, 2001). By identifying this information, the current thesis emphasises the influence of ageing upon female bra preferences and requirements, and thus the need for further investigations on the topic.

The thesis addressed the previous lack of awareness of the relevant bra performance variables for older women, by identifying that; comfort, bras ability to stay in place, bra fit, appearance under clothes, breast support, bra discreetness, shoulder straps, silhouette, breast shape, bra fabric and breast lift, were key bra

performance variables for women aged 45 to 65 years. Some of these variables have been recognised in previous literature (Birtwistle & Tsim, 2005; Kim et al., 2004; Liao & Lee, 2010), however, the current thesis is the only known study that provides an evidence base for the inclusion of these variables. These findings add novel knowledge of the bra requirements and preferences of this sample, and allow the investigation of bra performance for this population, which was not previously possible. Future research should establish the key performance variables which determine appropriate bra performance in different populations. For example, conducting studies similar to studies one and two (qualitative investigation and survey) on different age ranges to determine the key bra performance variables for all ages. Quantification of the respective key bra performance variables could then determine whether any differences among specific populations are merely preference based or whether they are also anatomical requirements. Similarly, including variables such as puberty, pregnancy and breast feeding would increase the understanding of bra requirements for these specific populations, in order to optimise bra design for these groups.

Whilst investigating factors that may influence the importance rating of the key bra performance variables and women's current bra wearing habits, cup size was found to have a significant relationship with the importance ratings of internal bra related factors that regard the wearers own perception (support, comfort, fit, bras ability to stay in place, shoulder straps, fabric, discreetness). Older women within the 20 year age range were significantly less likely to own a sports bra, but were more likely to wear a bra with a lace design, and women with a larger cup size and band size were less likely to wear a padded bra. These important findings show that cup size, band size and age may therefore play an influential role in the style of bra worn by a woman, and should be considered during the bra design process. These internal and external factors could form the basis of subsequent studies in which the influence of bra size, population and occasion could be assessed. Findings from such a study would indicate the importance of each factor, and thus which factor should be of primary focus for bra design, within different bra sizes, populations and occasions. In addition, the reasons behind reduced sports bra use with increasing age should be investigated in order to

promote the use of sports bras within older populations (Gehlsen & Albohm, 1980; Lawson & Lorentzen, 1990; Scurr et al., 2010, 2011).

By identifying the 11 key bra performance variables for women aged 45 to 65 years, future research on bra optimisation for this population can be targeted to the correct areas. The novel methods developed within chapter five were designed to be used concurrently to create a holistic assessment of a bra's appropriateness for women aged 45 to 65 years. The procedure incorporates a measure for each of the 11 key bra performance variables whilst crucially maintaining a realistic expectation of participant's ability and time requirements. As a result of this thesis, it is now possible to reliably and validly assess an everyday bra's performance for women aged 45 to 65 years. The methods to assess the 11 key bra performance variables are useful not only in bra related research, but also have a clinical application and could be used to assess pre- and post-operative results of breast surgery. It is proposed that the methods developed within this thesis be used as a standard for bra assessment studies for women aged 45 to 65 years.

In addition to the extant application of the developed bra performance methods, the holistic mixed method design utilising a combination of qualitative and quantitative techniques presented within the current thesis extends upon the research process presented by previous product/event development literature (Birtwistle & Tsim, 2005; Kim et al., 2004; Liao & Lee, 2010). The systematic and sequential process of implementing; focus groups, questionnaires, laboratory testing and longer duration trials, is recommended as the optimal way to aptly assess the performance of any product or event. The process ensures that all relevant and important considerations are assessed and subsequently determines the performance of each variable. Therefore, the pertinent strengths and weaknesses of a product/event are indentified, which affect both the initial use (acute testing) and repeat use (longer term trials). For example, this process may be applied to assess the performance of, but not limited to; all items of clothing/footwear, household products, sporting equipment, electrical equipment, health interventions, business related training or social events.

The broad use of the mixed method design presented within the current thesis defines the appropriateness of a product or event. Chapter six summarises the appropriateness of the bras tested during the laboratory session for women aged 45 to 65 years. The key bra performance variables; appearance under clothes, discreetness, silhouette and breast shape, were not deemed appropriate (Bodian, et al., 2001; Boogaerts, et al., 2000; Roelants, et al., 2003; Serlin, et al., 1995). It is concluded that average subjective ratings of seven or above out of ten be used as the established acceptable boundary for key performance variables, in order to gauge the appropriateness of bras for a population of women.

Not previously suggested in the literature, the results of the thesis indicate specific design recommendations to improve bra design for older women. These include; 2 mm to 6 mm as an acceptable level of bra slippage, shoulder straps positioned 71% of the distance between the suprasternal notch and the acromion process is appropriate, and breast displacement of less than 13 mm and breast velocity of less than $.17 \text{ m}\cdot\text{s}^{-1}$ during treadmill walking is appropriate. Inappropriate measurements for the key bra performance variables breast shape and torso silhouette are also defined in the thesis. These objective criteria are the first to define an appropriate bra for women aged 45 to 65 years, and should be used in future bra research as an indicator of bra appropriateness for this population. The subjective findings of this thesis also indicate that the following adjustments are required; an alteration to the underwire design to maximise comfort, bras having non-slip shoulder straps, loosened elastic around the top of the bra cup, removing large seams from the front of the cup and providing sufficient breast projection and breast lift. This knowledge adds to the literature by presenting average values for objective measures of bra performance variables, however, the key bra performance variables not deemed appropriate indicate that further research is needed to manipulate these variables to determine appropriate criteria for these measures. Future research could also use these methods to determine population specific criteria for other groups, for example, breast feeding women or teenagers.

This thesis investigated the performance of a popular and unpopular bra for women aged 45 to 65 years. It is recommended that future research include a larger selection of bras on the market, to increase the range of values when quantifying key bra performance variables. This may subsequently lead to a better

understanding of the differences between bras that influence the subjective perception of each bra performance variable, identifying greater correlations between subjective and objective values. In addition, this thesis ensured all participants were bra fit according to the published best fit criteria (White & Scurr, 2012). As a large percentage (up to 85%) of the population are reported to wear the incorrect bra size (McGhee & Steele, 2010), assessing the key bra performance variables among ill fitting bras warrants investigation. This may determine the influence of poor fit on bra performance and extend the application of the findings from the current thesis.

In concurrence with previous literature, the attitudes of consumers appeared to alter somewhat following a wearer trial period (Ross & Harradine, 2010). Crucially, the results of this thesis show that a four week wearer trial period does have an influence on bra performance and appropriateness for women (as indicated by the amendments made from table 15 to table 18). Subjective comments provided by participants within the bra appraisal diary indicated that bra problems that were not apparent within the initial laboratory testing session became evident during the four week period. This bra related information only became evident following prolonged wear, and emphasises the importance of allowing women an extended period of time in which to determine the appropriateness of a bra. It is therefore recommended that future research incorporating bra assessment report the duration of bra use and wear, when a wearer trial period is not possible, as duration of use may influence the key bra performance variables. It is also suggested that multiple items of upper body clothing should be considered when rating a bra's appearance under clothes.

8.2 Assumptions and limitations

This thesis makes some broad assumptions regarding the generalisation of the findings. Firstly, the 20 year age range selected for participant inclusion may require narrowing to provide the maximum bra optimisation for women within this population. Study two indicated some differences in bra preferences due to age (older women in the cohort were less likely to own a sports bra, but were more likely to wear a bra with a lace design). The optimum bra design may therefore differ for the older and younger range within the 45 to 65 year age range.

However, the current thesis is conducted with the assumption of a homogenous population.

Although the focus of this thesis is the precursors that influence bra consumer behaviour in an ageing population, it is acknowledged that age may be one of many factors to influence bra preferences. Study two implemented word of mouth recruitment for survey respondents, although this is believed by some to better represent the sample population (Gray et al., 2007; Wright & Stein, 2005), it may have meant that surveys were distributed primarily within the same socioeconomic and cultural group. As generalisability is limited by the extent to which a sample represents the population, the findings are presented with the assumption that the samples used within each study do represent the broader population of women in this age range.

From a positivist perspective, this thesis assumes that the key bra performance variables are empirically measurable. Some literature suggests that consumers may understand their own likes and dislikes, but often lack the ability to express this and explain why (Franke et al., 2009; Malhotra & Birks, 2003). Each study within this thesis therefore assumes that the participants have the ability to accurately respond to questions regarding their perceptions of the key bra performance variables. Furthermore, limitations may exist in the objective methods to assess the key bra performance variables. For example, the method to assess a bra's ability to stay in place measured the position of key areas of the bra pre and post participants performing everyday activities, due to the limitations of the camera system it was not possible to record bra slippage in real time during activities, as markers were obscured by participant movement and position. The bra may therefore move during activities, but settle into the original position prior to the post activity static image being recorded.

The results of studies three, four and five reveal the breast shape method also includes an inherent limitation, by defining the half way position between the base of breast and suprasternal notch, the method currently exhibits differences in the defined 'top of the breast' position due to the lift provided when a bra is worn. However, due to the variable dispersion of breast tissue in the superior portion of the breast, it is not possible to define an exact boundary of the breast. The use of

rigid landmarks in this method would determine breast position on the torso, rather than the moveable shape of the soft tissue as required. The method to assess breast shape is therefore utilised with the assumption that the defined 'top of the breast' represents the most appropriate superior boarder of the breast.

Within the wearer trials in study five, it should be acknowledged that, in addition to the limitation of false compliance with paper diary use (Shiffman et al., 2001; Stone et al., 2002); consumer feedback on products may not always indicate the success of a product. A good product may be less popular than its competitor because it lacks funds to meet the competition, or because a competitor has built such a strong reputation that no amount of advertising can make an impression on consumers (Proctor, 2003). Indeed, product quality is only one aspect of success, a bra's price, marketing strategy and positioning in store will all influence a bra's dominance within the bra market (Malhotra & Birks, 2003). The selection of the popular and unpopular bra within studies four and five was made to investigate whether differences in the popularity were due to product differences, based on the results of this thesis it would suggest that many factors influence the purchase/wearing frequency, and product differences may not be key in bra selection.

8.3 Conclusion

This thesis employed both established and novel methodological approaches (Birtwistle & Tsim, 2005; Kim et al., 2004; Liao & Lee, 2010; Roe, 2004) in order to; provide a wider understanding of the bra requirements and preferences of women aged 45 to 65 years, to determine the key bra performance variables for women of this age and develop procedures by which to assess these variables, and to determine the current appropriateness of a small sample of bras for women of this age.

The series of research investigations conducted within this programme of work allow the following conclusions to be made:

- Women aged 45 to 65 years have acknowledged a change in their breasts and bra requirements, and subsequently seek bras that are different from those they previously would have worn.

- The bra requirements of women aged 45 to 65 years are multifaceted, incorporating 11 key bra performance variables (support, fit, shape, silhouette, shoulder straps, lift, appearance under clothes, discreetness, comfort, fabric and ability to stay in place) which can be grouped into functional and visual concerns.
- The development of methods and procedures to assess the 11 key bra performance variables of women aged 45 to 65 years advances the literature by enabling reliable and valid assessment of these bra variables.
- The key bra performance variables; discreetness, silhouette, breast shape and appearance under clothes were deemed inappropriate for women aged 45 to 65 years, indicating that these bra variables require improvements for this population. The key performance variables bra's ability to stay in place and bra fabric were also not deemed appropriate for older women following four weeks of use.
- An extended period of wear (four week wearer trial) revealed greater subjective feedback on the products and some differences among quantified variables, indicating that greater experience of a bra affected its performance.
- The findings suggest that factors additional to bra performance influence the usage and popularity of bra brands for women aged 45 to 65 years.

It is concluded that the methods developed within this thesis would be beneficial for use as a standard for bra assessment studies with women aged 45 to 65 years, and that average subjective ratings of seven or above out of ten be used as the established acceptable boundary for key performance variables, in order to gauge the appropriateness of bras for a population of women. The applications of the holistic mixed method approach utilised in this thesis extend beyond bra preferences and performance. The systematic implementation of focus groups, questionnaires, laboratory testing and wearer trials is advised as an optimal methodological approach within future research aiming to determine the performance of products or events.

References

- Ader, D. N., & Shriver, C. D. (1998). Update on clinical and research issues in cyclical mastalgia. *The Breast Journal*, 4 (1), 25-32.
- Agbenorku, P., Agbenorku, M., Iddi, A., Amevor, E., Sefenu, E. & Osei, D. (2011). Measurement of breasts of young West African females: a guideline in anatomical landmarks for adolescent breast surgery. *Aesthetic Plastic Surgery*, 35 (1), 49-54.
- Ashdown, S. & Na, H. (2008). Comparison of 3-D body scan data to quantify upper-body postural variation in older and younger women. *Clothing & Textiles Research Journal*, 26 (4) 292-307.
- Ashizawa, K., Sugane, A., & Gunji, T. (1990). Breast Form Changes Resulting From a Certain Brassiere. *Journal of Human Ergology*, 19 (1), 53-62.
- Assael, H. (1981). *Consumer Behavior and Marketing Action*. Boston, MA: Kent Publishing Company.
- Atkinson, G., & Nevill, A. (1998). Statistical methods for assessing measurement error (reliability) in variables relevant to sports medicine. *Sports Medicine*, 26 (4), 217-238.
- Avis, N., & Crawford, S. (2008). Cultural Differences in Symptoms and Attitudes Towards Menopause. *Menopause Management Journal*, 17 (3), 8-13.
- Ayres, B., White, J., Hedger, W., and Scurr, J. (2011). The influence of sports bra material properties on upper body and breast skin temperature and thermal comfort following exercise. In M. Sellens, G, Sandercock, m. Taylor, & D. Micklewright (eds.), *Proceedings of the BASES Annual Conference (pp. S51). September 2011, Essex, UK*.
- Ball, N., & Scurr, J. (2010). An assessment of the reliability and standardisation of tests used to elicit reference muscular actions for electromyographical normalisation. *Journal of Electromyography and Kinesiology*, 20 (1), 81-88
- Ballard, K., Elston, M., & Gabe, J. (2009). Private and public ageing in the UK: the transition through the menopause. *Current Sociology*, 57 (2), 269-290.
- Baltes, M., & Carstensen, L. (1996). The process of successful ageing. *Ageing and Society*, 16 (4), 397-422.
- Bannister, L. (1995). Females breasts. In Williams, P (Ed.). *Gray's Anatomy*. New York: Churchill Livingston.
- Barbour, R. (2008). *Doing focus groups*. London: SAGE Publications Incorporated.

- Barbour, R., & Kitzinger, J. (1999). *Developing focus group research, politics, theory and practice*. London: SAGE Publications Incorporated.
- Barrett, J., & Kirk, S. (2000). Running focus groups with elderly and disabled elderly participants. *Applied Ergonomics*, 31 (6), 621-629.
- Bartlett, M. S. (1954). A note on the multiplying factors for various χ^2 approximation. *Journal of the Royal Statistical Society*, 16 (2), 296-298.
- Baruch, Y. (1999). Response rates in academic studies - a comparative analyses. *Human Relations*, 52 (4), 421-438.
- Bass, F., Pessimier, E., & Lehmann, D. (1972). An experimental study of relationships between attitudes, brand preference, and choice. *Behavioral Science*, 17 (6), 532-541.
- Batterham, A., & George, K. (2003). Reliability in evidence-based clinical practice: a primer for allied health professionals. *Physical Therapy in Sport*, 1 (4) 122-128.
- Birtwistle, G., & Tsim, C. (2005). Consumer purchasing behaviour: an investigation of the UK mature women's clothing market. *Journal of Consumer Behaviour*, 4 (6), 453-464.
- Blaikie, N. (2003). *Analyzing Quantitative Data*. London: SAGE Publications Incorporated.
- Bodian, C., Freedman, G., Hossain, S., Eisenkraft, J., & Beilin, Y. (2001). The visual analog scale for pain, clinical significance in postoperative patients. *Anesthesiology*, 95 (6), 1356-1361.
- Boecker, F., & Schweikl, H. (1988). Better preference prediction with individualized sets of relevant attributes. *International Journal of Research in Marketing*, 5 (1), 15-24.
- Boogaerts, J., Vanacker, E., Seidel, L., Albert, A., & Bardiau, F. (2000). Assessment of postoperative nausea using a visual analogue scale. *Acta Anaesthesiologica Scandinavica*, 44 (4), 470-474.
- Bowles, K. A., Steele, J. R. & Munro, B. (2008). What are the breast support choices of Australian women during physical activity? *British Journal of Sports Medicine*, 42 (8), 670-674.
- Bowles, K. A., Steele, J. R., & Munro, B. (2011). Features of sports bras that deter their use by Australian women. *Journal of Science and Medicine in Sport*, 15 (3), 195-200.

- Brenner, S., Golan, H., Srebrnik, A., Martinez de Morentin, H., Wohl, Y. (2005). The normal and abnormal breast. *Sexuality, Reproduction & Menopause*, 3 (1), 31-36.
- British Association of Aesthetic Plastic Surgeons (2010). Breast lift. Retrieved on 17th May, 2009, from <http://www.baaps.org.uk>.
- Brown, T. P., Ringrose, C., Hyland, R. E., Cole, A. A., & Brotherton, T. M. (1999). A method of assessing female breast morphometry and its clinical application. *British Journal of Plastic Surgery*, 52 (5), 355-359.
- Bruton, A., Conway, J., & Holgate, S. (2000). Reliability: what is it and how is it measured? *Physiotherapy*, 86 (2), 94-99.
- Caldwell, D. (1981). *And all was revealed: Ladies' underwear, 1907-1980*. New York: St Martin's Press.
- Carmichael, A. R., Bashayan, O., & Nightingale, P. (2006). Objective analyses of mastalgia in breast clinics: Is breast pain questionnaire a useful tool in a busy breast clinic? *The Breast Journal*, 15 (4), 498-502.
- Caplan, S. (1990). Using focus group methodology for ergonomic design. *Ergonomics*, 33 (5), 527-533.
- Catanuto, G., Spano, A., Pennati, A., Riggio, E., Farinella, G., Impoco, G., Spoto, S., Gallo, G. & Nava, M. (2008). Experimental methodology for digital breast shape analysis and objective surgical outcome evaluation. *Journal of Plastic, Reconstructive and Aesthetic Surgery*, 61 (3), 314-318.
- Cha, S. (2012). The uplifting effect of a prototype brassiere. *International Journal of Clothing Science and Technology*. 24 (2/3), 154-169.
- Chan, C., Yu, W., & Newton, E. (2001). Evaluation and analysis of bra design. *The Design Journal*, 4 (3), 33-40.
- Chen, C., LaBat, K., & Bye, E. (2010). Physical characteristics related to bra fit. *Ergonomics*, 53 (4), 514-524.
- Chen, C., LaBat, J., & Bye, E. (2011). Bust prominence related to bra fit problems. *International Journal of Consumer Studies*, 35 (6), 695-701.
- Christie, D., O'Brien, M., Christie, J., Kron, T., Ferguson, S., Hamilton, C., & Denham, J. (1996). A comparison of methods of cosmetic assessment in breast conservation treatment. *The Breast*, 5 (5), 358-367.
- Clarke, L., & Griffin, M. (2008). Visible and invisible ageing: beauty work as a response to ageism. *Ageing and Society*, 28 (5), 653-674.

- Clarke, L., Griffin, M., & Maliha, K. (2009). Bat wings, bunions, and turkey wattles: body transgressions and older women's strategic clothing choices. *Ageing and Society*, 29 (5), 709-726.
- Clegg, F. (1998). *Simple Statistics*. Cambridge: Cambridge University Press.
- Coelho, P., & Esteves, S. (2007). The choice between a five-point and a ten-point scale in the framework of customer satisfaction measurement. *International Journal of Market Research*, 49 (3), 313-339.
- Cohen, J. (1988). *Statistical power analysis for the behavioural sciences* (2nd ed.). New Jersey: Lawrence Erlbaum.
- Colacurci, N., Mele, D., DeFranciscis, P., Costa, V., Fortunato, N., & Deseta, L. (1998). Effects of tibolone on the breast. *Journal of Obstetrics & Gynaecology and Reproductive Biology*, 80 (2), 235-238.
- Constantakos, A., & Watkins, S. (1982). Pressure analysis as a design research technique for increasing the comfort of nursing brassieres. *Home Economics Research Journal*, 10 (3), 271-278.
- Cooper, R. (1996). Overhauling the new product process. *Industrial Marketing Management*, 25 (6), 465-482.
- Croft, J. (1965). Alice in adland. *North American Review*, 250 (5), 37-37.
- Cummings, S. M., Savitz, L. A., & Konrad, T. R. (2001). Reported response rates to mailed physician questionnaires. *Health Services Research*, 35 (6), 1347-1355.
- Cummins, D., Bishara, S., & Jakobsen, J. (1995). A computer assisted photogrammetric analysis of soft tissue changes after orthodontic treatment. Part II: Results. *American Journal of Orthodontics and Dentofacial Orthopedics*, 108 (1), 38-47.
- Davies, E. L., Gateley, C. A., Miers, M., & Mansel, R. E. (1998). The long-term course of mastalgia. *Journal of the Royal Society of Medicine*, 91 (9), 462-464.
- Davis, J., Stinson, L., To, N. (2002). What does it really mean to be user-friendly when designing an expenditure diary? American Association for Public Research: Section on Survey Research Methods 2002 Proceedings, pp. 696-701,
- Dawson, J., Fitzpatrick, R., Murray, D., & Carr, A. (1998). Questionnaire on the perceptions of patients about total knee replacement. *The Journal of Bone and Joint Surgery*, 80 (1), 63-69.

- Deeks, A., & McCabe, M. (2001). Menopausal stage and age and perception of body image. *Psychology and Health*, 16 (3), 637-679.
- Del Carmen, M., Halpern, E., Kopans, D., Moy, B., Moore, R., Goss, P., & Hughes, K. (2007). Mammographic density and race. *Women's Imaging*, 188 (4), 1147-1150.
- Dennerstein, L. (1996). Well-being symptoms and the menopausal transition. *Maturitas Journal of the Climacteric and Postmenopause*, 23 (2), 147-157.
- Dennerstein, L., Dudley, E. C., Hopper, J. L., Guthrie, J. R., & Burger, H. G. (2000). A Prospective Population-based study of Menopausal Symptoms. *Obstetrics and Gynaecology*, 96 (3), 351-358.
- Dias, L. (2003). Generational buying motivations for fashion. *Journal of Fashion Marketing and Management*, 7 (1), 78-86.
- DiBernardo, B., Adams, L., Krause, J., Fiorillo, M., & Gheradini, G. (1998). Photographic standards in plastic surgery. *Plastic and Reconstructive Surgery*, 102 (2), 559-568.
- Dewsnap, B., & Hart, C. (2004). Category Management: a new approach for fashion marketing. *European Journal of Marketing*, 38 (7), 809-834.
- Dillman, D., Sinclair, M., & Clarke, J. (1993). Effects of questionnaire length, respondent-friendly design, and a difficult question on response rates for occupant-addressed census mail surveys. *Oxford Journals*, 57 (3), 289-304.
- Elackattu, A., Babade, M., Brodell, R. T., & Dewer, S. (2007). Bra-band wound in an adolescent. *Clinical Paediatrics*, 46 (5), 448-450.
- Engel, E., Blackwell, R., & Miniard, P. (1993). *Consumer Behavior, Seventh Edition*. Texas, USA: The Dryden Press.
- Escoffier, C., Rigal, J., Rochefort, A., Vasselet, R., Leveque, J., & Agache, P. (1989). Age related mechanical properties of human skin. *Journal of Investigative Dermatology*, 93 (3), 353-357.
- Expert Village (2007). Exercises for women over 50: shoulders and neck exercises for women over fifty. Retrieved July 10th, 2010, from <http://www.youtube.com/watch?v=UBepBsKjfO8&feature=channel>
- Fereday, J., & Muir-Cochrane, E. (2006). Demonstrating rigor using thematic analysis: a hybrid approach of inductive and deductive coding and theme development. *International Journal of Qualitative Methods*, 5 (1), 2-11.

- Field, A. P. (2009). *Discovering statistics using SPSS*. London, UK: SAGE Publications Incorporated.
- Franke, N., Keinz, P., & Steger, C. (2009). Testing the value of customization: when do customers really prefer products tailored to their preferences? *Journal of Marketing*, 73 (5), 103-121.
- Frazer, L., & Lawley, M. (2000). *Questionnaire design & administration*. Queensland, AUS: John Wiley & Sons Australia Ltd.
- Garland, R. (1991). The mid-point on a rating scale: is it desirable? *Marketing Bulletin*, 2 (research note 3), 66-70.
- Gateley, C., & Miers, M. (1991). *The Cardiff mastalgia clinic experience of the natural history of mastalgia*. British Breast Group Conference, March 1991. Manchester, UK: Parthenon Publishing Group LTD.
- Gefen, A., Dilmoney, B. (2007). Mechanics of the normal woman's breasts. *Technology and Health Care*, 15 (4), 259-271.
- Gehlsen, G., & Albohm, M. (1980). Evaluation of sports bras. *The Physician and Sports Medicine*, 8 (10), 85-96.
- Gehlsen, G., & Stoner, L. J. (1987). The Female Breast in Sport and Exercise. In M. Adrian (Ed.), *Sports Women* (pp. 13-22). Michigan, USA: Karger.
- Gho, S. A., Steele, J. R. & Munro, B. J. (2008). Can reductions in bra band pressure increase comfort during exercise in lumpectomy patients?. *Emed Scientific Meeting 2008* (pp. 29-29). Dundee, Scotland: University of Dundee.
- Gillham, B. (2007). *Developing a questionnaire 2nd Edition*. London: Continuum International Publishing Group.
- Godwin, y., Wood, S. H., & O'Neill, T. J. (1998). A comparison of the patient and surgeon opinion on the long-term aesthetic outcome of reduction mammoplasty. *British Journal of Plastic Surgery*, 51 (6), 444-449.
- Goffman, E. (1968). *Stigma: Notes on the Management of Spoiled Identity*. Harmondsworth, UK: Pelican Books.
- Goldsberry, E., Shim, S. & Reich, N. (1996). Women 55 years and older: part I. current body measurements as contrasted to the PS 42-70 data. *Clothing and Textiles Research Journal*, 14 (2), 121-132.
- Granot, E., Greene, H., & Brashear, T. (2010). Female consumers: decision-making in brand-driven retail. *Journal of Business Research*, 63 (8), 801-808.

- Gray, P., Williamson, J., Karp, D., and Dalphin, J. (2007). *The research imagination, an introduction to qualitative and quantitative methods*. New York, USA: Cambridge University Press.
- Greenbaum, A. R., Heslop, T., Morris, J., & Dunn, K. W. (2003). An investigation of the suitability of bra fit in women referred for reduction mammoplasty. *British Journal of Plastic Surgery*, 56 (3), 230-236.
- Guest, G., Bunce, A., & Johnson, K. M. (2006). How many interviews are enough? An experiment with data saturation and variability. *Field methods*, 18 (1), 59-82.
- Haars, G., Van Noord, P., Van Gils, C. H., Grobbee, D. E., & Peeters, P. (2005). Measurement of breast density: no ratio for a ratio. *Cancer Epidemiology, Biomarkers and Prevention*, 14 (11), 2634-2640.
- Hadi, A. (2000). Sports brassier: is it a solution for mastalgia? *The Breast Journal*, 6 (6), 407-409.
- Hanton, S., Fletcher, D., & Coughlan, G. (2005). Stress in elite sport performers: a comparative study of competitive and organizational stressors. *Journal of Sports Sciences*, 23 (10), 1129-1141.
- Hardaker, C. & Fozzard, G. (1997). Communications: the bra design process - a study of professional practice. *International Journal of Clothing Science and Technology*, 9 (4), 311-325.
- Hart, C. & Dewsnap, B. (2001). An exploratory study of the consumer decision process for intimate apparel. *Journal of fashion marketing and management*, 5 (2), 108-119.
- Hasson, D., & Arnetz, B. B. (2005). Validation and findings comparing VAS vs. Likert scales for psychosocial measurements. *International Electronic Journal of Health Education*, 8, 178-192.
- Haycock, C. E., Shierman, G., & Gillette, J. (1978). The Female Athlete: Does Her Anatomy Pose Problems? *Proceedings of the 19th American Medical Association Conference on the Medical Aspects of Sport*. (pp. 1-8) . Monroe, WI: AMA Press,
- Heil, J. (1993). *Psychology of Sport Injury*. Champaign, USA: Human Kinetics.
- Hindle, W. H. (1991). The Breast and Exercise. In R. W. Hale (Ed.), *Caring for the Exercising Woman* (pp. 83-92). New York, USA: Elsevier.
- Hinkin, T. R. (1995). A review of scale development practices in the study of organizations. *Journal of Management*, 21 (5), 967-988.

- Hinton, P., Brownlow, C., McMurray, I., & Cozens, B. (2004). *SPSS Explained*. Sussex, UK: Routledge.
- Hopkins, W. G. (2000). Measures of reliability in sports medicine and science. *Sports Medicine*, 30 (1), 1-15.
- Hsia, H., & Thomson, J. G. (2003). Differences in breast shape preferences between plastic surgeons and patients seeking breast augmentation. *Plastic and Reconstructive surgery*, 112 (1), 312-320.
- Hsieh, C., & Trichopoulos, D. (1991). Breast size, handedness and breast cancer risk. *European Journal of Cancer*, 27 (2), 131-135.
- Hurd, T., & McIntyre, A. (1996). The seduction of sameness: Similarity and representing the other. *Feminism and Psychology*, 6 (1), 86-91.
- Jacobs, K. (2008). *Ergonomics for therapists*. Philadelphia, USA: Elsevier.
- Jamieson, S. (2004). Likert scales: how to (ab)use them. *Medical Education*, 38 (12), 1212-1218.
- Jones, G., & Hanton, S., & Connaughton, D. (2002). What is this thing called mental toughness? An investigation of elite sports performers. *Journal of Applied Psychology*, 14 (3), 205-218.
- Katch, L., Campaigne, B., Freedson, P., Sady, S., Katch, F., & Behnke, A. (1980). Contribution of breast volume and weight to body fat distribution in females. *American Journal of Physical Anthropology*, 53 (1), 93-100.
- Keleher, H., & Verrinder, G. (2003). Health diaries in a rural Australian study. *Qualitative Health Research*, 13 (3), 435-443.
- Khan, S., & Apkarian, v. (2002). The characteristics of cyclical and non-cyclical mastalgia: a prospective study using a modified McGill Pain Questionnaire. *Breast Cancer Research and Treatment*, 75 (2), 147-157.
- Kim, J., Hong, K., & Scheurell, D. (2004). Applying QFD for the development of sensible brassieres for middle aged women. *Journal of the Korean Society of Clothing and Textiles*, 28 (12), 1596-1604.
- Kim, M., Reece, G., Beahm, E., Miller, M., Atkinson, E., & Markey, M. (2007). Objective assessment of aesthetic outcomes of breast cancer treatment: measuring ptosis from clinical photographs. *Computers in Biology and Medicine*, 37, (1), 49-59.
- Kite, M., & Wagner, L. (2002). Attitudes towards older adults. In T. Nelson (Ed.), *Ageism: Stereotyping and Prejudice Against Older Persons* (pp. 129-160). Cambridge, Massachusetts: MIT Press.

- Kleinberg, K. (2007). Variation in proportion indices and angles between selected facial landmarks with rotation in the Frankfort plane. *Medicine, Science and the Law*, 47 (2), 107-116.
- Krenzer, G., Starr, C., & Branson, D. (2005). Development of a sports bra prototype: patternworks international best solution to a patternmaking problem 2000. *Clothing and Textile Research Journal*, 23 (2), 131.
- Krippendorff, K. (1980). *Content analysis. An introduction to its methodology*. London, UK: Sage Publications.
- Krouskop, T. A., Wheeler, T. M., Kallel, F., Garra, B. S., & Hall, T. (1998). Elastic moduli of breast and prostate tissues under compression. *Ultrasonic Imaging*, 20 (4), 260-274.
- Krueger, R. (1998). *Developing questions for focus groups. Focus groups kit 3*. London, UK: SAGE Publications Incorporated.
- Laerhoven, H. v., Zaag-Loonen, H. J. V. d., & Derkx, B. H. F. (2004). A comparison of Likert scale and visual analogue scales as response options in children's questionnaires. *Acta Paediatrica*, 93 (6), 830-835.
- Larroy, C. (2002). Comparing visual-analogue and numeric scales for assessing menstrual pain. *Behavioral Medicine*, 27 (4), 179-181.
- Lawson, L., & Lorentzen, D. (1990). Selected sports bras: comparisons of comfort and support. *Clothing and Textiles Research Journal*, 8 (4), 55-60.
- Lee, H., & Hong, K. (2007). Optimal brassiere wire based on the 3D anthropometric measurements of under breast curve. *Applied Ergonomics*, 38 (3), 377-384.
- Lee, Y., Hyun, K., & Tokura, H. (2000). The Effects of Skin Pressure by Clothing on Circadian Rhythms of Core Temperature and Salivary Melatonin. *Chronobiology International*, 7 (6), 783-793.
- Legg, L., Drummond, A., & Langhorne, P. (2009). Occupational therapy for patients with problems in activities of daily living after stroke. *Cochrane Database of Systematic Reviews 2006* (4), CD003585.
- Ley, C., Lees, B., & Stevenson, J. (1992). Sex- and menopause- associated changes in body-fat distribution. *The American Journal of Clinical Nutrition*, 55 (5), 950-954.
- Liang, X. (2008). *An investigation into the pressures and sensations caused by wearing a bra and the influence of these on bra fitting*. (Unpublished doctoral dissertation). De Montfort University, UK.

- Liao, C. & Lee, C. (2010). The application of codesign in new bra product innovations. *International Journal of Clothing Science and Technology*, 22 (2/3), 211-227.
- Litwin, M. (1995). *How to measure survey reliability & validity*. London, UK: SAGE Publications Incorporated.
- Liu, C., & Arnett, K. (2000). Exploring the factors associated with web site success in the context of electronic commerce. *Information and Management*, 38 (1), 23-33.
- Lorentzen, D., & Lawson, L. (1987). Selected sports bras: a biomechanical analysis of breast motion while jogging. *The Physician and Sports Medicine*, 15 (5), 128-139.
- Lotiasselik, L. (2003). *Using focus groups in research*. London, UK: Continuum International Publishing Group.
- Love, S. (2000). *Dr Susan Love's Breast Book*. Cambridge, UK: Perseus Publishing.
- Mackinnon, S. (1999). Relating heart rate and rating of perceived exertion in two simulated occupational tasks. *Ergonomics*, 42 (5), 761-766.
- Malhotra, N., & Birks, D. (2003). *Marketing research, an applied approach*. London, UK: Pearson Education Limited.
- Marks and Spencer (2009). Marks and Spencer annual report 2009. Retrieved from <http://corporate.marksandspencer.com/page.aspx?pointerid=ad6248969dcf4934b8c4a57934935baf> on 5th June, 2010.
- Mason, B., Page, K., & Fallon, K. (1999). An analysis of movement and discomfort of the female breast during exercise and the effects of breast support in three cases. *Journal of Science and Medicine in Sport*, 2 (2), 134-144.
- May-Plumlee, & Little. (2001). Consumer purchase data as a strategic product development tool. *Journal of Textile and Apparel, Technology and Management*, 1 (3), 1-10.
- McGhee, D., & Steele, J. (2006). How do respiratory state and measurement method affect bra size calculations? *British Journal of Sports Medicine*, 40 (12), 970-974.
- McGhee, D., & Steele, J. (2010). Optimising breast support in female patients through correct bra fit. A cross-sectional study. *Journal of Science and Medicine in Sport*, 16 (6), 568-572.

- McGhee, D., Steele, J., & Munro, B. (2010). Education improves bra knowledge and fit, and level of breast support in adolescent female athletes: a cluster-randomised trial. *Journal of Physiotherapy*, 56 (1), 19-24.
- McGhee, D., Steele, J., & Power, B. (2007). Does deep water running reduce exercise induced breast discomfort? *British Journal of Sports Medicine*, 41 (12), 879-883.
- McKinlay, S., Jefferys, M., & Thompson, B. (1972). An investigation of the age at menopause. *Journal of Biosocial Science*, 4 (2), 161-173.
- McLaren, L., & Kuh, D. (2004). Body dissatisfaction in midlife women. *Journal of Women and Aging*, 16 (1-2), 35-54.
- Mellalieu, S. D., Neil, R., Hanton, S., & Fletcher, D. (2009). Competition stress in sport performers: stressors experienced in the competition environment. *Journal of Sports Sciences*, 27 (7), 729-744.
- Melzack, R. (1975). The McGill Pain Questionnaire: major properties and scoring methods. *Pain*, 1 (3), 277-299.
- Mentz, H., Ruiz-Razura, A., & Miniell, L. (2007). Correction of the bra strap shoulder groove deformity in women. *Plastic and Reconstructive Surgery*, 120 (7), 2122-2123.
- Milligan, C., Bingley, A., & Gatrell, A. (2005). Digging Deep: using diary techniques to explore the place of health and well-being amongst older people. *Social Science and Medicine*, 61 (9), 1882-1892.
- Milligan, D., Drife, J., & Short, R. (1975). Changes in breast volume during normal menstrual cycle and after oral contraceptives. *British Medical Journal*, 4 (5995), 494-496.
- Miyatsuji, A., Matsumoto, T., Mitarai, S., Kotabe, T., Takeshima, T., & Watanuki, S. (2002). Effect of clothing pressure caused by different types of brassieres on autonomic nervous system activity evaluated by heart rate variability power spectral analysis. *Journal of Physiological Anthropology and Applied Human Sciences*, 21 (1), 67-74.
- Moody, W., Kinderman, P., & Sinha, P. (2010). An exploratory study. Relationship between trying on clothing, mood, emotion, personality and clothing preference. *Journal of Fashion Marketing and Management*, 14 (1), 161-179.
- Moody, W., Morgan, R., Dillon, P., Baber, C., & Wing, A. (2001). Factors underlying fabric perception. In C. Baber, M. Faint, S. Wall, & A. Wing

- (Eds.), *Proceedings of the Conference on Eurohaptics*, Birmingham, UK, (192–201).
- Morgan, D. L., & Spanish, M. T. (1984). Focus groups: a new tool for qualitative research. *Qualitative Sociology*, 7 (3), 253-270.
- Moutinho, L., & Evans, M. (1992). *Applied marketing research*. Wokingham, England: Addison-Wesley Publishers Limited.
- Murtagh, E., Boreham, C., & Murphy, M. (2002). Speed and exercise intensity of recreational walkers. *Preventive Medicine*, 35 (4), 397-400.
- National Health Service. (2008). Menopause Treatment. Retrieved from <http://www.nhs.uk/Conditions/Menopause/Pages/Treatment.aspx> on 29th October 2009.
- Noyes, F., & Gross, E. (1976). The strength of the anterior cruciate ligament in humans and Rhesus monkeys. *Journal of Bone and Joint Surgery*, 58 (8), 1074-1082.
- Oberg, P., & Tornstam, L. (1999). Body images among men and women of different ages. *Ageing and Society*, 19 (5), 629-644.
- Paek, S. (1983). Consumer Preference for Skin Contact Wear Fabrics. *Textile Research Journal*, 53 (4), 264-265.
- Page, k., & Steele, J. R. (1999). Breast motion and sports brassiere design, implications for future research. *Sports Medicine*, 27 (4), 205-211.
- Pallant, J. (2005). *SPSS survival manual*. New York, USA: McGraw-Hill.
- Patton, M. (2002). *Qualitative research and evaluation methods (third edition)*. California, USA: SAGE Publication Incorporated.
- Paulson, S., & Willig, C. (2008). Older women and everyday talk about the ageing body. *Journal of Health Psychology*, 13 (1), 106-120.
- Pechter, E. (2008). An improved technique for determining bra size with applicability to breast surgery. *Plastic and Reconstructive Surgery*, 121 (5), 348-350.
- Pisacane, A., & Continisio, P. (2004). Breastfeeding and perceived changes in the appearance of the breasts: a retrospective study. *Acta Paediatrica*, 93 (10), 1346-1348.
- Prior, J. (1998). Perimenopause: the complex endocrinology of the menopause transition. *Endocrine Reviews*, 19 (4), 397-428.
- Proctor, T. (2003). *Essentials of marketing research (third edition)*. London, UK: Pearson Education Limited.

- Qiao, Q., Zhou, G. & Ling, Y. (1997). Breast volume measurement in young Chinese women and clinical application. *Aesthetic Plastic Surgery*, 21 (5), 362-368.
- Queniart, A., & Charpentier, M. (2012). Older women and their representations of old age: a qualitative analysis. *Ageing and Society*, 32 (6), 983-1007.
- Reel, J., Soohoo, S., Summerhays, F., & Gill, D. (2008). Age before beauty: an exploration of body image. *Journal of Gender Studies*, 17 (4), 321-330.
- Richards, E., & Sturman, S. (1977). Life-style segmentation in apparel marketing. *The Journal of Marketing*, 41 (4), 89-91.
- Riggio, E., Quattrone, P., & Nava, M. (2000). Anatomical study of the breast superficial fascial system: the inframammary fold unit. *European Journal of Plastic Surgery*, 23 (6), 310-315.
- Rinker, B., Veneracion, M., & Walsh, C. (2008). The effect of breast feeding on breast aesthetics. *Aesthetic Surgery Journal*, 28 (5), 534-537.
- Risius, D., Milligan, A., Ayres, B., & Scurr, J. (2011). An investigation of the relationship between breast kinematics and subjective ratings of breast support during treadmill activity. In M. Sellens, G. Sandercock, M. Taylor, & D. Mickelwright (eds.), *Proceedings of the BASES Annual Conference (pp. S51). September 2011, Essex, UK.*
- Roberts, H. (1981). *Doing Feminist Research*. London, UK: Routledge & Kegan Paul.
- Robinson, M., & Wise, E. (2004). Prior pain experience: influence on the observation of experimental pain in men and women. *The Journal of Pain*, 5 (5), 264-269.
- Roe, M. (2004). *Market research in action*. London, UK: Thomson Learning.
- Roelants, F., Rizzo, M., & Lavand'homme, P. (2003). The effect of epidural neostigmine combined with ropivacaine and sufentanil on neuraxial analgesia during labor. *Anaesthesia and Analgesia*, 96 (4), 1161-1166.
- Rosen, M. (1973). *Popcorn Venus*. New York, USA: Avon Publishing.
- Rosen, P. (2001). *Rosen's Breast Pathology (second edition)*. Philadelphia, USA: Lippincott Williams & Wilkins.
- Rosenthal, J. (1996). Qualitative descriptors of strength of association and effect size. *Journal of Social Service Research*, 21 (4), 37-59.

- Ross, J., & Harradine, R. (2010). Value brands: cheap or trendy? An investigation into young consumers and supermarket clothing. *Journal of Fashion Marketing and Management*, 14 (3), 350-366.
- Russo, J., & Russo, I. (1996). Role of hormones in human breast development: the menopausal breast. *Maturitas*, 27 (1), 5-5.
- Ryan, E. (1984). Breast weight and industrial fatigue. *The Medical Journal of Australia*, 147 (5), 261.
- Ryan, E. (2000). Pectoral girdle myalgia in women: a 5 year study in a clinical setting. *Clinical Journal of Pain*, 16 (4), 298-303.
- Scurr, J., Galbraith, H., Hedger, W., & White, C. (2007). A procedure for the analysis of three-dimensional breast displacement during treadmill exercise. 12th Annual Congress of the ECSS, 11-14th July 2007, Jyvaskyla, Finland.
- Scurr, J., White, J., & Hedger, W. (2009). Breast displacement in three dimensions during the walking and running gait cycles. *Journal of Applied Biomechanics*, 25 (4), 322-329.
- Scurr, J., White, J., & Hedger, W. (2010). The effect of breast support on the kinematics of the breast during the running gait cycle. *Journal of sports sciences*, 28 (10), 1103-1109.
- Scurr, J., White, J., & Hedger, W. (2011). Supported and unsupported breast displacement in three dimensions across treadmill activity levels. *Journal of Sports Sciences*, 29 (1), 55-61.
- Serlin, R., Mendoza, T., Nakamura, Y., Edwards, K., & Cleeland, C. (1995). When is cancer pain mild, moderate or severe? Grading pain severity by its interference with function. *Pain*, 61 (2), 277-284.
- Shangold, M., & Murkin, G. (1985). *The complete sports medicine book for women*. New York, USA: Simon and Schuster.
- Shiffman, S., Hufford, M., & Paty, J. (2001). Subject experience diaries in clinical research, part 1. the patient experience movement. *Applied Clinical Trials*, 10 (2), 46-56.
- Shrout, P. & Fleiss, J. (1979). Intraclass correlations: uses in assessing rater reliability. *Psychological Bulletin*, 86 (2), 420-428.
- Silverman, D. (2004). *Qualitative research theory, method and practice*. London, UK: SAGE Publications Incorporated.

- Singer, S. R., & Grismaijer, S. (2006). *Dressed to kill the link between breast cancer and bras*. New York, USA: Avery Publishing Group.
- Smith, D., Palin, W., Katch, V., & Bennett, J. (1986). Breast volume and anthropomorphic measurements: normal values. *Plastic and Reconstructive Surgery*, 78 (3), 331-335.
- Smith, S.D. & Smith, J.A. (2006). Head and helmet biodynamics and tracking performance in vibration environments. *Aviation, Space and Environmental Medicine*, 77 (4), 388-397.
- Starr, C., Branson, D., Shehab, R., Farr, C., Ownbey, S., & Swinney, J. (2005). Biomechanical Analysis of a Prototype sports Bra. *Journal of Textile and Apparel, Technology and Management*, 4 (3), 1-14.
- Stone, A., Shiffman, S., Schwartz, J., Broderick, J., & Hufford, M. (2002). Patient non-compliance with paper diaries. *British Medical Journal*, 324 (7347), 1193-1194.
- Stuempfle, K., Drury, D. & Wilson, A. (2004). Effect of load position on physiological and perceptual responses during load carriage with an internal frame backpack. *Ergonomics*, 47 (7), 784 – 789
- Sudman, S., & Ferber, R. (1971). Experiments in obtaining consumer expenditure by diary methods. *Journal of the American Statistical Association*, 66 (336), 725-735.
- Sukumar, S. (2007). The bra and the Indian woman's notion of sexuality. *Journal of Creative Communications*, 2 (3), 267-278.
- Swan, J., & Combs, L. Product performance and consumer satisfaction: a new concept. *Journal of Marketing*, 40 (2), 52-33
- Swanson, E. (2008). Changes in breast shape after cosmetic surgery – a photometric study of 147 patients. *Plastic and Reconstructive Surgery*, 122 (4S), 25-26.
- Szmigin, I., & Carrigan, M. (2001). Learning to love the older consumer. *Journal of Consumer Behaviour*, 1 (1), 22-34.
- Tanis, P. J., Nieweg, O. E., Olmos, R. A., & Kroon, B. R. (2001). Anatomy and physiology of lymphatic drainage of the breast from the perspective of sentinel node biopsy11No competing interests declared. *American College of Surgeons*, 192 (3), 399-409.
- Thelwell, R., Weston, N., Greenlees, I., & Hutchings, N. (2008). Stressors in elite sport: a coach perspective. *Journal of Sports Sciences*, 26 (9), 905-918.

- Thorne, S. (2000). Data analysis in qualitative research. *Evidence Based Nursing*, 3(3), 68-70.
- Tonkelaar, I., Peeters, P., & Noord, P. (2004). Increase in breast size after menopause: prevalence and determinants. *Maturitas*, 48 (1), 51-57.
- Thompson, M.A. & Gray, J.J. (1995). Development and validation of a new body-image assessment scale. *Journal of Personality assessment*, 64 (2), 258-269.
- Twigg, J. (2007). Clothing, age and the body: a critical review. *Ageing and Society*, 27 (2), 285-305.
- Twigg, J. (2012). Adjusting the cut: fashion, the body and age on the UK high street. *Ageing and Society*, 32 (6), 1030-1054.
- Utian, W. (2002). Weight, Menopause and Hormones. *Menopause Management Journal*, 11 (6), 7-8.
- Utian, W. (2009). Skin: Impact of Menopause, Aging and Hormones. *Menopause Management Journal*, 18 (3), 11-25.
- Vink, P., & Hallbeck, S. (2012). Editorial: comfort and discomfort studies demonstrate the need for a new model. *Applied Ergonomics*, 43 (2), 271-276.
- Wacherbarth, S. B., Streams, M. E., Smith, M. K. (2002). Capturing the insights of family caregivers: survey item generation with a couples interview/focus group process. *Qualitative Health Research*, 12 (8), 1141-1154.
- Weideger, P. (1978). *Female cycles*. London, UK: Women's Press.
- Weir, J. P. (2005). Quantifying test-retest reliability using the intraclass correlation coefficient and the SEM. *Journal of Strength and Conditioning Research*, 19 (1), 231-240.
- Westreich, M. (1997). Anthropomorphic breast measurement: protocol and results in 50 women with aesthetically perfect breasts and clinical application. *Plastic and Reconstructive Surgery*, 100 (2), 468-479.
- White, J., Scurr, J., & Smith, N. (2009). The effect of breast support on kinetics during over-ground running performance. *Ergonomics*, 52 (4), 492-498.
- White, J., Scurr, J., & Hedger, W. (2011). A comparison of three-dimensional breast displacement and breast comfort during over ground and treadmill running. *Journal of Applied Biomechanics*, 27 (1), 47-53.
- White, J., & Scurr, J. (2012). Evaluation of professional bra fitting criteria for bra selection and fitting in the UK. *Ergonomics*, 55 (6), 704-711

- Williams, C., & Wragg, C. (2004). *Data analysis and research for sport and exercise science: a student guide*. New York, USA: Routledge.
- Wing, R., Matthews, K., Kuller, L., Meilahn, E., & Plantinga, P. (1991). Weight gain at the time of menopause. *Archive of Internal Medicine*, 151 (1), 97-102.
- Winslow, E. & Jacobson, A. (1997). Urinary incontinence: which pad is best? *American Journal of Nursing*, 97 (12), 21-21.
- Winter, D. (1990). *Biomechanics and motor control of human movement (second edition)*. Waterloo, Canada: John Wiley & Sons, Incorporated.
- Winterich, J., & Umberson, D. (1999). How women experience menopause: the importance of social context. *Women and Aging Journal*, 11 (4), 57-73.
- Wisbey, J., Kumar, S., Mansel, R., Peece, P., Pye, J., & Hughes, L. (1983). Natural history of breast pain. *Lancet*, 17 (2), 672-674.
- Wood, K., Cameron, M., & Fitzgerald, K. (2008). Breast size, bra fit and thoracic pain in young women: a correlation study. *Chiropractic and Osteopathy*, 16 (1), 1-7.
- Wood, L., White, J., Milligan, A., Ayres, B., Hedger, W., & Scurr, J. (2012). Predictors of three-dimensional breast kinematics during bare-breasted running. *Medicine and Science in Sports and Exercise*, 44 (7), 1351-1357.
- Wren, B. G. (1996). The breast and the menopause. *Balliere's Clinical Obstetrics and Gynaecology*, 10 (3), 433-447.
- Wright, R., & Stein, M. (2005). Snowball Sampling. In K. Kempf-Leonard (Ed.), *Encyclopaedia of Social Measurement* (pp. 495-500). Cambridge, Massachusetts: Elsevier Academic Press.
- Yip, J., Law, D., & Wong, Z. (2007). *An investigation of intimate apparel buying behavior among fashion conscious and non-fashion conscious Chinese Hong Kong female consumers*. Presented at the 2007 Annual Research Meeting, Feng Chia University.
- Yoo, S., & Barker, R. (2005). Comfort properties of heat resistant protective work wear in varying conditions of physical activity and environment. Part II: perceived comfort response to garments and its relationship to fabric properties. *Textile Research Journal*, 75 (7), 531-541.
- Yu, X., Wang, K., He, J., & Zhang, W. (2011). Factorial Analysis on breast lifted and gathered effects caused by bra straps. *Advanced Materials Research*, 332-334, 1451-1456.

- Zhou, J., Yu, W., & Ng, S. (2011). Methods of studying breast motion in sports bras: a review. *Textile Research Journal*, 81 (912), 1234-1248.
- Zhou, J. (2011). *New methods of evaluating breast motion in braless and sports bra conditions*. Unpublished doctoral dissertation, The Hong Kong Polytechnic University, Hong Kong.
- Zhou, J., Yu, W., Ng, S., & Hale, J. (2009). Evaluation of shock absorbing performance of sports bras. *Journal of Fibre Bioengineering and Informatics*, 2 (2), 108-113.

Appendix A: Semi-structured focus group and interview guide

Focus Group Structure

Intro:

- Introduce myself, about research group in breast health, about this study
- You've all been asked here because.... Shouldn't take more than 120 minutes
- Explain – use of data, confidentiality, participants right to withdraw, reason for audio taping
- State- no right or wrong answers
- Ask them to briefly introduce themselves, name, where from etc.
- Please try not to talk over each other

Sign consent forms and fill out questionnaires

Begin Recording

- Individual: Define a 'good' bra?
- Individual: Tell me about your favourite bra, why is it your favourite?
- Things that make a good bra, e.g. good fit, supportiveness etc, aesthetics – ask to define each thing
- Discuss each item – why is this important?
- Can you think of any factors that would mean you definitely would NOT buy the bra?
- In terms of current bras out there on the market, in what way do you feel they fulfil your needs? Or don't?
- In terms of what you want and need from a bra, how do you feel this has changed as you've aged?
- Refer to the poster identifying further bra factors that may be important. Ask women to comment and define any factors they focus on.

End – After this discussion, please define a good bra again.

Summarise then ask - Is this an adequate summary?
Anything you'd like to add before we leave?

Appendix B: Chapter four survey

Breast Health,
Department of Sport and Exercise Science,
Spinnaker Building,
Tel: 02392 845161
www.port.ac.uk/breastresearch
email: breastresearch@port.ac.uk



Portsmouth University has a well established research group working specifically on breast health and bra needs of women of all ages. If you would like further information on our research you can visit the Portsmouth University website on www.port.ac.uk/breastresearch. We are interested in your views on how your bra needs have changed since age 45. Please only complete this questionnaire if you are between the ages 45 and 65 years old. This questionnaire should take no longer than ten minutes to complete. If you have any queries about this questionnaire please do not hesitate to contact Debbie Risius on 02392 843085 or write to breastresearch@port.ac.uk.

CONSENT TO PARTICIPATE IN THIS STUDY

By completing this questionnaire you are giving consent for the information you provide on this form to be included in a study on breast health in the UK. Your participation is voluntary and is specific to this study, and shall not be taken to imply consent to participate in any subsequent experiment or deviation from that detailed. You may withdraw from this experiment at any time and you do not have to give a reason. All personal details will remain anonymous and you will be referred to as ‘the participant’ in all documentation.

To qualify to participate in this study you must fulfil the following criteria:

1. Female
2. No surgical procedures to the breast/s
3. Not currently undergoing any clinical breast treatment
4. UK resident
5. Over the age of 45 years and under the age of 65 years.

Once you have completed this questionnaire please return it in the pre-aid envelope provided.

If you would be happy for us to contact you regarding future studies undertaken by the Research Group in Breast Health please provide your details below.

Name:

Contact Number:

Section A – Personal Information

1. Age:
2. Weight:
3. Bra Size
4. Country of residence:
5. What is your menopausal status?
 (Please note, if your last period was over 12 months ago you are ‘post-menopause’)
 Pre-menopause
 Mid-menopause
 Post-menopause
6. How many pregnancies have you had?
7. Did you breast feed any of your children? (please tick one box)
 Yes
 No
 Not Applicable
8. On average, how long did you breast feed your child/children?
 (Please tick one box)
 Up to 3 months
 Up to 6 months
 Up to 1 year
 Over 1 year
 Not applicable

9. How would you describe your present level of activity? (Please tick one box)

- Sedentary
 Moderately active
 Active
 Highly Active

10. Do you experience breast pain of any kind? (Please tick)

- Yes
 No

11. If you experience breast pain, what do you do to relieve the pain?

12. Are you taking hormone replacement therapy (HRT)?
 (Please tick)

- Yes
 No

Section B – Breast History

13. Out of all the physical changes you have experienced through ageing, how significant has the change to your breasts been?
 (Please circle)

Extremely					Not at all
	5	4	3	2	1

14. What is the most significant change in your breasts since the age of 45?

15. Since the age of 45, do you feel the size of your breasts has become: (Please tick a box)

- Larger
- Somewhat larger
- Smaller
- Somewhat smaller
- Same size

16. Since the age of 45, if you noticed a change in breast size, please state your size before and after this change:

Size Before _____ Size After _____

17. Since the age of 45, have your breasts become: (please tick a box)

- More sensitive/painful
- Less sensitive/painful
- Same sensitivity/painful

18. Please tick the statement that applies most to your breasts:

- a tool for seduction
- you are proud of them
- part of your femininity
- a functional tool
- you dislike them

19. To what extent do you agree with the statement 'I am happy about my age'? (Please circle)

Extremely					Not at all
	5	4	3	2	1

20. To what extent do you agree with the statement 'I do my best not to look my age'? (Please circle)

Extremely					Not at all
	5	4	3	2	1

Section C – Bra Habits

21. When were you last professionally measured for bra size?

(Please tick a box)

- Last 3 months
- Last 6 months
- Within the last year
- Over a year ago
- Can't remember
- I have never been fitted

22. How often do you buy a new bra?

(Please tick a box)

- Every 3 months
- Every 6 months
- Every year
- Less than once a year
- Less than once every 2 years

23. Where do you currently purchase your bras from? (Please list shops, including any online websites you have used)

24. What is the brand of bra that you wear most often? (Please tick one box)

- Marks and Spencer
- Debenhams
- Triumph
- Playtex
- Fantasie
- Berlei
- Other (Please specify).....

25. Which of the following brands have you worn in the past 6 months? (Please tick all that apply)

- Marks and Spencer
- Debenhams
- Triumph
- Playtex
- Fantasie
- Berlei
- Other (Please specify).....

26. Which of the following brands have you worn in the past 5 years? (Please tick all that apply)

- Marks & Spencer
- Debenhams
- Triumph
- Playtex
- Fantasie
- Berlei
- Other (Please specify).....

27. When shopping, do you have difficulty finding the bra size you need? (Please tick)

- Yes
- No

28. Please list all the colours of bras that you currently wear:

29. Are the majority of your bras under wired? (Please tick)

- Yes
- No

30. Are the majority of your bras padded? (Please tick)

- Yes
- No

31. Are the majority of your bras lacy? (Please tick)

- Yes
- No

32. Do you own a sports bra? (Please tick)

- Yes
- No

33. Do you own different 'evening bras' and 'day bras'? (Please tick)

- Yes
- No

34. Think of the bras you wore when you were in your 20s, would you wear them now? (Please tick)

- Yes
- No

35. Think of the bras you wear now, would you have worn them in your 20s? (Please tick)

- Yes
- No

36. Think of your favourite bra, please explain WHY this particular bra is your favourite:

- 37.** I want a bra to make me feel
 (Please tick all that apply):
- Ready to meet the day
 - Attractive
 - Secure
 - Self assured
 - Slimmer
 - Free to do what I want
 - Feminine
 - Better about my body

Section D – Your future bra requirements

- 38.** How important is the FIT of a bra to you? (Please circle)

Extremely					Not at all
	5	4	3	2	1

- 39.** If a bra did not fit properly, but was appropriate in every other way, would you purchase it? (Please tick)
- Yes
 - No

- 40.** How important is COMFORT in a bra? (Please circle)

Extremely					Not at all
	5	4	3	2	1

- 41.** If a bra was not comfortable, but was appropriate in every other way, would you purchase it? (Please tick)
- Yes
 - No

- 42.** How important is the FABRIC that the bra is made of? (Please circle)

Extremely					Not at all
	5	4	3	2	1

- 43.** If a bra was the wrong sort of fabric, but appropriate in every other way, would you purchase it? (Please tick a box)
- Yes
 - No

- 44.** How important is SUPPORT in a bra? (Please circle)

Extremely					Not at all
	5	4	3	2	1

- 45.** If a bra was not supportive, but was appropriate in every other way, would you purchase it? (Please tick a box)
- Yes
 - No

- 46.** Please select any activities you partake in when you feel breast support is most important: (Tick all that apply)

- Walking
- Brisk walking
- Jogging
- Going up stairs
- Going down stairs
- Doing housework
- Other (please specify).....

47. How important is breast LIFT in a bra? (Please circle)

Extremely					Not at all
5	4	3	2	1	

48. If a bra did not lift your breasts, but was appropriate in every other way, would you purchase it? (Please tick a box)

- Yes
 No

49. How important is the design of the shoulder STRAPS in a bra? (Please circle)

Extremely					Not at all
5	4	3	2	1	

50. If a bra had the wrong shoulder strap design, but was appropriate in every other way, would you purchase it? (Please tick a box)

- Yes
 No

51. Please describe an appropriate shoulder strap design for a bra?

52. How important is it that a bra stays in place all day long? (Please circle)

Extremely					Not at all
5	4	3	2	1	

53. How important is COLOUR in a bra? (Please circle)

Extremely					Not at all
5	4	3	2	1	

54. If a bra was the wrong colour, but was appropriate in every other way, would you purchase it? (Please tick a box)

- Yes
 No

55. Please select an appropriate breast SHAPE created by a bra?

- Round
 Pointy
 Tear drop
 Flat
 Other (please specify).....

56. How important is the breast SHAPE created when wearing a bra? (Please circle)

Extremely					Not at all
5	4	3	2	1	

57. If a bra did not create the breast shape you wanted, but was appropriate in every other way, would you purchase it? (Please tick a box)

- Yes
 No

58. How important is it to you that a bra creates a nice silhouette?
 (Please circle)

Extremely 4 3 2 1 Not at all

59. How important is the way your bra looks underneath your clothes?

Extremely 4 3 2 1 Not at all

60. If a bra did not look right underneath your clothes, but was appropriate in every other way, would you purchase it? (Please tick)

- Yes
 No

61. How important is bra brand to you? (Please circle)

Extremely 4 3 2 1 Not at all

62. If a bra was made by a brand that you disliked, but was appropriate in every other way, would you purchase it? (Please tick a box)

- Yes
 No

63. How important is matching underwear with a bra? (Please circle)

Extremely 4 3 2 1 Not at all

64. If a bra did not have the option to buy matching underwear, but was appropriate in every other way, would you purchase it? (Please tick a box)

- Yes
 No

65. How important is price in your decision to buy a bra? (Please circle)

Extremely 4 3 2 1 Not at all

66. What is the average amount you would expect to spend on a bra?

67. What is the maximum amount you would spend on a bra?

68. How well do you feel the current bras on the market fulfil your needs? (Please circle)

Extremely 4 3 2 1 Not at all

69. If you do not feel the current bras on the market fulfil your needs, please explain why:

70. Please rank these bra features in order of importance to you (1=most important, 10=least important)

- Comfort
- Colour
- Brand/make
- Support
- Shape
- Fit
- Good Straps
- Appearance under Clothes
- Fabric
- Price
- Attractiveness
- Lift

Is there anything else you would like to tell us about yourself, your breasts or your bra needs?

Any additional comments or feedback:

**END OF QUESTIONS
THANK YOU FOR YOUR PARTICIPATION**

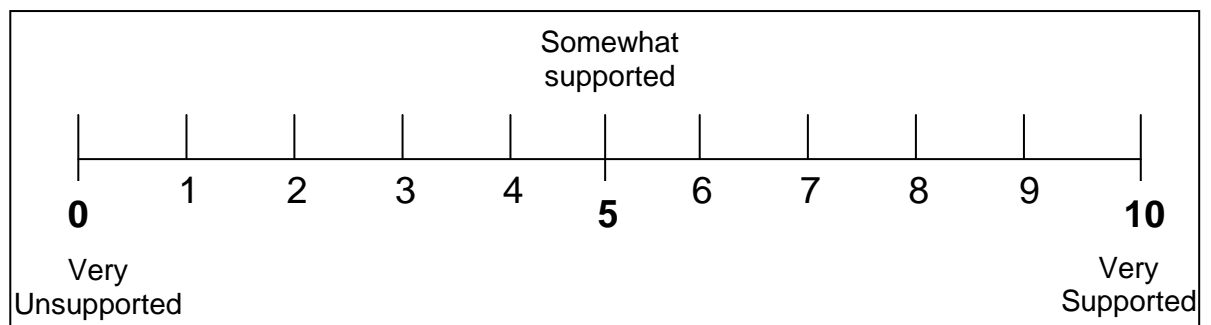
Please return this questionnaire in the pre-paid envelope provided

**Appendix C: Questionnaire used during laboratory testing
in the bare breasted condition**

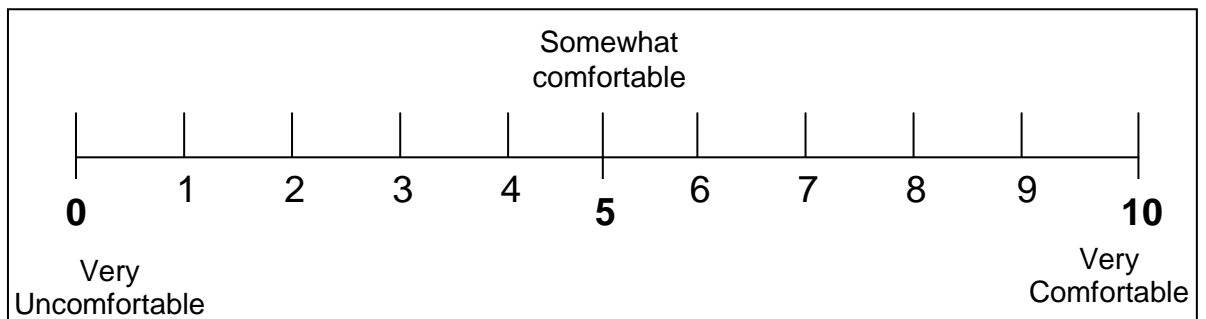
**Questionnaire
Bare Breasted**

Participant: _____

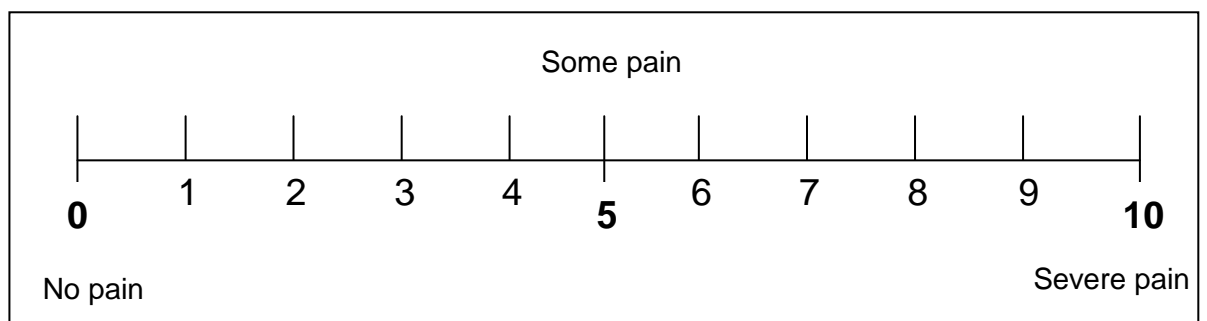
- 1) How **supported** did your breasts feel when you were completing the trial? (*Please circle*)



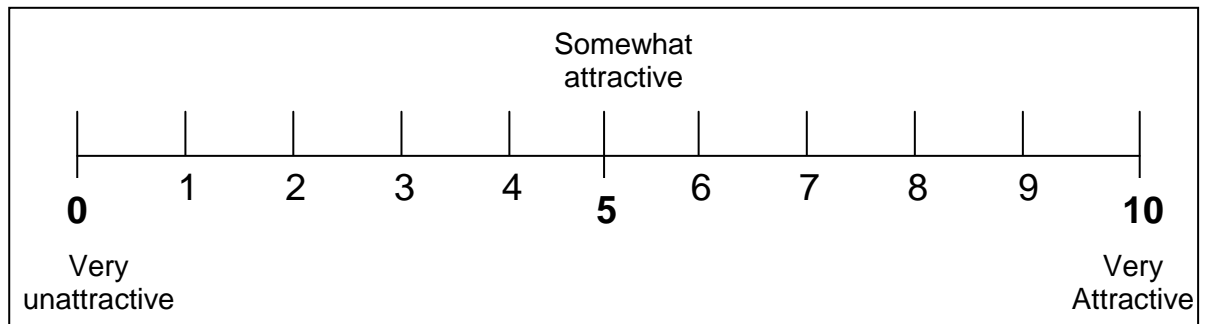
- 2) How **comfortable** were you when completing the trial? (*Please circle*)



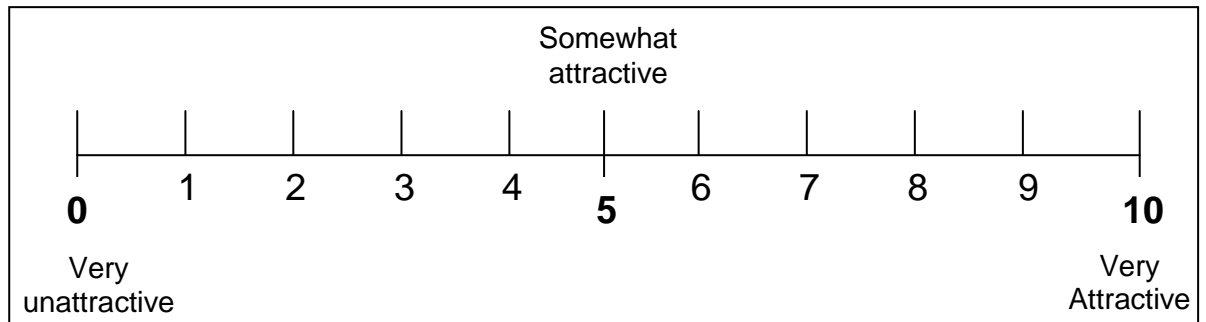
- 3) Please rate the level of breast **pain** experienced (if any) during your trial (*Please circle*)



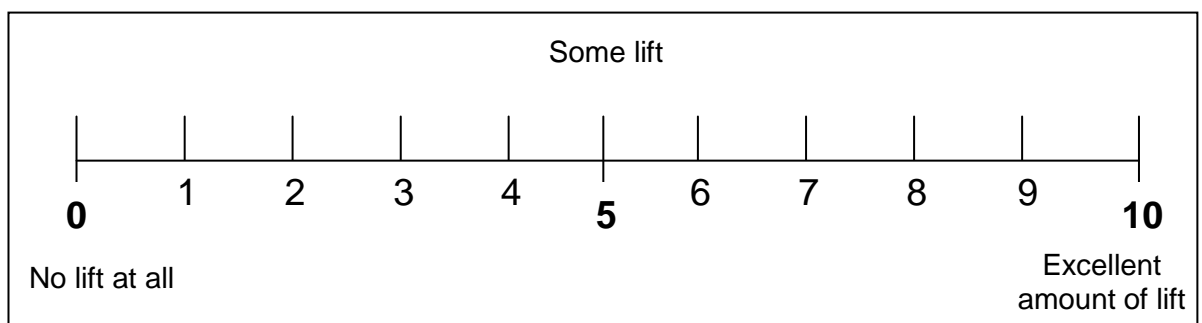
4) What did you think of your breasts appearance underneath your top? *(Please circle)*



5) What do you think of your breasts shape when not wearing a bra? *(Please circle)*



6) Please rate the level of breast lift you feel you have when bare breasted. *(Please circle)*



7) When bare breasted, how attractive do you think the silhouette of your upper torso is? *(Please circle)*

Somewhat attractive										
0	1	2	3	4	5	6	7	8	9	10
Very Unattractive						Very Attractive				

8) Would you ever go bare breasted during the day? (Please tick)

 Yes No

9) Please explain your main reasons for wearing a bra?

10) Please add any further comments

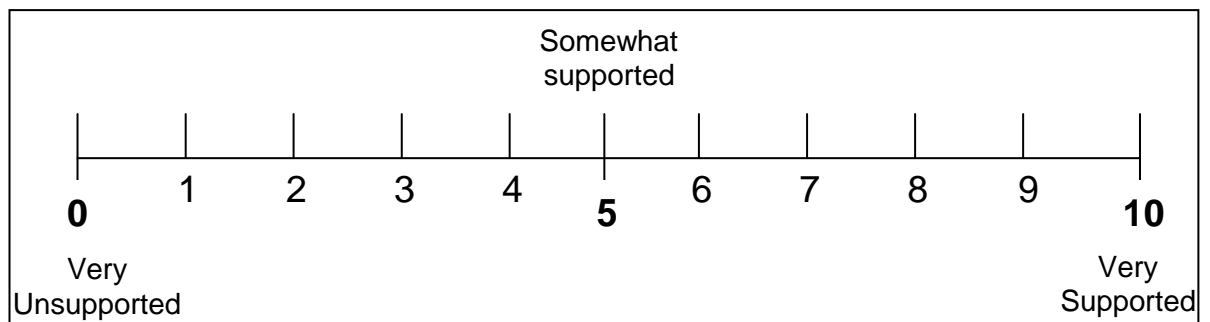
**Appendix D: Questionnaire used during laboratory testing
in a bra condition**

Questionnaire

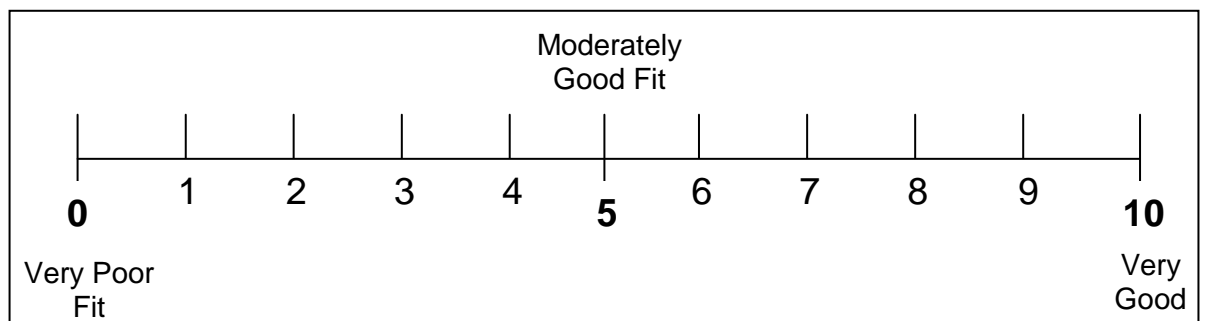
Bra:

Name of Participant: _____

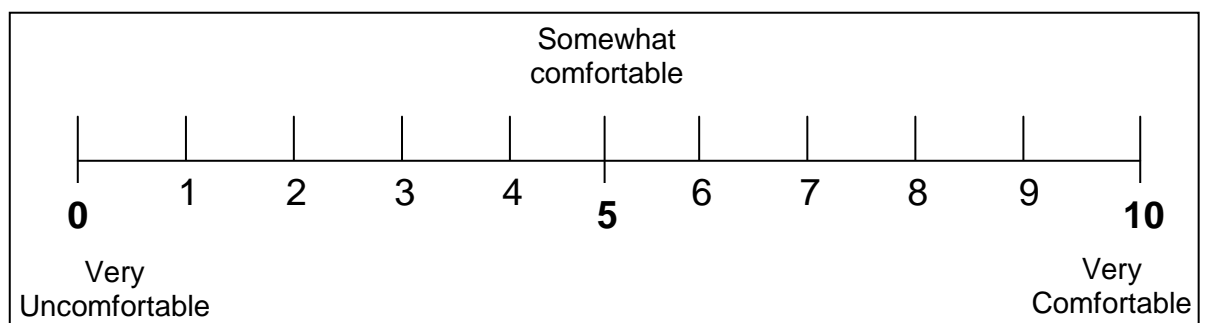
- 1) How **supportive** did the bra feel when you were completing the trial? (*Please circle*)



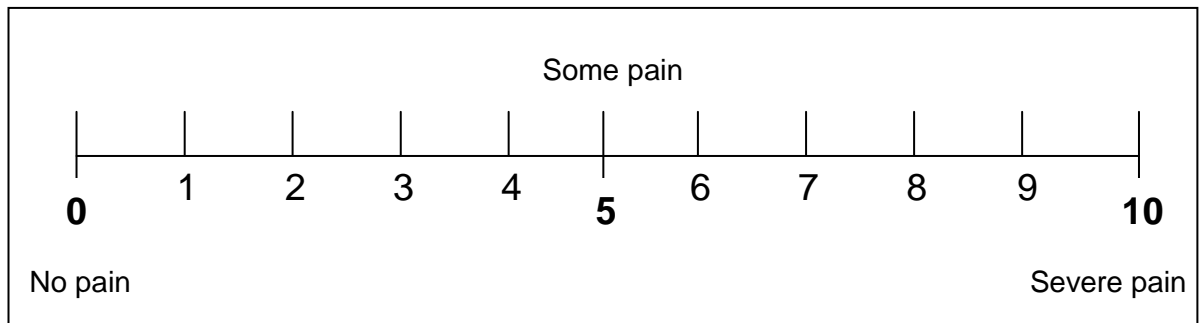
- 2) What was the **fit** of the bra like? (*Please circle*)



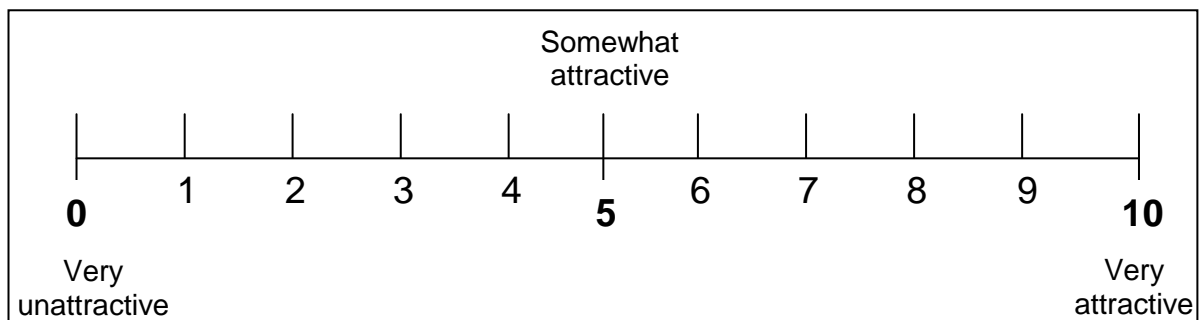
- 3) How **comfortable** were you when completing the trial? (*Please circle*)



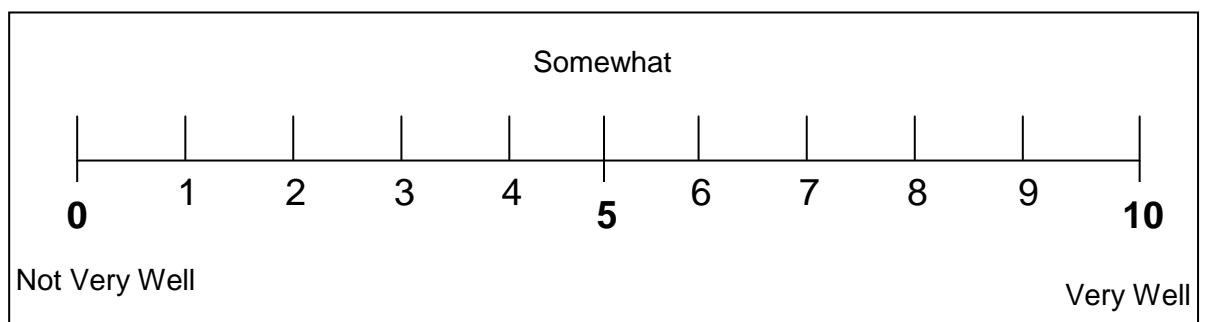
- 4) Please rate the level of breast **pain** experienced (if any) during your trial (*Please circle*)



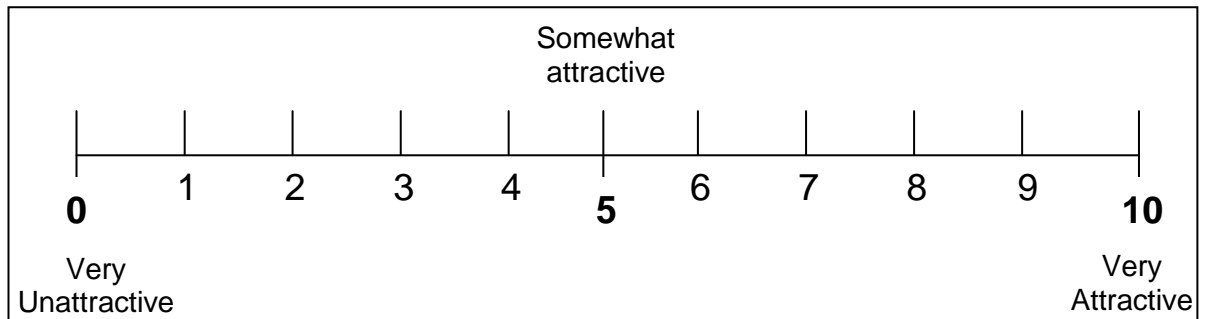
- 5) What did you think of your breasts appearance **underneath your top** when wearing the bra? (*Please circle*)



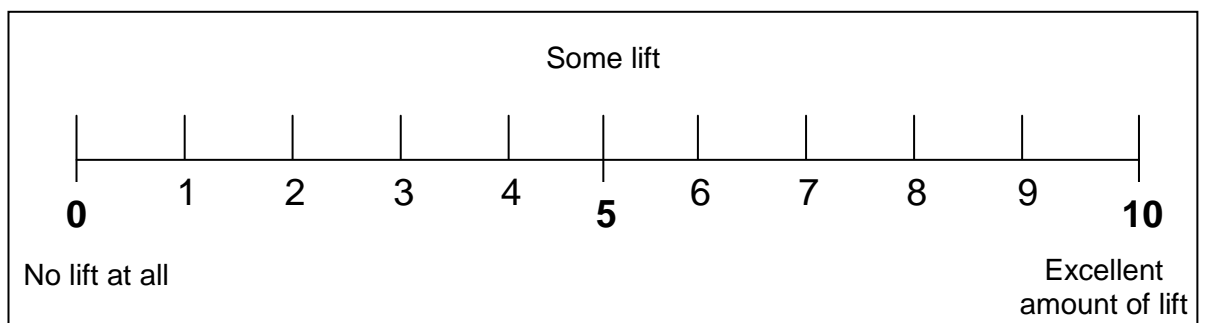
- 6) How well did you feel the bra **stayed in place** during the trial? (*Please circle*)



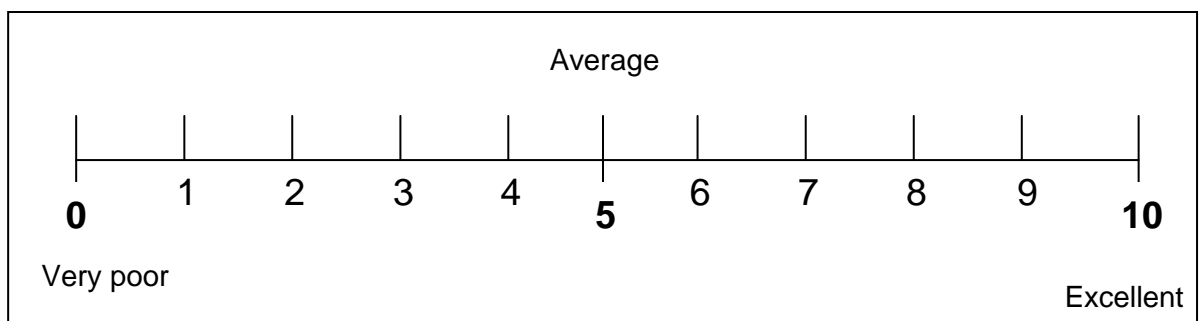
7) What did you think of your breasts shape when wearing the bra? (*Please circle*)



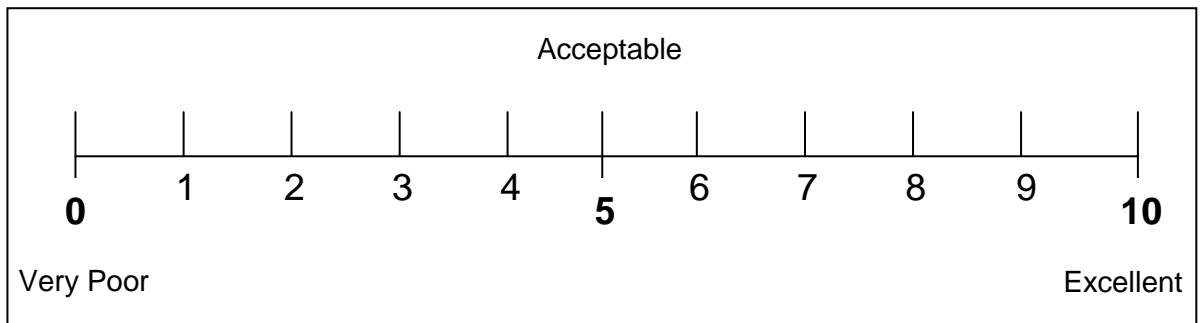
8) Please rate the level of breast lift you feel you have when wearing this bra? (*Please circle*)



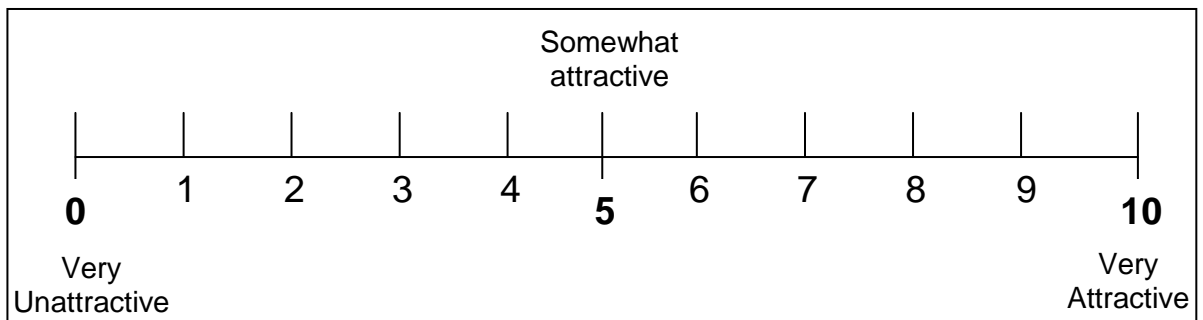
9) How would you rate the appropriateness of the shoulder straps of the bra? (*Please circle*)



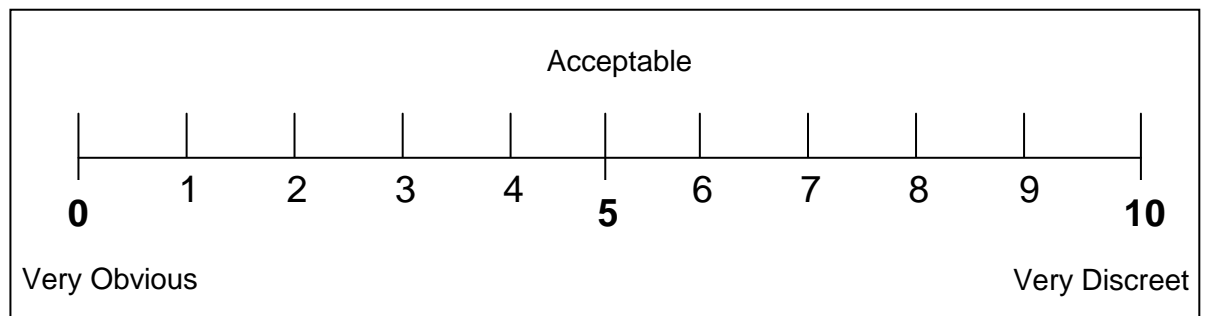
10) How would you rate the **fabric** of the bra? *(Please circle)*



11) When wearing the bra, how attractive do you think the **silhouette** of your upper torso is? *(Please circle)*



12) How **discreet** was the bra underneath your clothes? *(Please circle)*



- 13) Were there any **design features** in this bra which you particularly liked/ disliked? (e.g. the way it looked, straps, fabric etc)

LIKED: _____

DISLIKED: _____

- 14) Do you have any suggestions for **improvements** to the product

- 15) Please add any further comments

Appendix E: Bra Appraisal Diary

Bra Appraisal Diary



Participant Name:

Researcher: Debbie Risius

If you have any questions regarding this form or relating to this study please don't hesitate to contact Debbie on 02392 843085 or Debbie.Risius@port.ac.uk

Your second laboratory testing session is booked for

_____ at _____.

The testing will be identical to the previous session, and will be in the Spinnaker Building, room 0.05 (Biomechanics laboratory).

Please note the following information:

Answer all questions daily

RED items indicate an answer is required

The bras are as follows:

Bra A



Bra B



Example answer:

How supportive did the bra feel?

Not Very 0 1 2 3 4 5 6 7 8 9 10 Very

How has the supportiveness of this bra changed?

Less supportive having been washed.

Day (example)

Date:

Bra Worn (please tick one box)

A B Other

Duration worn for (to nearest hour)

_____ hours

Bra washed since previous use

Yes No

Overall opinion of the bra worn today

Dislike 0 1 2 3 4 5 6 7 8 9 10 Like

Please rate the following:

How supportive did the bra feel?

Not Very 0 1 2 3 4 5 6 7 8 9 10 Very

How well did the bra fit you?

0 1 2 3 4 5 6 7 8 9 10

How comfortable did the bra feel?

0 1 2 3 4 5 6 7 8 9 10

How good did the bra look underneath your top?

0 1 2 3 4 5 6 7 8 9 10

How well did the bra stay in place?

0 1 2 3 4 5 6 7 8 9 10

How good was the breast shape created by the bra?

0 1 2 3 4 5 6 7 8 9 10

How good was the amount of breast lift the bra provided?

0 1 2 3 4 5 6 7 8 9 10

How appropriate were the bra's shoulder straps?

0 1 2 3 4 5 6 7 8 9 10

How nice was the fabric of the bra?

0 1 2 3 4 5 6 7 8 9 10

How good was the silhouette created by the bra?

0 1 2 3 4 5 6 7 8 9 10

How discreet was the bra underneath your top?

0 1 2 3 4 5 6 7 8 9 10

Please rate the following:

How has the supportiveness of this bra changed?

How has the fit of this bra changed?

How has the comfort of this bra changed?

How has the bra's appearance under clothes changed?

How has the bra's ability to stay in place changed?

How has the breast shape created by this bra changed?

How has the breast lift provided by this bra changed?

How has the bra's shoulder straps changed?

How has the bra's fabric changed?

How has the silhouette created by this bra's changed?

How has the discreetness of this bra changed?

Thank you for completing your 4 week Bra Appraisal Diary

Your final laboratory testing session is booked for

_____ at _____.