Design requirements for female boomer activewear: A sequential exploratory mixed methods study

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Design requirements for female boomer activewear: A sequential exploratory mixed methods study

by

Chanmi Hwang

A dissertation submitted to the graduate faculty in partial fulfillment of the requirements for the degree of DOCTOR OF PHILOSOPHY

Major: Apparel Merchandising and Design

Program of Study Committee:
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The student author and the program of study committee are solely responsible for the content of this dissertation. The Graduate College will ensure this dissertation is globally accessible and will not permit alterations after a degree is conferred.

Iowa State University
Ames, Iowa

2017

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ABSTRACT

The emerging phenomena of active aging brought new challenges for professionals to respond to female boomers’ demands on special needs for fit and styling of activewear. Since this market is not well understood, a holistic research that integrates both consumer behavior and product development is needed. Thus, this study explored and analyzed design requirements for female boomer activewear for indoor fitness through a sequential exploratory mixed methods research. This method consists of three phases that begins with the collection and analysis of qualitative data and builds from the qualitative results to a quantitative phase.

In the first phase, 15 in-depth interviews were conducted to explore female boomers’ functional, expressive, and aesthetic (FEA) needs based on FEA Consumer Needs Model (Lamb & Kallal, 1992). In the second phase, themes and preferences found in the first phase were translated into garment engineering details in terms of design features and textile properties: interaction matrix and design problem-approach analysis were conducted. The fit issues were addressed by comparing two parametric avatars of missy and female boomer figures and the data were further transferred to visual representations by 3D virtual prototyping. In the third phase, online survey was conducted where 321 female boomers across the United States evaluated the developed 3D prototypes. Specifically, FEA attributes of the activewear were evaluated and the relationship between FEA needs and wearing intention were examined.

The results of the 3D virtual comparisons showed that there is difference in body shapes between the female boomer and missy figures that influence design requirements. Based on the results, this study proposed a conceptual model that illustrates the
interrelationships of factors influencing design requirements for female boomer activewear including aging factors, FEA dimensions, and wearing intention. The findings of the final evaluation phase along with the model testing confirm the importance of all three FEA dimensions and indicate that the proposed virtual prototypes meet the needs of female boomers that have positively effects on wearing intention.

This present study has both theoretical and practical implications and contributes to the growing body of research on examining female boomers as a vital consumer sector in the apparel industry. The present study confirms the appropriateness of the extended FEA model and further validates the efficacy of the model in explaining female boomers needs and preferences on activewear. It also brings increased conceptual clarity to the concepts of age appropriateness and further confirms the applicability of using mixed methods research in the discipline of textiles and clothing. Lastly, the findings of this study have practical implications for product developers and retailers on product development and commercialization strategies for female boomer consumers.
CHAPTER 1. INTRODUCTION

Background

Staying healthy and active is one of the most important lifestyle characteristics of baby boomers and it has become an important part of everyday life for older individuals. Baby boomers, those born between the years 1946 and 1964, with the youngest being 52 years old and the oldest being 70 years old as of 2016 (Howden & Meyer, 2011), are more active than any generation before them (Rahulan, Troynikov, Watson, Janta, & Senner, 2013). Consequently their willingness to stay active and fit reflects the emerging phenomenon of active aging. Active aging is “the process of optimizing opportunities for health participation and security in order to enhance the quality of life as people age” (World Health Organization, 2002, p. 12). These individuals are reinventing aging and stereotypes of aging, and mostly are leading independent and social lives. Thus, new challenges have emerged for the 21st century to respond to their new demands and make these added years of life in old age as healthy and productive as possible (Healy 2004).

One of the challenges to meet the consequent demands from baby boomers is that they have special needs for fit and styling of apparel that are difficult to find in today’s marketplace (Borcherding & Bubonia, 2015). Currently, the apparel industry has been quite slow to react and target the needs of this growing demographic, that is perceived as America’s most valuable or powerful generation due to their size and disposable income (Paul, 2003). Baby boomers outspend other generations by approximately $400 billion each year on consumer goods and services, according to the U.S. Government Consumer Expenditure Survey (U.S. Bureau of Labor Statistics, 2015). Specifically, female boomers are more frustrated than other generations when shopping for apparel items, and women 55-
65 years of age are the most dissatisfied of any age group with the fit of ready-to-wear (Ashdown & O’Connell, 2006). Further, female boomers are unhappy with the assortment of apparel merchandise in department stores which have attributes too young or too old for them, therefore unable to find their fit between their daughter’s and their mother’s clothing (O’Donnell, Petrecca, & Butrymowicz, 2008). Consumers in this age group are frustrated in their search for “apparel that is designed for their bodies, expressive of their style, and functional for their needs” (Borcherding, & Bubonia, 2015, p.77).

Specifically there are many needs on activewear because current trends of walking, yoga, Pilates, and weight training all led to new apparel styles and allowed for a 24/7 approach to activewear dressing (Borcherding & Bubonia, 2011). Twenty-five percent of the 41 million health-club members in the U.S. are over 55 years old and this age group has been the fastest-growing segment of health-club memberships since American Sports Data started to study fitness gym trends in 1988 (Bixler, 2014). Baby boomers are six percent more likely than the national average to engage in some kind of sports activity (Solomon, 2013), and the increasing awareness of the benefit of physical fitness has motivated older women to join exercise classes and created a demand for activewear over the years (Zhang, 2004). Studies have shown that the older a person is, the more they rely on others to stay physically active in a collective workout environment and classes for aerobics, walking, Pilates, and yoga are among the fastest-growing group activities in the US (Borcherding & Bubonia, 2015).

However, the attributes of activewear are usually targeted for younger generations with skin tight and revealing designs. Thus, many complaints were shared in online communities by female boomers. For instance, a mother pleaded to activewear apparel companies to make clothes that “help us [female boomers] look slimmer, support us better, hide the parts that
need works, and still look good on us” on her blog which created many supports from other female boomers (Cliffmama, 2012). Activewear could affect the wearer’s physical activity involvement and mood and as such, well-designed activewear is expected to boost the motivation to exercise and may help them adhere to it (Zhang, 2004). Thus, new directions for activewear that target female boomers must be initiated and satisfy this powerful consumer group.

Actively aging female boomers want to stay active, and the opportunity for apparel and textile manufacturers to meet the needs of this market is huge. To satisfy female boomers, activewear can be further improved by integrating user-assistive technologies integrated into clothing design. The sports performance activewear market has grown comparatively by introducing innovative garments that merge smart materials with functional design for apparel (Borcherding & Bubonia, 2011). Functional clothing is perceived to be of particular relevance to older consumer groups, not only from a medical perspective, but also in helping them to lead fuller and more active lives into old age (Jones, 2015). The motivation for participation in active sports and healthy exercises will increase if the activity is pleasurable, and it is expected that features specifically defined by user requirements will enhance the safety and enjoyment in healthy exercise (McCann, 2009). Other technologies such as 3D virtual prototyping process can be adopted by product developers to examine fit issues. As the leading edge of consumers who will live longer and more active lifestyles, baby boomers continue to open an opportunity for the textile and apparel market (Borcherding & Bubonia, 2011, p.38).
Purpose

In spite of the importance of the consumer segment of the female boomers, academia and industry have neglected a gap in the market for the activewear and little has been done to address design requirements of older wearers. The existing knowledge provides only insights on older women's general body characteristics (Paulson & Willig, 2008) and attitudes regarding apparel and fit preferences (Howarton & Lee, 2009; Holmlund, Hagman, & Polsa, 2011; Lee, 2005). Even though Chae and Evenson (2013) and Zhang (2004) examined older women’s activewear (golf wear and tops for aerobics) from a product development approach, a more holistic in-depth research is necessary to investigate female boomers’ demands on activewear that are distinguished from younger generations, reflecting their body changes and preferences. Thus, the purpose of this study is to explore and analyze design requirements and then virtual develop prototypes for female boomer activewear for indoor fitness through a sequential exploratory mixed methods research process. The researcher will adopt theoretical framework of Generational Cohort Theory (Petroulas, Brown, & Sundin, 2010), and Functional, Expressive, Aesthetic (FEA) Consumer Needs Model (Lamb & Kallal, 1992). Both 2D and 3D virtual prototyping technology will be used to aid the design assessment and design processes within the product development model of Integrative Process Model for Universal Design (Park, 2014). The findings of this study can make a contribution to increase an understanding of the aging population and have practical implications for fashion retailers and researchers to improve female boomers’ needs for current activewear market. Further, this research can inform and teach product developers and designers how to better understand the needs and design requirements of a demographic group often ignored the professional-female consumer markets. Lastly, this theory-based,
mixed methods research in design and product development may initiate new opportunities and challenges in clothing and textile scholarship.

**Research Questions**

For this study, the following research questions were identified:

RQ1. What are functional, expressive, and aesthetic (FEA) needs for female boomer activewear?

RQ2. What are the design attributes of activewear for female boomer market and how do they differ from younger generations?

RQ3. How do consumers evaluate and perceive activewear that are designed for female boomers?

**Objectives**

To answer the research questions, specific objectives include to:

1. identify functional, expressive, and aesthetic (FEA) needs for female boomer activewear;

2. generate an illustrative model of factors influencing design requirements for female boomer activewear;

3. analyze interaction matrix and design problem-approach for female boomer activewear;

4. conduct 3D tension map testing for old and missy figures;

5. develop virtual prototypes for female boomer activewear through 2D and 3D simulations; and
6. examine consumers’ evaluations and perceptions towards activewear that are designed for female boomers.

**Scope and Limitations**

The sample selected to participate in the study does not represent all female boomers in the United States and that all participants for the study are volunteers. The sample was limited to the self-defined female boomer population who volunteered at the time of the current study. The following criteria were used for the selection of all the participants in the study that all:

1. are female
2. are between ages of 50 and 70 years old
3. exercise at least once a week at a fitness center/ gym/ studio

**Definitions**

*Active aging:* “the process of optimizing opportunities for health participation and security in order to enhance the quality of life as people age” (World Health Organization, 2002, p.12).

*Activewear:* it is about “functionality, comfort and safety with the specification developed and designed to deliver a product that fits in with the performance needs of the sportsman and sportswoman” (Dhanapala, 2015, p.2). In this paper, activewear refers to clothing for indoor fitness (e.g., yoga, aerobics, walking).
Aesthetic attributes: this study refers to aesthetic attributes as the human desire for beauty and relate to “the use of elements such as line, form, color, texture, and pattern to create a pleasing design” (Lamb & Kallal, 1992, p.43).

Apparel design: system for creating garment silhouettes, concepts, styles, and collections (Keiser & Garner, 2012).

Apparel fit: “apparel fit is defined as the relationship between the size and contour of the garment and those of the human body” (Shan, Huang & Qian, 2012, p. 1).

Baby boomers: a group born between the years 1946 and 1964, with the youngest being 52 years old and the oldest being 70 years old as of 2016 (Howden & Meyer, 2011).

Design: it is converting the actual to the preferred and a conversation with materials of a situation (Schon 1983); The arrangement of elements, guided by aesthetic principles, to create products that are considered pleasing to the observer (Keiser & Garner, 2012).

Design research: it is accessible, systematic inquiry based on the practice of designing that uses analysis and synthesis to discover new knowledge (Bye, 2010, p. 206).
Exercise: activity requiring physical effort, carried out especially to sustain or improve health and fitness. In this paper, the term is interchangeable with physical activity and fitness.

Health: a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity (World Health Organization, 2016).

Prototyping: the tangible creation of artifacts at various levels of resolution (Martin & Hanington, 2012).

Smart clothing: garment-integrated devices which augment the functionality of clothing, or which impart information-processing functionality to a garment" (Dunne, Ashdown, & Smyth, 2005, p.2).

Wearable technology: “Wearable technology is a term used to describe many different forms of body mounted technology, including wearable computers, smart clothing, and functional clothing” (Dunne, 2004). In this paper, wearable technology refers to the overlapped areas of smart and functional clothing where technology is attached or integrated into clothing.
CHAPTER 2. LITERATURE REVIEW

This chapter contains relevant literature linked to the important aspect of female boomers and activewear. First, the researcher provides in-depth information on female boomers’ psychographics and how this market plays an important role in the apparel industry. The researcher further provides background on the concept of activewear and the role of smart clothing in the active aging population to better satisfy user needs. Lastly, the researcher discusses mixed methods research, theoretical framework (Generational cohort theory and Functional, expressive, and aesthetic consumer needs) and product development models (Integrative process model for universal design) that were used for this study.

Active Aging and Baby Boomers

The World Health Organization defines active aging as “the process of optimizing opportunities for health participation and security in order to enhance the quality of life as people age…allowing people to realize their potential for physical, social and mental well being throughout the life course” (World Health Organization, 2002, p.12). The word “active” refers to continuing participation in social, economic, cultural, spiritual and civic affairs. The first wave of baby boomers has already entered the “active aging” life stage and this definition well reflects the way baby boomers plan to live the next stage of their lives (Borcherding & Bubonia, 2015). The term “baby boomer” takes its name from the accelerated growth, or “boom,” in birth rates that occurred in Western countries following World War II. According to the U.S. Census Bureau, American turns 50 every seven seconds, which is equivalent to more than 12,5000 people every day: By 2030, more than 20 percent of U.S. residents are projected to be aged 65 and over, compared with 13 percent in 2010 and 9.8 percent in 1970 (Colby & Ortman, 2014). The baby boomers began turning 65
in 2011, and by 2056, the population 65 years and over is projected to become larger than the population under 18 years.

Today’s mature consumers are not aging like their predecessors, who are portrayed as sedentary and frail. However, they are leading varied healthy lifestyles, including exercise participation (Zhang, 2004). Baby boomers control half of the wealth of the nation (Matorin, 2003), and are responsible for over half of consumer spending in the United States and 80% of leisure and travel expenditures (Borcherding & Bubonia, 2015): consumers aged 45 to 54 spend the most of any age category on apparel (38 percent above average). The media often publishes articles describing them as a key cohort in the potential revision of aging (Borcherding & Bubonia, 2015). Scholars also recognize baby boomers as cultural pioneers since they invented youth culture and went on to develop lifestyle oriented consumption culture (Gilleard & Higgs, 2008). Improved health status with this economic prosperity has led older adults to participate in diverse leisure and social activities. Boomers continue to affect housing, childcare, automobiles, clothing, and many other products to suit their needs (Solomon, 2013).

**Female Boomer Psychographics**

Female boomers are women born from 1946 to 1964, and there are approximately 38 million female boomers in the United States (Colby & Ortman, 2014). Between 2011 and 2050, the number of women who are 55 years of age and older is projected to grow by more than 26 million, with women continuing to outnumber men (U.S. Department of Labor, 2013). Mature women of today are educated, employed, and more self-confident about their looks than women 10-15 years younger (Wray & Hodges, 2008). Female boomers are fulfilled by a combination of work, family, friends and personal accomplishments, and are
the most economically secure group of women in American history (Morton, 2001). Among 55-to 64-year-olds, women’s rate of labor force participation increased from 41.3 percent in 1980 to 59.4 percent in 2012, and is expected to reach 66.6 percent by 2020 (U.S. Department of Labor, 2013). During their lifetime, female boomers were shaped by birth control and the women’s movement where along with education, empowered women and gave them a sense of control (Wray & Hodges, 2008). Women are interested in things that make them feel better, such as being health-conscious, working out frequently, and shopping (Wray & Hodges, 2008). Activities and lifestyle play a big role in determining clothing requirements and female boomers are still in the work force and live active volunteer and social lives (Lee 2005). Even though younger women shop more, mature women spend more: women aged 45 to 65 were found to shop less frequently but they spend 40% more on clothing in-store than their younger counterparts (Alasagas, 2015).

Specifically, Borcherding and Bubonia (2011) describes how the baby boomer generation has been effective in redefining apparel throughout their lives:

Their [baby boomers’] teenaged years influenced the opening of junior and varsity departments in major department stores that focused primarily on casual sportswear and denim apparel. Their college years brought about the collapse of formal dress codes for college campuses and specific school-related fleece sportswear came into vogue. Athletic apparel and athletic shoes became acceptable as everyday casual apparel, no longer worn just for participating in athletic activities. (p.35)

The demands can be reflected as many websites and social networking have emerged just for baby boomers, specifically for female boomer such as “50 is the new forty,” “A baby boomer woman’s life after 50,” “BoomerGirl Diary,” and “Boomer Women Speak.” For instance, a
social networking site for boomers, www.enos.com, states that the average age of site users is between 50 and 60 with more than 100,000 members (Crean, 2007). These sites discuss about life after 50 including fashion, beauty, health, fitness and even relationships.

Specifically, personal fitness has become an important part of everyday life for female boomers (Wray & Hodges, 2008). Currently, 21st century trends of indoor fitness such as walking, yoga, and Pilates has led to new apparel trends and allowed activewear dressing to be part of one’s lifestyle (Borcherding & Bubonia, 2011): the number of active participants who visit the gym at least 100 times per year in the 55–plus category jumped 33 percent, compared to just 13 percent for the under 34 group. (Bixler, 2014). Female boomers strongly feel the pressure from the media and American society to stay young (Lee 2005) and as a result, they like to see models in advertisements that represent their lifestyles. The boomer participants in some studies indicated that they enjoy all manner of exercise, but particularly physically active forms such as walking and aerobics (Wray & Hodges, 2008).

**Age-Related Female Physical Changes**

Extensive research studies of female body scans have confirmed many changes in the body with aging: most aging adults experience a gradual shift in their posture, causing the shoulders to round forward, the back to curve, and often creating an asymmetry to the shoulders, bust, and hip area measurements (Borcherding & Bubonia, 2011; Ashdown & O’Connell, 2006). Common difficulties caused by the aging process are joint issues that can range from occasional pain to debilitating and crippling arthritis. No accurate anthropometric data on mature women existed until 1994 when the American Society for Testing and Materials (ASTM) published the ASTM D5586. This is the result of an extensive anthropometric survey of 6,786 U.S. women who were 55 years or older at the time. Up to
75% of body measurements in ASTM D5586 were significantly different from those in PS42-70, confirming changes in body dimensions affecting the fit of apparel (Zhang, 2004). For instance, osteoporosis can lead to fractures of the vertebral bodies, resulting in height loss and a stopped or hunched posture, which clothes may start to fit poorly (National Osteoporosis Foundation, 2016).

Women also experience both an increase in bust size as well as a drop in their bust line and these changes become more significant as people age and vary by individual. Researchers have shown that as women age, they naturally tend to increase in weight by between five to ten pounds throughout their lifetime, and females inevitably grow three to five inches in the waist, one to three inches in the hips and four to six inches in the chest as they age (Sorkin, 2004; Prevos, 2005). Due to the widened hips, female boomer’s figure changes from an hourglass shape to a more pear shape over the years (Sorkin, 2004), as shown in figure 2.1.

![Figure 2.1. Body Shape: Hourglass (left), Pear (right).](image)

Menopause is an unavoidable change that most woman experiences when she reaches middle age and beyond. Menopause is a natural consequence of aging, and this transition
tends to occur over a period of years, signaling the end of the fertile phase of a woman’s life (National Association of Baby Boomer Women, 2015). Women’s health issues during this time of midlife transition include everything from dealing with menopause symptoms, to the importance of maintaining heart health, cancer screening, changes in weight, and sexual wellbeing (National Association of Baby Boomer Women, 2015).

With age, a person’s skin also becomes thinner due to a decrease in elasticity of collagen and reticular fibers in the dermis that requires recovery time or return to the original thickness for mature women (Daly & Odland, 1979). Thus, thin skin can lead to increased incidence of tears and some inappropriate clothing may lead to further tears: non-adhesive dressings are preferred and designs should avoid sharp edges or areas that could tear the skin such as smoother and easy zips and closures (Edwards, Gaskill, & Nash, 1998). Further, due to age-related decreases in metabolic rate, heat production is lower with aging and it leads to increased heat loss in cold environments (Pascoe, Bellingar, & McCluskey, 1994). Female boomers also experience delayed onset of sweating and decreased sweat output and this process put them at a greater risk of illness or injury from heat or cold (Stevens & Fuller, 2015).

**Health Benefits of Exercising**

Researchers recommend that after age 50, one needs a routine that consist of warm-up, aerobic exercise, and strength training where aerobic includes speed walking, biking, jogging, using an elliptical machine, or swimming (McCann, 2009). Especially, walking is by far the predominant activity reported in surveys of older people where it can range from extreme hill walking to more moderate exercise. Participation in regular, moderate physical activity can delay functional declines. Physical activity has a positive effect such as on
balance problems, muscle weakness, high blood pressure and osteoporosis in the aging population (Carlson, Ostir, Black, & Markides, 1999). Along with the physical benefits, exercising can also improve mood, lower anxiety, reduce the chance of cognitive impairment and improve life satisfaction (Carlson et al., 1999).

Boomers appreciate active sports that were not jarring to their bodies, but instead were burning calories by strengthening and stretching muscles and building stronger bones (Borcherding & Bubonia, 2011). Thus, baby boomers participate in individual or group exercise for fitness as prevention to ill health. Keeping fit is a proactive way to protect the body from a number of medical problems such as high blood pressure, heart disease and osteoporosis (McCann 2009). Thus, Dr. Henry Lodge and Chris Crowley, authors of the Younger Next Year for Women: Live Strong, Fit, and Sexy- Until You’re 80 and Beyond, state that the first rule to help limit decay in an aging body is to exercise six days a week for the rest of the life, especially after age 50.

**Clothing Design and Functional Preferences**

Mature women are fully aware of traditional norms in relation to dress and age and acknowledge the modesty pressures with age (Twigg, 2013). For baby boomers, ageless style is important as a stylist and a author of Style Evolution: How to Create Ageless Personal Style in Your 40s and Beyond states that the goal as one gets older is to look effortless, sophisticated, current and cool, and it is about not looking too young or like one has given up (Farr, 2009). Looking at female boomers aged 45 to 54 in Canada, Spadaro (2012) found that:

the clothing they preferred did not change along with the natural changes their body undertook as they aged. This suggests that there is a need to change the fit model at
the production level to accommodate the changes that take place as women enter late adulthood. (p. 218)

Specifically, mature women are dissatisfied with ready-to-wear ranges since their changing body measurements and posture are overlooked by designers. For them, “quality, fit, comfort, material, style and design more than price and fissionability influence clothing purchasing decision” (Nam, Hamlin, Gam, Kang, Kim, Kumphaic, Nam, Richards, & Starr, 2007, p.102). Researchers also found that maturewomen considered new fashionable clothes to make them feel better about themselves by giving them self-assurance and influencing their total well-being (Holmlund et al., 2011). Mature women follow fashion changes, but want to avoid fashion that is “too” conspicuous. The present idealization of slimness and youth has influence on mature women’s clothing choices as they want to look smaller and slimmer and therefore prefer flattering styles as well as details and cuts that do not make them look older and fatter (Holmlund et al, 2011).

Female Boomers identified specific user needs for an activewear garment in terms of design, materials, and fit that would meet the needs of consumers like them (McCann, 2009). Zhang (2004) conducted individual face-to-face interviews with 20 mature women aged 55 or over and concluded that 10 essential values (ease of movement, ease of care, fit, appearance/ body image, friction against the body, ease of dressing, cover imperfections, fabric performance, durability, modest, and thermal comfort) were derived in relation with the design features and textile properties of activewear. Zhang (2004) further found that some of the recommended improvements by mature women include:

- easy-to-read fiber content/ fabric care labels and laundering instructions; use of pre-shrunk fabrics with stain-free-finishes; wider availability in lengths of pants and
sleeves, especially shorter lengths; 31/4 length sleeve styles; pants that did not exaggerate or call attention to heavy hips and thighs, special features such as extra pockets to accommodate eye glasses, tissues, etc.; wider, lower cut necklines; zipper with large pull; and pants that are easier to draw the feet through (i.e., pants with wider openings at the ankles and Velcro® tab closings). (p.14)

Rahulan, Troynikoy, Watson, Janta, & Senner (2015) also found that fit and size availability are factors that were ranked as important by female boomers in regard to compression sportswear, and they preferred to wear something less skin tight. Female boomers felt that they are a segment not catered to clothing wise and feel dissatisfied with the options offered by retailers. Garment fit and comfort is important attributes where the tightness and weight of a garment affect its thermal and skin sensorial properties (Stevens & Fuller, 2015).

**Activewear**

The concept of activewear has changed over time where it used to describe only to clothing designed for athletic purposes: activewear now includes casual clothes worn by anyone for daily activities and can be defined as apparel made for sports and recreation involvement (Ko, Taylor, Sung, Lee, Wagner, Navarro, & Wang, 2012). In addition, activewear can be called as any clothing product purchased with the intent for the use in active sports (Newbery, 2009). By definition, it is about functionality, comfort and safety with the specification developed and designed to deliver a product that fits in with the performance needs of the sportsman and sportswoman (Dhanapala, 2015). Dhanapala (2015) categorizes activewear into sectors by sporting pursuit and leisurewear such as outdoor pursuits, leisurewear excluding outdoor wear, team sportswear, running, aerobics and indoor
fitness, swimwear, racket sports, and golf. In this research, activewear specifically refers to clothing worn for indoor fitness.

Activewear was sold seasonally, but is now sold year-round and evolved into separate category with many specializations dedicated to specific sports. Most are separates-pants, tops, jackets, and are produced for both men and women (Keiser & Garner, 2012). The convergence between performance, functionality and fashion has allowed companies such as Nike to capitalize on the trend, with sales growing from $3.9 billion to $27.8 billion from 1993 to 2014 (Nikeinc.com 2014). Especially, companies such as Nike and Lululemon became successful at targeting athleisure, athletic apparel that people can wear in non-athletic settings (Petro, 2015). Activewear and athletic-casual wear has become increasingly acceptable by consumers and is a global phenomenon and the sportswear market represented $282 billion worldwide in 2014, a 7% increase on the previous year and outpacing the growth of broader apparel, which stands at 5.8% of the market (Bearne, 2014). The largest market is the United States, which accounts for over 35% of sales globally, and the activewear market experienced growth of 4 percent or higher in every year from 2000 to 2013 in the US (Kondej, 2013). Some of the largest companies in activewear market include Nike Inc (e.g., Nike, Converse), Adidas AG (e.g., Adidas, Reebok), VF Corp (e.g., The North Face, Nautica, Timberland), Puma SE, Asics Corp, Under Armour Inc, and Columbia Sportswear Co. Other apparel companies started to launch activewear lines such as H&M and Topshop who started joint venture with Beyonce’ to launch Parkwood Topshop Athletic Ltd, to product a global athleisure brand in winter 2015 (Green, 2014). The crossover between sportswear and fashion is increasingly seen in mainstream fashion as the design is further enhanced to take account of style and fashion (Dhanapala, 2015). This also reflects the
change in lifestyle where someone needs the dual functionality of sportswear where for instance, yoga pants can be worn to work and then straight to the gym (Dhanapala, 2015). The increase in sports participation by females has enhanced the growth for the apparel sector in the activewear market (Wray and Hodges, 2008). Many fashion designers such as Giorgio Armani, Donna Karan, Ralph Lauren, and Prada offer lines of activewear.

The sports performance activewear market integrates innovative technology with functional design for apparel (Borcherding & Bubonia, 2011). Activewear is getting lighter, more breathable, and improving in wicking, flexibility, and fit and strength (Dhanapala, 2015). Nylon, the first synthetic fiber, and polyester had been used in activewear since the 1970 because the fabrics are durable, easy to care and resilient. Currently, high functional fibers, microfibers, and nanofibers have been emerged in activewear with thermoregulation, moisture management, and performance monitoring attributes (Dhanapala, 2015). Active sportswear could affect the wearer’s physical activity involvement and mood (Sinden, Ginis, & Angove, 2003), so its function is more than just clothing to cover up one’s body.

**The Role of Smart Clothing for the Active Aging Population**

Clothing often holds the key to enhance body functions (Malmivaara, 2009). With the rapid textile and technological innovation, electronics are becoming embedded into textiles and garments. Wearable technology describes, “many different forms of body mounted technology, including wearable computers, smart clothing, and functional clothing” (Dunne, 2004, p. 5). A more specific classification of wearable technology in relation to clothing is called smart clothing, or interactive or digital clothing, and is defined as a "garment-integrated device which augment[s] the functionality of clothing, or which impart[s] information-processing functionality to a garment" (Dunne et al., 2005, p. 2). Researchers
agree that “intelligent,” or “smart,” means an ability to sense stimuli from the environment, and then react or adapt behavior to the circumstances (Baurley, 2004). Technology is designed smaller and embedded into the fabric, creating clothing that is more responsive to our changing personal needs and environmental conditions (Amitai & Seymour, 2014).

Current use of smart clothing include monitoring body vital signs with woven electrodes and integrated sensors, environmental protection, create warmth or coolness when sensors measure temperature changes, fashion and social applications (Malmivaara, 2009). Apparel companies are using textiles that include technology for graphic communications, GPS monitoring, alarm systems, Bluetooth technology, pedometers, RFID chips, and heart rate and respiration monitors. Over the last 10 years, many large apparel companies have added advanced functionality to their products by incorporating electronic features such as entertainment controls, lighting devices, sensors, heating panels, and other smart features (Jones, 2015). Some of the smart clothing in the market include The North Face’s MET5 jacket that generates heat (Best Inventions of 2001, 2001) and the Hug Shirt with electronic sensors that gauge body temperature and heart rate (Voigt, 2007). Fashion designer Hussein Chalayan has experimented with dresses that glow and show color with built-in LED’s (Borcherding & Bubonia, 2011).

Especially, the baby boomer market is opening a new opportunity for technical fabrics and apparel companies. The attributes of modern textiles may enhance the independence, safety, wellbeing and sense of adventure in the everyday lives of older wearers with a focus on walking. For instance, some of the functional attributes could include information and communication (security and safety) and data could be mapped for identification, location and environmental conditions (e.g. weather). Based on similar
garments used in the health industry, sports compression garments can provide the user with increased blood flow and oxygen to the muscles, reduced muscle vibration, injury and fatigue and faster recovery (Kang, Mahoney, Hoenig, Hirth, Bonato, Hajjar, & Lipsitz, 2010).

Recent innovations embrace ‘soft shell’ garments that incorporate a hybrid of attributes such as the protection of outer garments, the comfort and insulation of mid layers, and the characteristics of neoprene in certain waterproof breathable laminates. LED modules can be applied as garment trims and improve the visibility on poorly lit streets. Further, skin sensors that are integrated in textile chest straps, bras and other intimate apparel can monitor heart rate and respiration rate: for the aging population, this unobtrusive wearable sensor technologies allows them to monitor their performance levels during exercise and benefit from the healthcare and medical aspects of the technology, optimizing their chances of living a healthier life longer into old age (Jones, 2015).

**Mixed Methods Research**

The complexity of social science research cannot be adequately addressed by the use of either quantitative or qualitative approaches by themselves (Creswell, 2009). Mixed methods research (MMR) utilizes the strengths of both qualitative and quantitative research. Therefore, by combining both qualitative and quantitative research, it provides more insights and an expanded understanding of research problems. Some reasons for researchers to employ a mixed methods design are “to broaden understanding by incorporating both qualitative and quantitative research or to use one approach to better understand, explain, or build on the results from the other approach” (Creswell, 2009, p. 204).

MMR is commonly been associated with the convergence of the results and is an interactive, cyclical approach to research and includes both deductive and inductive logic in
the same study (Teddlie & Tashakkori, 2009). However, MMR is more than simply collecting and analyzing both kinds of data. It involves the use of both approaches in tandem so that the overall strength of a study is greater than either qualitative or quantitative research (Creswell & Plano Clark, 2007). The overall purpose for mixing methods in social inquiry is to develop a “better understanding” of the phenomena being studied (Green, 2007, p. 98).

Greene (2007) presents five distinct purposes for mixing methods: mixing methods for purposes of: (a) triangulation, (b) complementarity, (c) development, (d) initiation, and (e) expansion.

The purpose for mixing methods for this study is both development and complementarity. The mixed methods development rationale aims for better understanding by capitalizing on inherent method strengths (Greene, 2007). In this mixed method research, the results of one method are used to inform the development of the other method, where development is broadly construed to include sampling and implementation, as well as actual instrument construction (Greene, 2007). For the complementarity purpose, the results from the different methods serve to “elaborate, enhance, deepen, and broaden the overall interpretations and inferences from the study” (Greene 2007, p.100), since most social phenomena are complex and multifaceted that a complementarity mixed methods, purpose fits many inquiry contexts.

Thus, this study falls into a paradigm of pragmatism where the ontology (a question of what is real: the philosophical study of the nature of existence, being or reality) is constructed, based on world we live in and explanations that produce the best desired outcomes (Maxwell, 2005). While epistemology (a question of what is true: the study of the nature of knowledge and justification) is objective and subjective points of view and
methodology is qualitative and quantitative (Maxwell, 2005). Since this study adopts both qualitative and quantitative approaches to answer research questions using best methods, the dimension of contrast is pragmatism and the logic is both inductive and deductive (Teddlie & Tashakkori, 2009). Thus, MMR provides more comprehensive evidence because there is no data restriction and it can help to answer complex questions that cannot be answered by qualitative or quantitative approaches alone.

**Theoretical Frameworks**

**Generational Cohort Theory**

Generational cohort theory states that individuals born in the same period would have similar preferences and attitudes in their adult years, since they had similar experiences (Petroulas, Brown, & Sundin, 2010). Strauss and Howe (1997) defines a generation as an “aggregate of all people born over roughly the span of a phase of life who share a common location in history and hence, a common collective persona” (p.61). A generation is usually 20-25 years in length and is delineated by its years of birth (Schewe & Noble, 2000). For instance, some generational cohorts include baby boomers, born between 1946 and 1964, Generation X, born between 1965 and 1976 and Generation Y, born between 1977 and 1994 (Quester, Neal, Pettigrew, Grimmer, Davis, & Hawkins, 2007). Because of the same life span, each generation has gone through the same social events and external influences in their formative years, thus creating similar life experiences. These external events further help mold their core values. As a generation ages, its inner beliefs retain certain consistency over its life cycle, like that of an aging individual. Generation theory is a dynamic, socio-cultural theoretical framework that pinpoints patterns and propensities at an aggregate level across the generational groups, rather than for individuals (Pendergast, 2010). Thus, these
experiences influence values, attitudes, preferences, expectations and buying behaviors of the generational groups. As a result, these factors remain constant throughout the generation’s lifetime and constitute a generational identity (Jackson, Stole, & Brantley, 2010).

**Functional, Expressive, Aesthetic (FEA) Consumer Needs**

According to Lamb and Kallal (1992), three dimensions of clothing are useful in assessing consumer needs and wants: functional, expressive, and aesthetic (FEA). This design framework suggests that all three dimensions should be taken into consideration while addressing consumer wants and needs for innovative design (Lamb & Kallal, 1992). This framework was originally developed to examine functional clothing for consumers with special needs and was proposed for multipurpose intentions in apparel design. The researchers proposed that this framework could be applied to all types of apparel design. The FEA model suggests that functional dimension of clothing includes fit, mobility, protection, and comfort that relates to its utility. The expressive clothing dimension proposes symbolic communicative characteristics, such as values, roles and self-esteem that establish identity. Aesthetic considerations deal with the use of elements such as design principles, and the body/garment relationship. This user-centered model has been applied to functional clothing design research such as needs for hospital gowns (Cho, 2006) and adolescent girls with disabilities (Stokes & Black, 2012). Lamb and Kallal (1992) state that the concept of FEA can be used in product assessment where "the target consumer (intended user) is at the core of the model" (p. 42).

Previous studies show that physical comfort, as recognized in the FEA model (Figure 2.2), was an important factor influencing overall evaluation of the product (Frith & Glesson, 2004). Along with functional considerations, consumers are also concerned about expressive
considerations (Stokes & Black, 2012). Lastly, aesthetic criteria are central to consumers' evaluations of apparel (Chattaraman, 2006; Eckman, Damhorst, & Kadolph, 1990). Previous studies show that aesthetic attributes of apparel such as color, styling, and fabric were the most important criteria for women when purchasing clothing (Eckman et al., 1990; Fiore & Damhorst, 1992). This user-centered model has been applied to functional clothing design research such as needs for hospital gowns (Cho, 2006) and adolescent girls with disabilities (Stokes & Black, 2012).

![Diagram](image)

Figure 2.2. The FEA consumer needs model (Lamb & Kallal, 1992).

**Product Development Model**

**Integrative Process Model for Universal Design**

This study adopts an integrative three-stage process model for universal design (IPD-UD) by Park (2014) shown in figure 2.3 that is based on the framework of Lamb and Kallal (1992). Lamb and Kallal (1992) extended Watkins (1988) model to better combine functional, expressive, and aesthetic preferences in functional design (FEA) by using Koberg
and Bagnall (1972) model and an industrial design framework by Hanks et al. (1977) called SAFE (simple, appropriate, functional, and economical).

In general, the proposed universal design “seeks design solutions for products, environments, and systems to provide as much support and facilitation as possible to assist people to achieve their utilitarian and aesthetic goals through design… the elimination of potential barriers is central to the universal design philosophy” (Park, 2014, p. 180). This model pursues new design solutions to address the demanding user needs of diverse populations and aim to respond to changing social and cultural trends through reconfiguration of the look and purpose of designed object (Park, 2014). This circular model integrates three stages: (a) user needs assessment, (b) creative exploration and prototyping, and (c) evaluation and confirmation. During user needs assessment stage, market research should be conducted to assess potential user needs for a target product. Specifically, the seven principles of universal design and the FEA attributes must be examined and integrated into research instruments such as interview and survey questions (Park, 2014). Thus, user needs identified in this stage provides designers with specific guidelines for the design process. For the creative exploration and prototyping stage, every aspect of design elements, such as silhouette, size, materials, color, texture, and balance should be thoroughly considered. In the last stage of evaluation and confirmation, users can be involved in evaluating the prototype and feedback from potential users is sought (Park, 2014). The model validity was evaluated with an empirical design case of hospital patient apparel by Park (2014).
Virtual Prototyping

According to Martin and Hanington (2012, p. 138), prototyping is “the tangible creation of artifacts at various levels of resolution, for development and testing of ideas within design teams and with clients and users. In the prototype development stage, ideas that hold the most promise are tested. Prototypes could be sample garments or samples of garment components (Lamb & Kallal, 1992). In recent years, computer aided design (CAD) technology has become a standard tool for designers to ideate their design concepts, sketching directly on the computer screen. Although it may take as long to render artwork electronically as by hand, the opportunity to alter colors, change scale, and repeat forms is greatly enhanced once the design exists in the virtual domain (Treadaway 2004). It also facilitates communication of design visualization between the company designers and suppliers and retailers. This provides opportunity for intervention in the design process prior to manufacturing (Park & DeLong, 2009).
Particularly, 3D technology generates increased accuracy of body assessment data and accelerates the prototyping process. The 3D simulation provides 3D view of styles during product development, often with manipulation of a digital human avatar to simulate garment performance in response to lifelike body movements. Use for consumer virtual “try-on” or dressing room applications and to test pattern fit without or before making a sample (Park & DeLong, 2009). Virtual prototyping phase also aims to test the viewer’s perception (McCann & Bryson, 2015). Thus, 3D technology reduces the cost of prototyping from actual material samples to virtual images and benefits the company profit wise (Park & DeLong, 2009). Rapid prototyping technology is considered more environmentally friendly than the conventional sample-making system along with its time and cost-effectiveness.

**Summary**

Important aspects of active aging, baby boomers, and activewear were discussed along with mixed methods research and theoretical framework of this study. Improved health status with economic prosperity led active aging population to exercise, and boomers continue to affect demands for clothing with purchasing power. Especially, personal fitness has become an important part of everyday life for female boomers. However, mature women are dissatisfied with ready-to-wear ranges since their needs are overlooked by designers. Female boomers identify specific user needs for an activewear garment in terms of design, materials, and fit that would meet the needs of consumers like them (McCann, 2009). The sports performance activewear market integrates innovative technology with functional design and the baby boomer market is opening a new opportunity for technical fabrics and apparel companies. To provide more insights and an expanded understand of research questions, mixed methods research design was used. Generational cohort theory was used as
a theoretical framework for this study and integrative process model for universal design and virtual prototyping were used for product development process.
CHAPTER 3. METHODS

This study used a mixed-method research design to answer the research questions. Specifically, this study adopted a sequential exploratory mixed methods design with three phases: (a) qualitative analysis of face-to-face interview data was used to identify and define factors related to FEA attributes of activewear, (b) virtual prototypes were generated for online survey stimuli, and (c) online survey was used to examine how consumers evaluated and perceived activewear that were designed for female boomers. In the following sections, the researcher explains the sequential exploratory mixed methods design and further discusses each of the three phases as shown in Figure 3.1.

![Figure 3.1. A proposed sequential exploratory mixed methods design.](image-url)
Sequential Exploratory Mixed Methods Design

The sequential exploratory design consists of two phases that “begins with the collection and analysis of qualitative data, builds from the qualitative results to a quantitative phase, and is used when a topic needs to be explored qualitatively before it can be measured or tested quantitatively” (Plano Clark & Creswell, 2008, p.377). The primary focus of this model is to initially explore a phenomenon and expand on the qualitative findings (Creswell, 2009). Therefore, for this study, an in-depth qualitative study (face-to-face interviews) was conducted and research framework and virtual prototypes were generated based on the qualitative results. These two phases were followed by a quantitative study (online survey) that assessed the prototypes and tested the extent to which the qualitative results generalized to a larger sample based on quantitative results (Creswell, 2009). Using this three-phase approach (Figure 3.1), the researcher first gathered qualitative data and analyzed it, and then used the analysis to development an instrument that was subsequently administered to a sample of a population (Creswell & Plano Clark, 2007). This strategy was adopted because it was often discussed, as the procedure of choice when a researcher needed to develop an instrument and existing instruments were inadequate or not available. Therefore, the theoretical drive as the researcher conducting this study is inductive with sequential pacing. The qualitative data component involved face-to-face interviews with thematic analysis, and the quantitative data component used prototypes and instruments that were developed from the first phase to assess female boomers’ perceptions through an online survey. Integrating both data collection and analysis methods enhance and brings synergistic effects for answering research questions, and offer theoretical and practical implications in the clothing and textile discipline.
Phase 1. Face-to-Face Interviews

Sample and Procedure

Qualitative data were collected from in-depth interviews with semi-structured questions. The method of interviews allow an in-depth exploration of a particular topic or experience (Charmaz, 2006) and the semi-structured design gives the participants sufficient time and scope to express their views and allows the researcher to follow up on emerging ideas (Nohl, 2009). For this study, convenience sampling, choosing settings, groups, and/or individuals that were conveniently available and willing to participate (Collins, 2010), was adopted. Participants had to be: (a) born between the years, 1947 and 1963, with the youngest being 50 years old and the oldest being 70 years old as of 2016, (b) female, and (c) exercise at least once a week at a fitness center such as walking on a treadmill or participating in yoga/ Pilates classes.

After receiving the university’s Institutional Review Board (IRB) approval letter (APPENDIX A), participants were recruited from various fitness centers and gym facilities in the area of Urbana-Champaign, Illinois. Facilities with exercise programs for seniors or ages fifty and older were contacted, such as YMCA, Mettler Center, Refinery, The Fitness Center, Yoga Institute of Champaign Urbana, McKinley Fitness Center, and Living Yoga Center. The researcher worked with each supervisor and activity director to announce the information regarding this study by placing flyers in facilities and through online community boards. The flyer included qualifications to participate and the researcher’s contact information (APPENDIX B). When a participant emailed the researcher to participate, the researcher replied with an informational letter with the purpose of the study and set up dates, times, and meeting areas for the face-to-face interview. The time and location of each
interview was arranged based on availability of the participants. Participants were compensated for participating in this study with a $10 Target gift card.

Before each interview began, the participants were informed about the purpose and procedures of the study and asked to review and sign a consent form (APPENDIX C). For confidentiality of participants’ identities, each participant was assigned a number. In the beginning of the interview, a clear definition of activewear were explained, and each interview session was audio recorded and lasted approximately 20 to 40 minutes. After each interview, the researcher recorded reflective commentary through detailed memos to document procedural decisions and notes about potential themes and patterns emerging from the interviews. The signed informed consent forms and data collected from the participants remained confidential. The transcripts and audio recordings were kept in a locked file for security. The aforementioned participants’ assigned numbers (e.g. P1 and P2) were used in any reporting of quotes.

Interview Development

The semi-structured interview questions (APPENDIX D) were developed based on FEA consumer needs model and previous design research investigating specified target markets and clothing related issues (Lamb & Kallal, 1992; Park, 2014; Zhang, 2004). Semi-structured interviews allowed participants to express their views openly and fully without excessive probing from the researcher (Esterberg, 2002). A short paper-based survey included questions about demographic information, such as age, income, education level, body type/shape, and exercise routines, as well as satisfaction level with current activewear in the marketplace were developed (APPENDIX E). An interview protocol was developed to guide the face-to-face interview sessions (APPENDIX F).
The Researcher’s Role

In qualitative research, the researcher’s role is important since the background of the researcher has a significant impact on the research process including research topic selection, data collection, and data analysis. For example, the researcher’s gender, age, and ethnicity, and the researcher’s set of personal values, as well as the researcher’s cultural landscape position all influence how the researcher perceives and interprets life (Saldana, 2015). Thus, the researcher examined her background to understand the perspectives including the assumptions and beliefs she brings to this particular research.

The researcher is an Asian, in her late 20s with a passion to improve quality of life through her specialization of apparel design and product development. Specifically, the researcher’s interactions with her mother motivated her to conduct a research on this topic. Her mother is a female boomer, in her late 50s, and recently started regular indoor fitness activities. Her mother constantly expressed difficulties in finding activewear that satisfy her needs. The researcher tried to help her mother find activewear from both online and offline stores, and realized that there was a limited selection of activewear for more mature women. From this experience, the researcher assumed that other female boomers might also have difficulties in finding activewear that satisfy their needs. The researcher further wondered what design attributes would improve the activewear market for female boomers.

The researcher had the position of outsider and insider. She recognized her outsider’s position because she is in her late 20s and not going through the same body changes that female boomers are experiencing. The researcher embodied an insider position because of her gender and her personal experiences of finding satisfied activewear in the current market. As a doctoral student in the discipline of textiles and apparel, the researcher’s professional
industry experience and coursework have prepared her to explore this topic. She has industry experiences in the women’s wear market in the apparel industry as a technical designer and a production manager where she examined fit and style issues for target consumers. In academia, the researcher specialized in apparel design and developed skills in garment pattern making and draping, as well as using virtual prototyping technologies. She has also conducted studies using both inductive and deductive approaches to understand consumer behaviors. These experiences prepared the researcher to be an effective researcher and a designer that suit the needs of this topic.

**Data Analysis**

To analyze the data, the audio recordings were first transcribed by the researcher. The researcher reviewed the transcribed data several times to gain overall understanding of the data. To identify and build the data into understandable units, open coding that generates categories of information was conducted. It is an extensive process where units of raw data were named to identify underlying concepts (Corbin & Strauss, 2007). As the initial phase of open coding, transcripts from every fourth interview were independently read and coded by the researcher and an audit coder (the dissertation advisor) using MaxQDA a software package for managing and analyzing qualitative data. Both coders have backgrounds in apparel design/product development and qualitative research. Meetings were held after the analysis of each transcript to discuss the concepts they identified and after negotiations of first two interviews, a preliminary coding guide was developed with early coding terms and definitions. This coding guide was discussed reviewed by the researcher and advisor. Constant comparative analysis (Strauss & Corbin, 1990) was then used to continuously contrast incidents both within and between the data and develop descriptive codes (Miles &
Huberman, 1994). The data were examined line by line and subthemes within a theme were identified. The coding guide (APPENDIX G) was reviewed and revised continuously by the researcher and advisor to refine coding techniques and definitions and to prevent the researcher from imposing concepts determined a priori or based on personal bias.

For the coding process, MAXQDA 12, a software program designed for computer-assisted qualitative and mixed methods data, was used. Each transcribed interview was uploaded in MAXQDA workplace and which allowed the researcher and advisor to easily assign code to segments of texts from the interviews and create a coding system that could be shared with each other. In the coding system, codes can be arranged and combined through MAXMaps according to its hierarchical tree structure with multiple sub-codes for content analysis if needed. As shown in Figure 3.2, the researcher created a coding system that was easily browsed through with assigned color-coded segments. The coding system shows the numbers of codes across the 15 interviews and allowed the researchers to leave sticky notes to address any questions or write any information regarding the code. Figure 3.3 shows an example of coding for MAXMaps that was used to organize each code in the coding system.

![Figure 3.2. An example of MAXQDA code system for participant 9 in this study.](image-url)
For establishing trustworthiness of the analysis and data, several actions were taken. Terms such as trustworthiness, authenticity, and credibility address validity in qualitative research (Creswell & Miller, 2000). A second coder, the dissertation advisor, coded the transcripts separately. Then the researcher calculated inter-rater reliability coefficient to determine the level of consistency of coding. Inter-coder reliability coefficient was calculated by multiplying the number of coders (2) by the number of agreement scores divided the total number of decision scores, which is the number of codes that were assigned by the two coders (Touliaitos & Compton, 1988). Miles and Huberman (1994) recommended that the consistency of the coding be in agreement at least 80% of the time for good qualitative reliability. Disagreements in coding were negotiated between the researcher and the second coder, and the inter-coder agreement was 95% for this study. Other strategies for ensuring credibility included frequent debriefing sessions with the advisor and the researcher’s reflective commentary which all enhanced credibility in preference to internal validity (Shenton, 2004).
Phase 2. 3D Virtual Prototyping

Procedure

Based on the interview data from the first phase, design attributes of activewear for female boomers were identified. As discussed in the literature review section, the integrative process model for universal design (IPD-UD) by Park (2014) guided the development process of prototypes. Specific design process included: (a) 3D comparison of female boomer and missy figures based on ASTM D5586/D5586M-10 and D5585, (b) 3D tension map testing, (c) interaction matrix and design problem-approach analysis, (d) design sketches, (e) 2D virtual pattern making through Optitex, and (f) 3D simulation of virtual try-on.

Instrument: Optitex PDS System

Optitex PDS system was used to aid the design process of activewear prototypes for female boomers. 2D and 3D virtual product development would allow designers to virtually create and manipulate garment patterns, as well as retrieve real-life sample simulations. Even though 3D simulation technology has some limitations, such as discrepancies between visualized fit and actual fit, according to Dunne 2012, it offers “dramatic increase in time required for 3D pattern tests, augmented visualization of the transition between 2D and 3D, and enhanced visualization of the relationship between garment and body” (para. 15). As shown in Figure 3.4, the researcher could extract body measurements from various angles and poses and use virtual try-on application to test pattern fit before constructing a sample. The Optitex (2014) promotes the effects of virtual prototyping as “a picture is worth a thousand words and a prototype (virtual product) is worth a thousand pictures.”
Development of Parametric Avatars: ASTM D5586/D5586M-10 and D5585

The American Society of Testing and Materials (ASTM) D5586 and D5585 were used to develop parametric avatars for this study. ASTM D5586 provides a list body measurements of adult women age 55 and over. These body measurements can be used as a baseline in designing apparel for adult women in the age group. This database of body measurements is the results of an extensive anthropometric survey of 6,786 United States women age 55 and over and are representative of mature women’s physical characteristics. Researchers have suggested that ASTM D5586 is an invaluable database for developing well-fitting clothing for mature women (Campbell, 1998; Charbonneau, 1999).

ASTM D5585 was used to develop a virtual avatar of conventional adult missy figure. This lists body measurements of missy figure, at a standard height of 5 feet and 5 inches that are currently used in the apparel industry. The measurements were developed from data published by the United States Department of Commerce, Caesar Study, Size USA Study, current USA industry and studies, plus scans and documentation from Alvanon.
Incorporated (ASTM, 2011). For developing virtual avatars, size 10 from both ASTM D5586 and D5585 was chosen since the size 10 was the most common size from the qualitative results in Phase 1 of this research project. Using the body dimension or morph dialog, each measurement was inserted and the avatars were morphed to represent size 10 of both female boomer and missy figures. The morphed avatars did not precisely reflect the body measurements of ASTM data, since it was not possible to control all morphs. Some body parts such as the measurements of outseam and inseam were automatically connected to the front and back waist lengths. Despite this limitation, parametric avatars that best reflect the ASTM measurements were created and successfully compared both missy and female boomer body shapes.

3D Tension Map Testing

3D tension map testing was conducted to examine fit differences between missy and female boomer figures. By comparing these two figures, it aids in visualizing and confirming the fit issues that participants had expressed in the previous phase. It also reflects body changes of female boomers and may provide insights for improvements for garment fit. To inspect the amount of physical tension influencing the cloth, various tension map testing in 3D simulation were conducted. Both tension and stretch options were used that estimate how much the material is “distorted” away from its default shape. Stretch is measured in percent-wise change (%) in the area and tension is measured in absolute in gram-force-per-cm (gf/cm). A total of eight tension map testing is conducted: Tension XY, tension X, tension Y, stretch XY, stretch X, stretch Y, normal collision pressure, and tangent collision pressure. Optitex Inc. (2017) describes and defines each testing as follows:
1) \textit{Tension XY} (fg/cm) measures the amount of physical tension influencing the cloth by looking at the gradient of UV changes.

2) \textit{Tension X} (fg/cm) measures the amount of physical tension influencing the cloth in the warp direction along the baseline of each piece.

3) \textit{Tension Y} (fg/cm) measures the amount of physical tension influencing the cloth in the weft direction perpendicular to the baselines of each piece.

4) \textit{Stretch XY} (%) measures the amount of the fabrics’ expansion in a percentage. The area of each face at the end of simulation is computed relative to the original face area.

5) \textit{Stretch X} (%) measures the amount of the fabrics’ expansion along the warp direction (meaning, how much the cloth stretched along the warp). As a ratio of the final face length to the initial face length along baseline *100%.

6) \textit{Stretch Y} (%) measures the amount of the fabrics’ expansion along the weft direction (meaning, how much the cloth stretched along the weft) as a ratio of the final face length to the initial face length in the direction perpendicular to the baseline *100%

7) \textit{Normal Collision Pressure} (pressure is the force per unit area). This option draws a heat map of the residual collision forces applied to each face in the direction perpendicular to the cloth’s mesh.

8) \textit{Tangent Collision pressure} (pressure is the force per unit area). This option draws a heat map of the residual collision forces applied to each face in the tangent direction along the cloth’s mesh.
Lastly, Adobe Illustrator and Photoshop were used to create design details (e.g., textile patterns, construction details) that may be integrated into prototype development.

**Phase 3. Online Survey**

**Sample and Procedure**

An online survey was conducted with convenience sampling. The sample design for this population would be a single-stage sampling procedure. A convenience sampling of 350 participants was recruited through Research Now, an online sampling and collection company. Only females who are in the age bracket of baby boomer generation were invited to participate in the survey. The prospective participants received an invitation letter along with a web-link including a short web-based questionnaire that would take about 15 minutes to complete. The invitation letter included the purpose and the significance of the study, a request for participation, and a guarantee of confidentiality of information (APPENDIX H). By clicking the URL for the questionnaire website, participants would consent to participate in the survey. The participants could voluntarily take part in the research on their own accord.

**Instrument Development**

The survey questions consisted of three parts for the evaluation stage of the prototypes with both closed and open-ended questions (APPENDIX I). The first part of the questions contained items to assess demographic information that included age, ethnicity, education level, martial status, perceived body shapes and income. The second part of the questions included assessing the prototypes in terms of FEA needs. The third part contained questions assessing female boomers’ wear intention and the effects of FEA variables. The
research variables adopted into questions answered on a seven-point Likert type items, ranging from *Strongly Disagree* (1) to *Strongly Agree* (7), except attitude, which included seven-point semantic differential scales.

For perceived comfort (functional attributes), the instrument included four items with bipolar adjectives, each measured on a seven-point scale. The adjectives were adapted from a wearer acceptability scale developed by Huck, Maganga, and Kim (1997). Three items measuring perceived compatibility (expressive attributes) were adapted from Ko et al. (2009). The researcher measured perceived compatibility of smart clothing with questions on a five-point Likert-type scale, ranging from *Strongly Disagree* (1) to *Strongly Agree* (5), with a Cronbach’s alpha of .83. The researcher also adopted questions on seven-point Likert-type items based on a study by Eckman et al. (1990) for perceived aesthetic (aesthetic attributes).

In reviewing the criteria for evaluating women's apparel, the study by Eckman et al. (1990) found that an aesthetic set of intrinsic criteria, such as style, color and pattern, fabric, and appearance, are important criteria for the consumers. Based on the data from the first phase, the scales for age appropriateness and wear intention were developed to fit the context of this study as criteria for evaluating the prototypes. Face validity of the instrument was conducted by several researchers in the areas of textiles, clothing, and merchandising to confirm the clarity of the items (Burns, 1996).

**Pretest**

Prior to the main survey, a pretest was conducted to assess the clarity of the questionnaires, the website’s function, and to determine the participation time. The pretest was conducted with a convenience sample of 10 female boomers from a senior group at a church. The prospective participants received an email requesting their participation in the
web-based questionnaire and they were asked to note and provide feedbacks for any problems or difficulties they experience in completing the questionnaire (e.g., whether the instructions are clear, wording is clear etc.). Based on the pretest results and participants’ recommendations, the questionnaire and web-based survey procedures were modified.

**Data Analysis**

When examining female boomers’ evaluations and perceptions towards the prototypes, SPSS version 19.0 was used. Descriptive statistics were run and reported in the quantitative phase. The analyses would provide respondents’ demographic background profiles and user assessments of the proposed prototypes. Both exploratory factor analysis and confirmatory factor analysis were conducted to assess the convergent and discrimination validity of the research constructs. A reliability analysis was also conducted to test an internal consistency of measures by the Cronbach’s *alpha*. A minimum value of .70 was adopted for assessing internal consistency, because a Cronbach's alpha value of .70 or higher is considered a sufficient reliability for an item (Nunnally & Bernstein, 1994). A multiple regression analysis was conducted to test the effects of the FEA variables based on a proposed model in Phase 1.
CHAPTER 4. RESULTS

This chapter reports the results from the three phases of the sequential exploratory mixed methods study: (a) face-to-face interviews, (b) virtual prototyping, and (c) online survey. Both qualitative and quantitative results are presented and organized by the research questions that guided this study:

RQ1. What are functional, expressive, and aesthetic (FEA) needs for female boomer activewear?

RQ2. What are the design attributes of activewear for female boomer market and how do they differ from younger generations?

RQ3. How do consumers evaluate and perceive activewear that are designed for female boomers?

The results from each phase provide answers to these questions, followed by discussions.

Phase 1. Face-to-Face Interviews

Sample Profile

Participants in the first phase included 15 female baby boomers between the ages 55 to 69 years. The average age was 62 years old where nine participants were in their mid 50s to early 60s, and six of them were in their late 60s. All of the participants resided in Urbana-Champaign, Illinois and most of the participants (n=14) identified themselves as White and one participant identified herself as Asian. A majority of the participants (n=10) were retired; two participants were employed part time and other three were employed full time. For the martial status, ten participants were married, two were divorced, and one was a widow. More than half of the participants (n=8) had Master’s degrees, followed by Bachelor’s degrees (n=4), high school diplomas (n=2), and an Associate degree (n=1). The participants were
very active and exercised everyday \((n=3)\), five to six times per week \((n=7)\), and three to four times per week \((n=5)\). Five participants identified themselves with full hourglass body shapes followed by apple \((n=3)\), pear \((n=3)\), inverted triangle \((n=2)\), rectangle \((n=1)\) and lean column \((n=1)\) as shown in Figure 4.1. Six of the participants indicated that they usually wore a size medium \((M)\), four participants wore a large \((L)\), three wore an extra large \((XL)\), and two wore a small \((S)\) for top and bottom in general. All of the participants’ perceived health was good overall, and their satisfactions towards current activewear were dissatisfied \((n=5)\) followed by unsure \((n=3)\), somewhat satisfied \((n=3)\), and satisfied \((n=2)\).

**Research Question 1: Functional, Expressive, and Aesthetic Needs**

From the analysis of the interview data, the major theme *Exercising as new lifestyles* emerged in regards to the participants’ views, beliefs and actions related to exercising and aging. The interview data also revealed sub-themes of the established a priori themes of functional, expressive, and aesthetic needs specifically for activewear.

![Figure 4.1. Female boomers’ identified body shapes.](image)

**Exercising as New Lifestyles**

Participants’ responses to integrating exercise as a vital component of their lifestyles
showed as important factors influencing design attributes of activewear. Three sub-themes emerged under *exercising as new lifestyle* related to *active and consistent exercise routines, reason for exercising,* and *attitudes towards aging.*

**Active and consistent exercise routines.** Female boomers’ current exercise details indicated that they had *active and consistent exercise routines* with variety of physical activities including both individual and group workouts. The exercises included walking [*all participants*], yoga [*all participants*], Pilates [*n=8; P1; P2; P3; P6; P7; P10; P14; P15*], aerobics [*n=7; P1; P2; P7; P8; P9; P14; P15*], tai chi [*n=3; P1; P7; P8*], cycling [*n=2; P13; P15*], and weight lifting [*n=2; P13; P15*] at a fitness center. Most participants exercised everyday or at least four times per week, lasting more than an hour. Some participants exercised in both the morning and evening and engaged in different physical activities every night. In addition to their indoor exercise routines, some participants also engaged in outdoor exercises such as biking and hiking. For instance, participants rode a bike for transportation as P11 and P14 said respectively, “I use it [biking] for transportation, I try to bike to the library, to my yoga class” and “On the days that I don’t do classes, I walk or ride my bike.” Female boomers also “walked around neighborhood” [*P5*], “hiked at the local parks” [*n=3; P5; P6; P15*] and “walked to Farmers Market and church” [*P9*].

All of the participants acknowledged that they exercised more now, compared to when they were younger, because they now have more time to exercise and have access to facilities. For instance, P9 noted that starting in her 40s and 50s, she tried to be more active and after she retired, she had “a lot more time to be active” and felt exercising was a good way for her to spend her time. P15 also expressed that her lifestyle has changed after retiring:
If anybody told me I would get up early and go exercise three times a week now that I'm retired I would have said you are crazy! I tend to be a night owl so getting up at 7 to go exercise is insane to me, but I do it now.

Some reasons that female boomers could not establish a regular exercise routine were due to limited access to facilities and their children. P9 said a limited access to facility was a barrier that she could not exercise when she was young: “Say in my 30s and certainly college aged. When you were in college there were no things to go—you just take PE” [P9]. Another reason was due to their children as P2 noted, “I was not even interested in any of these [exercising] until my children are gone and about 20 years ago, I did exercise again and then last five years I got into the group exercise in a class” [P2].

**Reasons for exercising.** Female boomers expressed that they exercise because of physical and mental benefits, influence of family members, socialization, and commitment to group exercises. All of the participants admitted that both physical and mental benefits through exercising were priority and important proactive approaches when preparing for their ‘older’ years. One participant said, “I figured out that doing this [exercising] is a priority for me right now and again in preparation, I’m 65 so in preparation for you know, the next 20, 30 years whatever that looks like” [P10]. Female boomers wanted to keep up their healthy body as one participant noted, “I just wanted to be healthy. I want to live for a long time and I just want to keep my healthy body” [P2]. Specifically participants exercised for physical benefits, mostly for weight control, to lose or maintain weights. Along with controlling their weight, participants exercised for other physical benefits such as developing body strengths and energy [P7; P10; P11]. They believed that body strength and energy prevented falls for boomers and reduced aches or pains.
Few of the participants expressed that seeing their family members physically disabled due to aging, influenced them to exercise. For instance, P10 watched her parents and parents’ in-laws age and eventually pass away and said, “I always kid about how I want to be able to lift myself up out of the wheelchair or off the toilet and people don't think about that. [Looking at them] I want to able to do that.” Another participant indicated her grandmother and her great-grandmother motivated her to exercise since “they all died from dementia and didn’t know their children when they died” [P9]. Thus, she wanted to keep her brain active by exercising and thought these goals motivated her to exercise.

Importantly, participants indicated that one of the most important benefits they gained from exercising is the mental benefit of ‘feeling good’ factor, which boosts their moods. Further, participants enjoyed group exercises because of its socializing aspects and the creation of a collegial community. One participant said, “So, and now I’m part of a very large group of people at this gym whom I got to know and it’s a real community of people working toward feeling great, and admiring each other” [P1]. These female boomers also felt committed to exercising and their community provided motivation and accountability. P11 and P15 said respectively, “I have to make myself go. That's why I do a class. I'm not good at exercising on my own... but class I'll go I'll go and do the class” and “I always enjoyed the group because I like the friends and you know people notice if you are not there and it makes you accountable.”

**Attitude towards aging.** These female boomers’ overall attitude towards aging is an important factor that relates to age appropriateness and would influence their functional, expressive, and aesthetic needs of activewear. The participants were not ashamed of being older and proud of being baby boomers. P11 said, “It’s like a lot of women of my age we
don’t think as… like act into aging. We are proud of aging. Aging is beautiful. I love my silver hair. I love my age, I like to be with all ages of people.” Especially, many of the women distinguished themselves to the ‘old’ groups and did not want to look like the traditional ‘grandma look’: “There were clothes to me that looked like grandma that I didn't want to try on” [P15]; “I would hate for us [women in her exercise group] all to have to wear grandma outfits” [P12]. Interestingly, most of the female boomers considered themselves old, but to a degree, as one participant said, “I think people in my age group in general, we don't consider ourselves, I mean, we are old but not like old old, we are still active” [P11]. P11 further said, “When I think of what older people are now wearing, and it is ugly. It's frumpy and unattractive and… Yeah. I don't want to be in that group. Ever! Even when I'm that old, I don't want to wear those clothes.”

**Functional Needs**

In this study, five themes were identified as functional needs for female boomer activewear: *comfortable fit, thermal comfort, covering imperfections, smart functions* and *athleisure of dual function*. Sub-themes that emerged under *comfortable fit* related to sports bras, desired compression and support for bottoms, crotch length for bottoms, excessive compression and short length for tops. The major theme, sub-themes, and micro-themes of functional needs are discussed below.

*Comfortable fit.* Participants reported that *comfortable fit* in terms of the relationship between clothing and body is one of the most important priorities when selecting activewear, When female boomers referred to physical comfort when wearing activewear, they interchangeably used the terms fit and comfort. P4 and P5 said, “Fit and comfort. They are very important to me, you know, fit and comfort I guess they are kind of related” and “When
selecting clothing, comfort and fit are the most important to me.” In general, participants expressed that good fit and physical comfort make them, “feel better and workout more pleasant” [P3], “more comfortable and feel better” [P6], “always feel better” [P9], or “want to wear more, and buy more of them” [P12]; whereas uncomfortable fitting clothes made their “workout less pleasant” [P1]. Thus, some participants cared more about comfort than being brand conscious as P10 said, “And I’m not tied to a brand name. If I found something that really worked and was comfortable… I don't care if it has a swoosh on it or whatever.”

Sports bras. In terms of comfortable fit, participants had the most issues with comfort and fit of sports bras due to their body changes. Participants said their breasts became sag and bigger as they aged: “How has it changed? It's gone south. Just coasts down. That's the worst part” [P14], while it was lamented, “I have a fairly good figure. I wear a size 8 but do have those middle age like um saggy breasts…I look in the mirror at the gym and they are sagging --ugh!” [P4]. Thus, it was difficult for female boomers to find well-fitting and comfortable sports bras. Participants 6 and 11 respectively said, “And I find it difficult to find sports bras that fit well and are comfortable” and “I am big around the chest, but not big busted so if you get it big enough around the chest you know cups that are ridiculous. So I have a hard time finding a sports bra that actually fits me.” In terms of fit issues, participants want “more support and shape” [P6] as well as bigger size that reflects their body changes. They have also noted that sports bras are extremely difficult to wear. Along with these dissatisfactions, several participants expressed preferences for built in bras with camisole: “a tank top with a built in bra” [P11] or “a camisole with inserted built in bra top” [P4]. The built in bra, according to the participants, are supportive and comfortable in that: “The camisole tops that I wear are really just single straps so I can wear the camisole top over a
bra…If there was something that was a bra and a camisole top that would be perfect” [P8]. Participant 9 echoed these thoughts in: “Not necessarily a bra but it’s a cami-built in with a little bit of support. I don’t like sports bra because they are hard to get off when you are sweaty, so I love tops with built-in, and with one layer.”

*Desired compression and support for bottoms.* The participants considered tightness or compression capabilities of garments as one of the most important factor that influence comfortable fit when wearing activewear on the lower torso of the body. For instance, P7 and P3 respectively stated, “I like it to be a bit tighter or form fitting than my regular street clothes” and “I want to have tighter, not that tight but a bit more around the body so it helps me to see my posture.” Especially, as P3 stated above, form-fitting factor is directly related to comfort since the clothing influence participants’ movements and mobility while exercising. In terms of fit and tightness of the bottom, participants noted that poor support around the waist is an issue: “I had to keep pulling up my pants from sliding down and that bothers me. That’s not comfortable. So I rather have tight waist and not distracted by the loose fit” [P7]; “I found things that I like higher waist with leggings that they don’t slide down and you don’t have to keep pulling them up” [P1]. For instance, P9 said, “I want the clothes to fit properly and not bag or bind. In other words, I don’t want to be restricted or distracted by the clothing that I wear I want to focus on my movements and activities.” As a solution, she further said, “I wish that the waistbands had a wider elastic in them. I like something to be more firm or support my stomach.” The participants wanted more support for bottoms, especially on the waist areas, and further expressed about having more compression and supports like shapewear effects to “just hold on to the stomach” [P4] and “give strengths and firmly hold my form and support my body [P7].
Crotch length for bottoms. Other factors that influence comfortable fit when wearing activewear was the crotch length, a measurement of the distance from waist level at the center front, through the crotch and to the waist level at the center back. Participants had issues with having too short crotch length. For instance, P8 said, “So many of them you look at the crotch area and it's like two inches. No way. As I've gotten older, I'm not happy about it, I've gained weight, I have weight around my belly, which I never had before” [P8]. Some did not like if they are “too tight around the crotch area or too short” [P10], and they wanted “longer crotch area” [P9]. Further in terms of lengths, participants want to have “higher waist” [P13], and “mid-rise” [P8].

Excessive compression and short length for tops. Unlike the issue of loose fit for the bottoms, participants indicated problems of having too much tightness or compression with activewear tops and the tops “just don’t have ease” [P3]. Thus, for female boomers, tops were more difficult to find compared to bottoms. P14 and P8 said respectively, “Their pants fit fine usually the tight pants because I like them tight but the tops they just don't fit. They are too tight and I don't want too tight” and “I don't like the way they [tops] fit. I don't like a top to fit tight. I want some looseness there and I have to wear a bra.” Along with excessive compression, female boomers were also dissatisfied with the short length of the top where most of them do not hit under waistline or “cover the hip areas” [P3] and wanted it to be “longer and looser” [P14]. Participant 7 stated, “I wish that the length of the workout shirts was longer. I hate to have it ride up during yoga,” while participant 12 felt, “I would like to have longer tops that are not just like a big box” [P12]. Participant 14 summates, “All these girls wear theses really short tops and they show their belly but when you get my age you don’t want to show your belly anymore so you want the longer and looser top.”
Thermal comfort. The next sub-theme after comfortable fit is thermal comfort. The body temperature becoming too hot and resulting in sweatiness was a major issue with female boomers when exercising. However, sometimes, keeping body temperature low conflicts with breathability when wearing form-fitting clothing and these female boomers expressed that changes of their body temperature, especially being hot and sweaty, is a big factor that impacted the comfort of activewear. P3 said, “Comfort is a big one. Like its weight, because it’s hot. I really want some breathing because I get really hot… when you are overweight, you sweat more. So it’s [ priority of clothing] kind of more cooler and comfortable.” Some female boomers said they had passed the stage of hot flashes, but menopause still affected their body temperature: “I just get too hot when I work out. I don’t want to be distracted by being hot, and I want to concentrate on the class. I already passed on all that, the hot flashes. I just like to be cool as possible” [P2]. As participant 13 summarized:

I don't think it’s hot flashes so that's very weird I know. I'm usually cold most of the time except when I exercise and then I'll get hot pretty fast… Instead of having an entire area that's soaked, it's maybe just right around the neck.

The issues of being hot influenced participants’ preferences of garment lengths, especially the desire for shorter leggings and sleeves. Participant 13 expressed that being hot was an issue for her and she would “rather have sleeveless and be more embarrassed about my arms.” P4 also noted that she liked the lengths to be “long enough to hide jiggly arms but short enough to allow movement and not be too hot.”

Thermal comfort further influenced female boomers’ preferences on fabrics. They acknowledged that because of its flexibility, spandex or its blend is ok for bottoms: “If you wear just cotton shorts, they are usually not flexible, they don't feel stretchy or comfortable”
However, most participants noted that they preferred cotton or cotton blend for tops since the materials made them cooler and felt it was comfortable. Participant 5 stated, “I just like to wear comfortable clothing and I think cotton is comfortable.” Thus, participants wanted “more good quality cotton active wear for boomer women” [P6], “100% cotton fabrics for tops” [P11] and “cotton or cotton blend shirts” [P5].

**Covering imperfections.** The third sub-theme of functional needs is **covering imperfections** where the participants expressed their needs to cover body imperfections through clothing when exercising. Participants did not want to expose their knees since they “don’t feel confident about showing knees” [P7] and since their knees “are not pretty” [P7], “got too many wrinkles” [P14], and “have bump that is bursitis and so it looks very strange” [P9]. P9 further said, “At our age your skin is not what it was when you were 25.” Specifically, female boomers wanted to cover up their varicose veins, some are “very deep dark veins” [P10], around knees and thinning skin that are “not the same elasticity” [P9] due to aging. Participants 3 and 2 said, “I tend to go with capris, which is actually age related because of veracious veins” and “My legs are least attractive, because I have some, not many, spider veins.”

Another body part that most of the female boomers wanted to cover up or disguise was their hips. As they have expressed about their dissatisfactions with short lengths of tops, the participants wanted to have longer hems to cover their imperfections. Covering imperfections, such as hips, was related to psychological comfort that is “mentally comfortable” [P3] because exposing the areas bother them when exercising. For most of the female boomers, upper arms were another imperfections that they wanted to hide while
exercising describing them as “jiggly arms” [P4] and “bat wings” [P6]. Thus, they did not prefer sleeveless, but rather shorter sleeve lengths in garments.

**Smart functions.** Another functional need for female boomers was identified as *smart functions*. When participants were asked if they were interested in any smart functions or used different forms of body mounted technology for activewear, they indicated that they were interested and perceived the functions to be useful in improving their lifestyle and exercise routines. All of the 15 participants were interested in cooling technology for temperature control, followed by monitoring heart rate, tracking steps, UV protection, tracking calories burned, and monitoring respiration and muscles. Nine out of 15 participants were already actively using some kind of wearable technology such as Fitbit and Google watch to monitor their heart rates. Particularly, participants expressed that those technologies motivated them to exercise more since they could document and overview their physical activities and set goals:

> For me, it was a helpful tool that put me on track with my exercising. Sometimes, for me, the best way to do that was be aware of what I'm accomplishing and kind of give me goals and so I mean, I know not everyone needs to have one, it just works me kind of like a fitness pal where you monitor activities and your eating for me…if that helps you stay on track then it's worth it and that's why I use it. [P13]

Female boomers could see improvement over time by downloading the data on computer as P15 stated, “[I can download the data] and say that was a terrible month or it gives you your resting heart rate for thirty days and you can see how your heart rate is doing or if you are improving. I can't imagine not having one.” Participant 15 also noted that she wanted “more technology and more functionality” and for devices to be more “flexible and maybe more
fashionable.” Other smart functions that the participants were interested in included UV protection and cooling tech because, “I don’t know how it would work, but that is something I would be very interested” [P2].

**Athleisure of dual function.** The last theme for functional needs is *athleisure of dual function*. The participants’ lifestyles and exercising routines influenced them to wear clothing that were suitable for both functions of athletic apparel and casual, everyday wear. Most of the participants acknowledged that they wore activewear for daily wear. For example, P6 noted that she “put activewear in the morning and normally end[ed] up wearing it until night”, and others also wore activewear to outside for “running daily errands” \([n=7; \text{P1}; \text{P2}; \text{P4}; \text{P5}; \text{P10}; \text{P11}; \text{P13}]\) or “going for grocery” \([n=7; \text{P1}; \text{P2}; \text{P4}; \text{P5}; \text{P9}; \text{P10}; \text{P13}]\).

Specifically, comfort and convenience were important factors when wearing athleisure. For instance P14 said, “After I get done with the class, I keep this stuff on and I just wear it. Yes, I do wear it out, too. It's comfortable to me.” She further said that after she retired, she did not want to dress up: “Since I retired I don't want to dress up, I don't want to put anything nice on I just want to wear sportswear but I want it to be nice for my daily wear.” Female Boomers wanted exercise clothing that they could wear daily “to run errands afterwards” [P4] and “to go to the grocery store afterwards” [P15].

The participants further indicated that layering systems or layering clothing items (e.g., camisole, shirts, tunic, vest, sweaters etc.) together is essential for athleisure. By layering a tunic or long shirts over base layers such as camisole or leggings, the outfit was transformed to everyday wear clothing. Further, layering system also enhanced female boomers’ exercising so they could take off outer layers as the body temperature increased due to physical activities:
Which is interesting because I don't normally dress in layers but I do layers for yoga...I wear black capris and a black camisole top and then I have a collection of shirts and like flowy tops that are yoga like that I wear on top of that and then as I move through the practice and I start getting really warm and sweaty. I'll take the top off and then just wear the camisole and capris. [P8]

Another important factor for athleisure style was having pockets. Interestingly more than two third of the participants have expressed their dissatisfactions of not having pockets on activewear and that it was difficult to find activewear with pockets. For instance, P3 noted that she did not like carrying a bag with her all the time and end up sticking her keys in her bra or her waistband. The participants wanted pockets for “keys” [n=5; P10; P3; P9; P15; P6], “money” [n=5; P10; P3; P9; P15; P6], “kleenex” [n=2; P10;P15], “iphone or ipad” [n=3; P3; P4; P10], “little punch card” [P10], and “wallets” [n=2; P6; P15]. Some participants wore pants with pockets and were satisfied with the functions and wanted the styles to be unobtrusive.

**Expressive Needs**

In this study, two sub-themes, *age appropriateness* and *body consciousness* were identified for expressive needs in terms of female boomer activewear. Both age appropriateness, how female baby boomers looked appropriate and suitable for their own age group, and body consciousness, perceived appearance and image of one’s own body, were important factors influencing design attributes of activewear. The major theme and sub-themes of expressive needs are discussed below.

**Age appropriateness.** For female boomers, appearing age appropriately was an important factor when wearing activewear. Specifically, looking not too young influenced
female boomers view about the age appropriate style. For instance, P8 and P10 said respectively, “I don’t want to look like everyone my own age but I don’t want to dress inappropriately and look like I’m twenty” and “I want something that’s again, age appropriate because I don't want to look too young.” One of the important aspects of age appropriateness when wearing activewear was identified as limiting the amount of skin revealed. Participants 15 and 10 said, “Revealing. Yeah, that would be the most age appropriateness thing for me” and “I think some people would say a 65 year old woman of my size going out in public going out in stretch pants is never age appropriate, but I think it's okay. I think the problem is maybe too much plunging, showing too much skin.” Female boomers felt that clothing that is revealing “is for younger girls” [P2], “doesn’t look appropriate even though you are in a great shape” [P9] and “is not attractive where older women wear that type of [revealing] necklines” [P3].

Along with revealing skin, female boomers also viewed that revealing body in terms of tightness or “skin-tight” [n=4; P4; P5; P14] are not age appropriate. Further, one of the important aspects was looking appropriate when outside while wearing activewear. For instance, P5, P9, and P10 noted that they were professional people before retiring, and they wanted to be more presentable and did not want to feel embarrassed outside. The women perceived that age appropriateness also mean wearing clothing that was appropriate for body shape. Participants 2 and 6 stated respectively, “I want others to think that I’m dressing appropriate for my body shape. Doesn’t really have to be with my age, like… I don’t want people to see and say, ‘oh my gosh, that top is too tight’” and “Emphasizing around the body shapes or the changes would be helpful for the mature group.”
Body consciousness. The participants valued their perceived appearance and body image with aging. Thus, their body consciousness in terms of aging influenced their preferences when wearing activewear. P14 said, “Yeah it's more of an age related thing. It's more of being self-conscious about the way I look basically… like how other people might see me.” Female boomers indicated that seeing how other people of their age can look good and healthy makes them feel good since “it shows somebody that it has mature body type that workout clothes can still look good on them [P2]. Thus, these female boomers wanted to see older models or models “that are realistic and what real women look like” [P8] in the industry so they could relate to the models and “see the fit of the clothes on somebody that looks more like me” [P15]. Participant 15 continued, “There are skinny minny people and like we need more people of all ranges as models and I think it’s great when older ladies, you know are out there proving that we are not all perfect.”

Aesthetic Needs

Three sub-themes were identified as aesthetic needs for female boomer activewear: simplicity in design attributes, slimming effects, and fashion consciousness. Micro-themes under slimming effects related to long lines and dark colors. The major theme, sub-themes, and micro-themes of aesthetic needs are discussed below.

Simplicity in design attributes. Participants expressed their dissatisfactions with complicated designs of current activewear. Participants 5 and 11 stated that they preferred simplicity in design attributes and generic styles because they are comfortable: “I don’t like the top with lots of straps on the back, I just like simple thing and it’s comfortable to me” [P5] and “I usually wear simple design and comfortable clothing” [P11]. Female boomers
wanted “not tacky but just something plain” [P11] or “a generic style that a young person can wear it and the older person [can wear]” [P2].

In terms of colors, appropriate colors also made female boomers comfortable since they do not draw attention. Thus, simplicity in design attributes including colors influenced their socio-psychological aspects of comfort. Participants preferred “black color” and “conservative in color” [P10] because they are age appropriate and blend in to others easily. For instance, P8 stated, “I just feel comfortable in black clothing” and P4 stated, “I wind up buying mostly black or grey stuff so I can go to do these things without looking like I am 20 years old and just got off the Yoga floor.” When asked about colors other than basic dark colors, a few of participants noted that mixing some hints of colors or subtle prints such as abstract or nature are doable and comfortable. Some participants were interested in camouflage textile designs, since they can hide imperfections. Participant 6 liked to wear solid but sometimes she preferred to have some prints on the bottom so “it can distract other people from seeing things on [her] body” such as “panty line.”

**Slimming effects.** Most of the participants expressed that they would like to see **slimming effects** or some types of visual illusions that make body figures appear slender. Particularly, they noted about issues on gaining weights, especially around stomachs and hips as they aged. Micro-themes that emerged from the interviews about slimming effects included: **long lines** and **dark colors**.

**Long lines.** When asked about design elements for slimming effects, some participants stated they would like to portray “nice line” [P9] and “long line” [P1]. They felt vertical lines such as seam lines or stylized lines through stomach or thigh areas made them look slender compared to the plain ones. For instance, P5 stated, “You know the vertical lines
make you look longer than like horizontal lines. I read it somewhere…but it was from one of the magazines, it talked about plus size dress and the effects of different lines.”

Dark colors. Participants also stated that they preferred dark colors for bottom since darker colors have natural slimming effects. They thought dark color “is slimming” and “make [my] body, thighs, and hips to look slimmer” \(n=4;\ P2;\ P4;\ P10;\ P15\). Especially, some participants said black color is a good camouflage compared to other colors and expressed that any other colors or prints would make them bigger than it looks. Thus, most of participants’ favorite colors were black and some reasons included that it has natural slimming effects or they feel comfortable in black color, as in these examples: “My favorite outfit is black capris”[P2]; “I always wear black” [P8]; “I usually buy basic colors like black or greys” [P5]; “I just feel comfortable in black clothing and I've always worn black clothing” [P11]; “I like a lot of things that are in black, because I love exercising in black and I only wear black leggings” [P1]; and “I mean my pants are almost all black” [P5].

Fashion consciousness. Even though participants wanted simplicity in design attributes and generic styles for age appropriateness, most of the women were fashion conscious and would like to incorporate some fashion trends into their activewear wardrobe if possible. For instance, P1 said, “I like to look at what trends are and see how I want to incorporate them.” A few participants noted that activewear that female boomers wore in their exercise class were not attractive: “I think that there is a few people in my exercise class who actually have exercise clothing who actually do look better than the rest of us. Most of them wear kind of the elasticized pants but then they will wear a big t-shirt that comes.” The participants wanted to look “modern” \(n=3;\ P1;\ P3;\ P14\), “stylish” \(n=4;\ P1;\ P5;\ P11;\ P14\),
“attractive” [P11], “nice” [n=2; P9; P11] and did not want to look “frumpy” [n=1; P11] or “baggy” [P14] while exercising.

**Phase 2. Virtual Prototyping**

**Research Question 2: Design Attributes of Female Boomer Activewear**

This section reports the results from the second phase of the sequential exploratory mixed method study to answer the second research question:

Research Question 2: What are the design attributes of activewear for female boomer market and how do they differ from younger generations?

The results are presented in the following order of design process: (a) 3D comparison of female boomer and missy figures based on ASTM D5586/D5586M-10 and D5585, (b) 3D tension map testing, (c) interaction matrix and design problem-approach analysis, (d) design sketches, (e) 2D virtual pattern making through Optitex, and (f) 3D simulation of virtual try-on.

**Comparisons of Parametric Avatars: ASTM D5586/D5586M-10 and D5585**

As discussed in the method section, two parametric avatars, female boomer (D5586) and missy figure (D5585) were developed. The comparisons show that in general, the torso of the missy figure (M) was bigger than the torso of the boomer figure (B): Bust (B= 32.6”; M=37.25”), waist (B=28.4”; M=29”), upper arm (B=10.66”; M=11.5”), chest width (B=13.52”; M=14.62), bust to bust point (B=7.03”; M=8”), and mid neck (B=12.4”; M=13.87). In terms of vertical measurements, missy figure shows mostly longer lengths except hip height (B=33.7”; M=32.5”): Height (B=64”; M=65.5”), knee height (B=17.31”; M=17.87), waist to hip height (B=6.85; M=8.25), front waist lengths (B=13.28”; M=14.5”), and back waist lengths (B=15.98”; M= 16.12”). The total crotch length of the boomer figure
was much longer (B=27.34”) than the crotch length of Missy (M=25.87”), and the hip of boomer figure was larger than missy’s (B=36.4”; M=35.75”). Especially, the degree of the shoulder slope of boomer figure (degree=22.34) was larger than the slope of missy figure (degree= 19.5). Table 4.1 shows the body measurements of female boomer and missy figure of size 10 based on D5586 and D5585.

Table 4.1. Body Measurements of Boomer and Missy Figures based on D5586 and D5585

<table>
<thead>
<tr>
<th>Girth Measurements</th>
<th>Boomer</th>
<th>Missy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bust</td>
<td>32.60</td>
<td>37.25</td>
</tr>
<tr>
<td>Waist</td>
<td>28.40</td>
<td>29.00</td>
</tr>
<tr>
<td>Hip</td>
<td>36.40</td>
<td>35.75</td>
</tr>
<tr>
<td>Midneck</td>
<td>12.40</td>
<td>13.87</td>
</tr>
<tr>
<td>Neck Base</td>
<td>15.33</td>
<td>14.87</td>
</tr>
<tr>
<td>Armscye</td>
<td>16.43</td>
<td>16.25</td>
</tr>
<tr>
<td>Upper Arm</td>
<td>10.66</td>
<td>11.50</td>
</tr>
<tr>
<td>Elbow</td>
<td>9.93</td>
<td>9.87</td>
</tr>
<tr>
<td>Wrist</td>
<td>5.98</td>
<td>6.12</td>
</tr>
<tr>
<td>Thigh, Max</td>
<td>21.01</td>
<td>23.15</td>
</tr>
<tr>
<td>Total Crotch Length</td>
<td>27.37</td>
<td>25.87</td>
</tr>
<tr>
<td>Knee</td>
<td>13.86</td>
<td>14.50</td>
</tr>
<tr>
<td>Calf</td>
<td>12.76</td>
<td>14.00</td>
</tr>
<tr>
<td>Ankle</td>
<td>9.18</td>
<td>9.37</td>
</tr>
<tr>
<td>Vertical Trunk</td>
<td>58.59</td>
<td>60.00</td>
</tr>
</tbody>
</table>

| Vertical Measurements  |       |       |
| Height                 | 64.00 | 65.50 |
| Cervical Height        | 55.79 | 56.25 |
| Hip Height             | 33.70 | 32.50 |
| Knee Height            | 17.31 | 17.87 |
| Ankle Height           | 2.58  | 2.75  |
| Waist to Hip Hgt.      | 6.85  | 8.25  |
| Waist Length, Back     | 15.98 | 16.12 |
| Waist Length, Front    | 13.28 | 14.50 |

| Width and Length Measurements |       |       |
| Cross back shoulder      | 15.18 | 15.62 |
| Back Width               | 14.28 | 14.37 |
| Chest Width              | 13.52 | 14.62 |
| Shoulder Length          | 5.08  | 5.12  |
| Shoulder slope (degrees of slope) | 22.34 | 19.50 |
| Shoulder to wrist        | 23.02 | 23.00 |
| Bust point to BP         | 7.03  | 8.00  |
| Neck to bust point       | 10.68 | 10.50 |
| Armscye depth            | 6.98  | 6.12  |

Note. *Measurements in inches
Reflecting the body measurements of D5586 and D5585, Figure 4.2 shows visual comparisons of the two developed avatars, illustrating the shoulder slope of the female boomer is higher and has more hunched back, changing the standing posture of the figure. Also, there is a difference in the shape of busts where older figure has smaller and sagging busts as seen from the front and side view. Even though some of the circumference measurements seem similar, missy figure has longer lengths such as longer waist to hip height, distributing the fat compositions, resulting a slimmer look than boomer figure. Further, boomer figure has wider and lower body parts especially the hip areas.

Based on the measurements of bust, waist, and hip (BWH) ratio, body shapes for both missy and boomer figures are identified. The body shape of the missy figure is inverted triangle (bust=37.25”; waist=29”; hip=35.75”) where bust is large, hip is narrow and waist is not very well defined (Connell et al., 2006). The body shape of boomer figure is pear (bust=32.6”; waist=28.4”; hip=36.4”) where hip are larger than bust, and waist gradually
slopes out to the hips (Connell et al., 2006). Figure 4.3 shows the visual representation of body shapes of inverted triangle and pear of missy and old figures.

**Figure 4.3.** Front view comparisons: Missy (inverted triangle) vs. Boomer (pear).

**Tension Map Testing**

To inspect the amount of physical tension influencing the cloth worn on female boomers’ body, a total of eight tension map testing was conducted: Tension XY, tension X, tension Y, stretch XY, stretch X, stretch Y, normal collision pressure, and tangent collision pressure. First, a garment top pattern for upper body was drafted directly on the 3D parametric model of missy figure by using the Optitex Flattening module. A garment top was chosen for tension map testing since female boomer participants from the first phase were most dissatisfied with the fit of upper body. Thus, by fitting the garment on both missy and boomer avatars, tension and fit differences can be examined visually and quantitatively. To mark guidelines for draping, circumference disks were rotated around the X/Y/Z axis: sagittal, frontal, and transverse circumference disks were placed to divide the bodies into left
and right, front and back, and upper and lower portions as shown in the Figure 4.4. The drafted patterns on 3D window were flattened, converted to 2D from 3D patterns, and they were virtually stitched for 3D fitting simulation and tension map testing.

![Figure 4.4 Tension map testing: 3D draping process on missy figure.](image)

The results of the tension XY testing showed that missy figure has maximum value of 10.53 gf/cm, where there is more tension from tension Y (9.61 gf/cm) than tension X (3.38gf/cm) around the bust areas. The maximum stretch XY value was 9.38% and the minimum value was -7.43%. The value of stretch Y was higher (7.89%) than stretch X (4.34%). Both normal collision pressures (maximum value: 1091.35 dyn/cm²) and tangent collision pressure (maximum value: 562.54 dyn/cm²) were shown around bust areas. The
results of tension XY testing for boomer figure show a maximum value of 5.81 gf/cm, where tension Y was greater (5.39 gf/cm) than tension X (1.67 gf/cm) around the hip areas. The maximum stretch XY value was 4.13% with the minimum value of -4.93%. Stretch Y has greater value (4.92%) than stretch X (2.31%). Lastly, there were pressures around the hip areas where the maximum value for normal collision pressure was 499.97 dyn/cm^2 and tangent collision pressure was 461.67 dyn/cm^2. Table 4.2 summarizes the minimum and maximum values from the tension map testing. Reflecting the numbers, a visual representation of the tension map (see Figure 4.5.) shows the side-by-side comparisons of missy and boomer avatars. The tension increases as the colors gradually move from blue to red as shown in the figure.

Table 4.2. Tension Map Testing: Minimum and Maximum Values

<table>
<thead>
<tr>
<th>Testing</th>
<th>Missy</th>
<th>Boomer</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Minimum</td>
<td>Maximum</td>
</tr>
<tr>
<td>Tension XY</td>
<td>0</td>
<td>10.53 gf/cm</td>
</tr>
<tr>
<td>Tension X</td>
<td>0</td>
<td>3.38 gf/cm</td>
</tr>
<tr>
<td>Tension Y</td>
<td>0</td>
<td>9.61 gf/cm</td>
</tr>
<tr>
<td>Stretch XY</td>
<td>-7.43%</td>
<td>9.38%</td>
</tr>
<tr>
<td>Stretch X</td>
<td>-2.62%</td>
<td>4.34%</td>
</tr>
<tr>
<td>Stretch Y</td>
<td>-1.67%</td>
<td>7.89%</td>
</tr>
<tr>
<td>Normal Collision Pressure</td>
<td>0</td>
<td>1091.35 dyn/cm^2</td>
</tr>
<tr>
<td>Tangent Collision pressure</td>
<td>0</td>
<td>562.54 dyn/cm^2</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>499.97 dyn/cm^2</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>461.67 dyn/cm^2</td>
</tr>
</tbody>
</table>
Figure 4.5. Tension map testing: Missy vs. Boomer.
Interaction Matrix and Design Problem-Approach Analysis

Based on the results of the qualitative analysis from the first phase and the tension map testing, an interaction matrix of design specifications was developed (Table 4.3). The format of the interaction matrix was adopted from Bergen et al. (1996) and changed to fit the context of this study. The interaction matrix is used to illustrate: specifications that were in direct conflict with each other (0); specifications that required accommodation to be in the same design (1); specifications that created no conflict (2); and specifications that conform to each other (3). Four criteria, functional needs, smart functions, expressive needs, and aesthetic needs were examined. 17 pairs of specifications were identified as being in direct conflict. The specification under functional needs “comfort-good fit” conflicts with “internal and external pockets.” Having internal or external pockets on the waistband, side seams, or hip areas of leggings would create extra seaming or bulk. The specifications under smart functions, “tracking steps,” “monitoring heart rate,” and “monitoring muscles” also conflict with “comfort-good fit.” If the smart functions are not integrated within the textile or fabric, through means such as biosensing fibers, small devices would need to be integrated within the garment, which would create bulk or extra seaming. The specifications under smart functions also conflict with “durability” and “not irritate skin” under functional needs. Integrating technology into garments would be difficult to do garment care and small devices may irritate skin, especially with sweats.

Although, other pairs of specifications did not directly conflict, they did indicate a need for accommodation in the design. For instance, “comfort-good fit” and “easy closure” may be conflicted since any zipper closures on front of sports bra would be uncomfortable and may not be supporting. Also, “comfort-good fit” and “slimming effects- support” need
Table 4.3. Interaction Matrix of Garment Specifications for Female Boomer Activewear

|                  | 1  | 2  | 3  | 4  | 5  | 6  | 7  | 8  | 9  | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 |
|------------------|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| **Functional Needs** |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| 1 comfort- good fit | 2  | 2  | 1  | 0  | 2  | 2  | 1  | 2  | 0  | 0  | 0  | 2  | 2  | 2  | 3  | 2  | 3  | 2  | 2  | 2  | 2  | 2  | 1  | 2  |   |
| 2 durability      | 2  | 2  | 2  | 2  | 2  | 2  | 0  | 0  | 0  | 0  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  |   |
| 3 not iritate skin| 2  | 0  | 2  | 2  | 2  | 2  | 0  | 0  | 0  | 0  | 2  | 0  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  |   |
| 4 covering imperfections | 2  | 2  | 3  | 2  | 2  | 2  | 2  | 2  | 2  | 3  | 2  | 2  | 3  | 2  | 2  | 3  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  |   |
| 5 slimming effects- support | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 0  | 2  | 3  | 3  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  |   |
| 6 internal/ external pockets | 2  | 3  | 2  | 2  | 3  | 3  | 3  | 3  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 3  |   |
| 7 layering system | 3  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 3  | 2  | 3  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 3  |   |
| 8 athleisure of dual functions | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  |   |
| 9 easy closure    | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  |   |
| **Smart functions** |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| 10 cooling tech   | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  |   |
| 11 tracking steps | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  |   |
| 12 monitoring heart rate | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  |   |
| 13 monitoring muscles | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  |   |
| 14 UPF           | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  |   |
| 15 odor resistant | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  |   |
| **Expressive Needs** |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| 16 not revealing skin | 2  | 2  | 3  | 2  | 2  | 2  | 2  | 2  | 2  | 1  | 2  |    |    |    |    |    |    |    |    |    |    |    |    |    |    | |
| 17 appropriate for body shape | 2  | 3  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| 18 aesthetic- not too young | 2  | 3  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| 19 comfort- feeling covered | 3  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| **Aesthetic Needs** |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| 20 appropriate colors | 2  | 2  | 2  | 1  | 2  |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    | |
| 21 vertical lines around body shape | 3  | 2  | 2  | 2  | 2  |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    | |
| 22 slimming effects- design | 2  | 2  | 2  |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    | |
| 23 simplicity     | 1  | 2  |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    | |
| 24 fashion conscious | 2  |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    | |
| 25 athleisure style |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    | |

Note. 0= conflict; 1=accommodation; 2=no conflict; 3=conformation
accommodation since slimming effects through supporting materials such as shapewear effects around waist may feel tight and uncomfortable. The specification under aesthetic needs “simplicity” may be conflicted with the specifications under smart functions since the design may require complicated seams in order to accommodate functional devices. The specification of “fashion conscious” may be conflicted with expressive needs of “not revealing skin,” “appropriate colors,” and “simplicity” since fashion trends may be about bright color palettes or about laser cutting details, which may reveal skin. Several specifications conformed to each other, enhancing design elements. For instance, “internal/external pockets” under functional needs conform to smart functions since the pockets could store small devices. Having pockets also works well with “athleisure style” under aesthetic needs because pockets are useful for running daily errands. The specification under functional needs layering system conform to athleisure of dual function and also conform to specifications under expressive needs, not revealing skin, or comfort-feeling covered.

Based on the interview data from the phase one and the interaction matrix of garment specifications, design problems and approaches for female boomer activewear were identified (see Table 4.4). A total of four items were examined: (a) one item from bottom category includes leggings and (b) three items from top category including sports bras, tank/camisole, and t-shirts. Since female boomers expressed that, they had trouble wearing sports bras and had issues with fit and support. The design approach included combining sports bra and camisole that is 2-in-1 styles with wider straps. This enhances ease of wearing by removing sports bras and inserting built-in pocketed bra with sewn-in foam cups. Some of design approaches for t-shirts included having raglan short sleeves, ease at waist and hip areas, elongated curved hemline and slimming effects with age appropriate
designs. The design approaches for leggings included having longer hem that covers knee areas, internal or external pockets, wider waistband, long vertical lines, darker colors and 2-in-1 shorts over leggings. Overall, securing modesty and age appropriate design attributes were important aspects from expressive and aesthetic needs. Thus, the designs were simple and modern styles, avoiding complicated designs such as multiple straps and closures. Since grey colors and dark shades were used, the garments could be layered nicely with other clothing and offer a versatile look for daily wearing.

Table 4.4. Design Problems and Approaches for Female Boomer Activewear

<table>
<thead>
<tr>
<th>Item</th>
<th>Functional Attribute</th>
<th>Design Approach</th>
<th>Expressive &amp; Aesthetic Attribute</th>
<th>Design Approach</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sports bra</strong></td>
<td>fit and support</td>
<td>compression + encapsulation; combining bra and camisole</td>
<td>age appropriateness</td>
<td>no low necklines; no multiple back straps; simple design attributes</td>
</tr>
<tr>
<td>covering imperfections: sagging breasts</td>
<td>compression + encapsulation; wider band (+1.5”) bras + camisole; adjustable straps; wider straps on shoulder</td>
<td>layering nicely under shirts or tunics</td>
<td>not wide shoulder straps; generic colors to be hide under shirts</td>
<td></td>
</tr>
<tr>
<td>comfort- mobility</td>
<td>cooling tech; odor resistant combining bra and camisole; reverse opening</td>
<td>secured modesty</td>
<td>generic colors; higher neckline</td>
<td></td>
</tr>
<tr>
<td>being hot and sweaty</td>
<td>being hot and sweaty</td>
<td>being hot and sweaty</td>
<td>secures modesty</td>
<td></td>
</tr>
<tr>
<td>easier to wear</td>
<td>easier to wear</td>
<td>being hot and sweaty</td>
<td>showing bras</td>
<td></td>
</tr>
<tr>
<td><strong>Tanks/ Camisole</strong></td>
<td>breathability</td>
<td>adding micro-mesh panels; odor resistant slim racerback for free motion</td>
<td>securing modesty</td>
<td>showing bras</td>
</tr>
<tr>
<td>mobility</td>
<td>mobility</td>
<td>adding micro-mesh panels; odor resistant slim racerback for free motion</td>
<td>appropriate for body shape</td>
<td>wider straps</td>
</tr>
<tr>
<td>support</td>
<td>support</td>
<td>adding micro-mesh panels; odor resistant slim racerback for free motion</td>
<td>not complicated styles</td>
<td>wider straps</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2-in-1 Camisole + Bras compressions</td>
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<tr>
<td>Item</td>
<td>Functional Attribute</td>
<td>Expressive &amp; Aesthetic Attribute</td>
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<tr>
<td></td>
<td>Dissatisfaction/</td>
<td>Design Approach</td>
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<td></td>
<td>Design Problem</td>
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<td></td>
<td>Design Approach</td>
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<td></td>
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<tr>
<td>T-Shirts</td>
<td>breathability</td>
<td>cotton/ cotton blend; elongated vented hem' semi-sheer sleeves with micro-mesh; light weights and loose fit; raglan sleeves</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>being hot &amp; sweaty</td>
<td>securing modesty</td>
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<tr>
<td></td>
<td>cooling tech textile, layering system; odor resistant</td>
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<td></td>
<td>comfort- being covered</td>
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<td></td>
<td>layering system; tunics</td>
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<td></td>
<td>large tags</td>
<td>engraving/ digital prints</td>
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<tr>
<td></td>
<td>slimming effects</td>
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<tr>
<td></td>
<td>camouflage, curved vertical lines, shapewear effects, darker colors; center seam lends a slimming effects; forward-placed seam lines</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>bulky seams</td>
<td>In trend, fashion conscious</td>
<td>mixing prints</td>
<td></td>
<td></td>
</tr>
<tr>
<td>tight bust areas</td>
<td>relaxed fit- to give rooms to move without restriction; loose fitting back panels</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>tight stomach areas</td>
<td>elongated vented hem; 4way stretch; loose fitting back panels</td>
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<tr>
<td></td>
<td>short lengths of hem</td>
<td></td>
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<tr>
<td></td>
<td>Elongated curved hem; dropped back hem- hemline dips lower in the back to increase coverage; shirttail hem</td>
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<tr>
<td>Covering imperfections: under arms</td>
<td>short, above elbow, 3/4 length</td>
<td></td>
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<tr>
<td></td>
<td>offering a versatile look for daily clothing</td>
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<tr>
<td></td>
<td>Athleisure look; integrating tunics after workout' internal/ external pockets</td>
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<tr>
<td>Comfort- feel good in skin</td>
<td>Cotton vs. synthetic activewear</td>
<td></td>
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<tr>
<td></td>
<td>don't want to look &quot;too old&quot;, grandma look</td>
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<tr>
<td></td>
<td>avoid pastels and integrate prints in current trends; avoid baggy fit</td>
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<tr>
<td>Item</td>
<td>Functional Attribute</td>
<td>Expressive &amp; Aesthetic Attribute</td>
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<tr>
<td></td>
<td>Dissatisfaction/</td>
<td>low/small waistband; fold-</td>
<td></td>
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<tr>
<td></td>
<td>Design Problem</td>
<td>down waist</td>
<td></td>
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<tr>
<td></td>
<td>Design Approach</td>
<td>higher and wider waistband-</td>
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<tr>
<td></td>
<td></td>
<td>2.5&quot;</td>
<td></td>
<td></td>
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<tr>
<td>Leggings</td>
<td>breathibility</td>
<td>zoned cooling panels for</td>
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<td></td>
<td></td>
<td>enhanced ventilation;</td>
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<td>perforated back yoke for</td>
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<td></td>
<td></td>
<td>breathability</td>
<td></td>
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<tr>
<td>cooling</td>
<td>cooling temperature-</td>
<td>micromesh for seamlines-</td>
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<td></td>
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<tr>
<td>temperature-hot/</td>
<td>below knees; odor</td>
<td>below knees; odor resistant/</td>
<td></td>
<td></td>
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<tr>
<td>sweaty</td>
<td>resistant/antimicrobial-</td>
<td>antimicrobial- special fabrics</td>
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<tr>
<td></td>
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<td>(e.g., X-STATIC, inhibiting</td>
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<td></td>
<td></td>
<td>the growth of odor causing</td>
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<tr>
<td></td>
<td></td>
<td>bacteria on the leggings)</td>
<td></td>
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<tr>
<td>tight crotch areas</td>
<td>lower .5&quot;; spandex</td>
<td>thin fabrics that show</td>
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<tr>
<td></td>
<td>blend; adding a</td>
<td>underwear</td>
<td></td>
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<tr>
<td></td>
<td>gusset to crotch</td>
<td>heavier fabrics</td>
<td></td>
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<tr>
<td></td>
<td>seam line for comfort in mobility</td>
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<tr>
<td>ability to store</td>
<td>interior/hidden</td>
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<tr>
<td>small items- pockets</td>
<td>pockets at waist;</td>
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<tr>
<td></td>
<td>easy access leg</td>
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<tr>
<td></td>
<td>pockets; rear zip</td>
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<tr>
<td>not enough support</td>
<td>high waist band to</td>
<td></td>
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<tr>
<td>at waist</td>
<td>increase support and coverage</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>covering imperfections:</td>
<td>below knees; bottom ankle, pedal-pusher length</td>
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<tr>
<td>knees, varicose veins,</td>
<td></td>
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<tr>
<td>covering imperfections:</td>
<td>2-in-1; leggings + shorts; mid-rise waistband is titled up in back for ample coverage</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>exposing hips</td>
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</tbody>
</table>
Design Sketches

Based on the qualitative analysis, initial design ideas were sketched directly on an iPad Pro. Digital 2D sketching provided quick and flexible ways to collect ideas and transfer data among various programs (Adobe, art pads etc.). Nine ideation sketches for each of four garment categories (shirts, bra top, camisole, and 2-in-1 shorts) were drawn as shown in Figure 4.6. The initial design sketches were based on the qualitative analysis and two outfits (a raglan sleeve shirts with ¾ length leggings and a bra top camisole with 2-in-1 shorts over leggings) were selected for final 3D prototyping. The two designs were chosen since their design attributes best reflected the design requirements of female boomers. The final sketches of the two outfits are shown in Figure 4.7 with color renderings that were used for virtual prototypes for online survey in phase 3.

![Figure 4.6. Initial sketches.](image-url)
Virtual Pattern Development and 3D Simulation

After the designs were selected, each garment’s pattern pieces was drafted directly on the 3D parametric old avatar by using the Optitex Flattening module. This system enables on-screen transformation of three-dimensional objects’ surface into two-dimensional patterns. The symmetry guidelines were pinned on the center and back axis of the avatar as center front and center back marks. The drafted patterns were modified in 2D window and the edited patterns of the garments that were ready for virtual stitches for 3D simulation are shown in Figure 4.8.

Figure 4.7. Selected sketches for 3D prototyping on a female boomer body figure.
For virtual try-on of the developed garment patterns, cloth parameters were first selected for each pattern. The Optitex15 PDS system provides cloth parameters where real fabric characteristics tested in industry laboratories are converted using the Fabric Editor. The Fabric Editor supports Kawabata (KES) and Fast industry standards and automatically converts the results into Optitex cloth parameters. The cloth parameters contain information about the fabric behavior including values of fabric characteristics that define the material. According to Optitex Inc. (2017), there are six physical attributes of parameters as discussed below:

1) **Bending** - The resistance of the cloth to bending forces affects the rigidity of the fabric. High bending for stiffer materials, bounds 0-1,000,000.

2) **Stretching** - The resistance of the cloth to stretching forces in the warp (x) and weft (y) directions affect the elasticity of the fabric, bounds 10-100,000.

*Figure 4.8. 2D patterns: A. camisole, B. raglan shirts, C. 2-in-1 leggings.*
3) Shearing- The resistance of the cloth to shearing forces influence is on the diagonal direction of the fiber/cloth, bounds 10-20,000.

4) Friction- The resistance of the cloth to its motion on the body’s surface affects the way the cloth slides on the body, bounds 0-1.

5) Thickness- Sets the thickness of the fabric, bounds .02-3.94 inch.

6) Weight- Sets the weight of the fabric in grams per square meter, bounds 50-10,000.

The fabric parameter for leggings is knit interlock (94% polyamide, 6% elastane) since polyamide fibers have good abrasion resistance, absorb little moisture and have good crease-resistance and stability of shape. The fabric parameter for 2-in-1 shorts is woven micro fiber (86% polyester, 14% spandex), 2-in-1 camisole is knit interlock (94% polyamide, 6% elastane), and raglan shirts is knit jersey single (cotton/lycra). Table 4.5 describes the six physical attributes of each fabric that were used for virtual try-on of the garments.

Table 4.5. Fabric Parameters of the Garments

<table>
<thead>
<tr>
<th>Fabric Parameters</th>
<th>Leggings &amp; 2-in-1 Camisole</th>
<th>2-in-1 Shorts</th>
<th>Raglan Shirts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fabric Parameters</td>
<td>Knit Interlock</td>
<td>Woven Micro Fiber</td>
<td>Knit Jersey Single</td>
</tr>
<tr>
<td>4% polyamide, 6% elastane</td>
<td>100;313 dyn*cm</td>
<td>3.9; 6.5 dyn*cm</td>
<td>3;3.5 dyn*cm</td>
</tr>
<tr>
<td>Bending x;y</td>
<td>500.51;286.44 grf/cm</td>
<td>152.91; 655.45 grf/cm</td>
<td>1166.16;258.92 grf/cm</td>
</tr>
<tr>
<td>Stretch x;y</td>
<td>120 grf/cm</td>
<td>179 grf/cm</td>
<td>218 grf/cm</td>
</tr>
<tr>
<td>Shear</td>
<td>0.4</td>
<td>0.4</td>
<td>0.7</td>
</tr>
<tr>
<td>Friction</td>
<td>0.06</td>
<td>0.04</td>
<td>0.04</td>
</tr>
<tr>
<td>Thickness</td>
<td>369 gr/m^2</td>
<td>95 gr/m^2</td>
<td>65 gr/m^2</td>
</tr>
<tr>
<td>Weight</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
After fabric parameters were assigned to each garment patterns, 2D garment patterns were generated to 3D shape by virtually sewing the pieces together. This process applies physics models to simulate the fit, fall and drape of the garment on a specific figure as shown in Figure 4.9. The final designs of the four garments are presented in Figure 4.10 along with detailed spec sheets (see Figure 4.11 and Figure 4.12) and color variations (see Figure 18 and Figure 19).

*Figure 4.9. 3D simulation process of virtual try-on.*
Figure 4.10. 3D looks for final garments created.
### NAME: 2-in-1 Camisole  | SIZE: OLD-10
### DESCRIPTION: 2-in-1 scoop neck, racerback camisole with a waist yoke
### FABRICATION: Knit interlock (94% polyamide, 6% elastane); engineered; biosensing fibers

<table>
<thead>
<tr>
<th>MEASUREMENTS</th>
<th>FRONT</th>
<th>BACK</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neck drop</td>
<td>7</td>
<td>5.25</td>
<td></td>
</tr>
<tr>
<td>Neck width</td>
<td>9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neck circumference</td>
<td>18</td>
<td>12</td>
<td>30</td>
</tr>
<tr>
<td>Shoulder lengths</td>
<td>1.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HPS to waist</td>
<td>18</td>
<td>18</td>
<td></td>
</tr>
<tr>
<td>HPS to underarm</td>
<td>9.75</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Across chest</td>
<td>19</td>
<td>14.5</td>
<td>33.5</td>
</tr>
<tr>
<td>Across waist</td>
<td>15.5</td>
<td>13</td>
<td>28.5</td>
</tr>
<tr>
<td>Waist yoke- Height</td>
<td>12</td>
<td>13</td>
<td>4</td>
</tr>
<tr>
<td>Armhole circumference</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Side length</td>
<td>9</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Remarks: All measurements in inches
STITCH- DN-.25" from edge-hem, neck, sleeves; flat lock seams
Binding to finish 3/4"
Abbreviations: high point of shoulder (HPS), center front (CF), center back (CB), single needle (SN), double needle (DN)

### NAME: Raglan Shirts  | SIZE: OLD-10
### DESCRIPTION: Round neck, engineered shirts with short sleeves-raglan
### FABRICATION: Knit Jersey Single (Cotton/Lycra); cooling tech

<table>
<thead>
<tr>
<th>MEASUREMENTS</th>
<th>FRONT</th>
<th>BACK</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neck drop</td>
<td>3</td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td>Neck width</td>
<td>6.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neck circumference</td>
<td>7.25</td>
<td>5.75</td>
<td>13</td>
</tr>
<tr>
<td>HPS to underarm</td>
<td>7.75</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Across chest</td>
<td>19.5</td>
<td>18</td>
<td>37.5</td>
</tr>
<tr>
<td>Across waist</td>
<td>17</td>
<td>16</td>
<td>33</td>
</tr>
<tr>
<td>CF/CB lengths</td>
<td>23.25</td>
<td>27</td>
<td></td>
</tr>
<tr>
<td>Side length</td>
<td>17</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sleeve lengths- HPS</td>
<td>12.25</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sleeve lengths- underarm</td>
<td>5.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sleeve opening</td>
<td></td>
<td></td>
<td>13.75</td>
</tr>
<tr>
<td>Bottom edge opening (Sweep)</td>
<td>20</td>
<td>22</td>
<td>42</td>
</tr>
</tbody>
</table>

Remarks: All measurements in inches
STITCH- DN-.25" from edge-hem, neck, sleeves; flat lock seams
Abbreviations: high point of shoulder (HPS), center front (CF), center back (CB), single needle (SN), double needle (DN)

*Figure 4.11.* Spec sheets for camisole and raglan shirts.
**NAME:** 2-in-1 Leggings  
**SIZE:** OLD-10  
**DESCRIPTION:** 2-in-1 shorts over leggings with curved vertical lines  
**FABRICATION:** Knit interlock (94% polyamide, 6% elastane); moisture wicking tech; odor resistant

<table>
<thead>
<tr>
<th>MEASUREMENTS</th>
<th>FRONT</th>
<th>BACK</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waistline seam circumference</td>
<td>14.25</td>
<td>16.5</td>
<td>30.75</td>
</tr>
<tr>
<td>Waistband-Height</td>
<td></td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Shorts- High Hip (4&quot; from natural waist)</td>
<td>18</td>
<td>17</td>
<td>35</td>
</tr>
<tr>
<td>Shorts- Low Hip (7&quot; from natural waist)</td>
<td>19</td>
<td>18</td>
<td>37</td>
</tr>
<tr>
<td>Shorts- Rise</td>
<td>9.5</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>Shorts- Inseam</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shorts- Outseam</td>
<td>10.25</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leggings- High Hip (4&quot; from natural waist)</td>
<td>17.5</td>
<td>17</td>
<td>34.5</td>
</tr>
<tr>
<td>Leggings- Low Hip (7&quot; from natural waist)</td>
<td>18.5</td>
<td>18</td>
<td>36.5</td>
</tr>
<tr>
<td>Leggings- Rise</td>
<td>9</td>
<td>12.5</td>
<td></td>
</tr>
<tr>
<td>Leggings- Inseam</td>
<td>19.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leggings- Outseam</td>
<td>27.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thigh circumference</td>
<td>8.5</td>
<td>9.85</td>
<td>21</td>
</tr>
<tr>
<td>Knee circumference</td>
<td>6.5</td>
<td>7.5</td>
<td>14</td>
</tr>
</tbody>
</table>

Remarks: All measurements in inches  
STITCH: DN-.25” from edge-hem, neck, sleeves; flat lock seams  
Abbreviations: high point of shoulder (HPS), center front (CF), center back (CB), single needle (SN), double needle (DN)

**NAME:** Leggings  
**SIZE:** OLD-10  
**DESCRIPTION:** 3/4 length leggings with curved vertical lines  
**FABRICATION:** Knit interlock (94% polyamide, 6% elastane); moisture wicking tech; odor resistant

<table>
<thead>
<tr>
<th>MEASUREMENTS</th>
<th>FRONT</th>
<th>BACK</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waistline seam circumference</td>
<td>14</td>
<td>16.5</td>
<td>30.5</td>
</tr>
<tr>
<td>Waistband-Height</td>
<td></td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>High Hip (4&quot; from natural waist)</td>
<td>17.5</td>
<td>17</td>
<td>34.5</td>
</tr>
<tr>
<td>Low Hip (7&quot; from natural waist)</td>
<td>18.5</td>
<td>18</td>
<td>36.5</td>
</tr>
<tr>
<td>Rise</td>
<td>9</td>
<td>12.5</td>
<td></td>
</tr>
<tr>
<td>Inseam</td>
<td>19.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Outseam</td>
<td>27.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thigh circumference</td>
<td>8.5</td>
<td>9.85</td>
<td>21</td>
</tr>
<tr>
<td>Knee circumference</td>
<td>6.5</td>
<td>7.5</td>
<td>14</td>
</tr>
</tbody>
</table>

Remarks: All measurements in inches  
STITCH: DN-.25” from edge-hem, neck, sleeves; flat lock seams  
Abbreviations: high point of shoulder (HPS), center front (CF), center back (CB), single needle (SN), double needle (DN)

Figure 4.12. Spec sheets for 2-in-1 leggings and ¾ leggings.
Figure 4.13. Variations of leggings and 2-in-1 shorts over leggings.

Figure 4.14. Variations of raglan shirts & 2-in-1 camisole.
Phase 3. Online Survey

This section reports the results from the third phase of the sequential exploratory mixed method study to answer the three research question:

Research Question 3. How do consumers evaluate and perceive activewear that are designed for female boomers?

The results include a sample profile, descriptive statistics of female boomers’ overall evaluations on the activewear, and a linear regression analysis to examine the relationship between female boomers’ perceptions on FEA needs and wearing intention.

Sample Profile

A total of 321 female boomers completed the online survey. The results showed that the participants’ ages range from 50 to 70 years old where the mean age was 60 years old (SD=5.6). Particularly, the ages were evenly distributed with 22.3% being ages between 50-54 years old, 27.7% being 55 to 59, 25.5% being 60 to 64, and 24.5% being 65 to 70 years old. The majority of the respondents were White (85.8%), followed by Asian (6.6%), Black (3.5%), and Hispanic (2.8%). More than half of the female indicated that they were married (62%), followed by divorced/ separated (17.5%), single (14.9%) and widowed (3.2%). The results also showed that participants’ education level ranged from high school graduate to received doctoral degree, with 32.6% having a bachelor’s degree, followed by high school graduate (28.5%), Master’s degree (18.0%), Associate’s degree (17.7%), and Doctoral degree (3.2%). About 42% of the participants were employed full time, followed by retired (32.2%), employed part time (8.0%), and self employed (6.1%). Participants’ geographic regions were well distributed across the United States: 30.9% of the boomers were from Northeast, followed by Midwest (22.4%), Southeast (16.7%), and West (19.2%). Nearly 45% of the
respondents earned between $50,000 to $100,000, 18.0% earned over $100,000, and 16.1% earned between $10,000-$50,000.

In terms of exercising, more than a half of the participants exercise three to five times per week (51%), and about 19.2% exercise five to seven times per weeks. About 68% (N=214) of the participants agreed that exercising is a big part of their life. Specifically, the results of the types of exercises indicated that walking was the most popular exercise (86.7%, N=277), followed by weight training (23.1%, N=73), swimming (18.7%, N=59), yoga (17.4%, N=55), aerobics (14.9, N=47), cycling (10.13, N=32), running (6.7%, N=21), zumba (6.01%, N=19), and pilates (4.75, N=15). Other outdoor exercises included biking (17.2%, N=54) and hiking (18.0%, N=57).

When asked about any body changes they have experienced for the past few years, the participants indicated that they went through various changes that include gaining weight (52.9%, N=169), sagging breasts (39.18%, N=125), increasing body temperature (33.86%, N=108), varicose veins (21.94%, N=70), as well as changes in posture (21.94%, N=70). In addition, for perceived body shapes, female boomers indicated that they identified with apple (26.9%), followed by full hourglass (25.3%), pear (21.8%), rectangle (16.8%), and inverted triangle (16.8%). Only about 30% of the participants indicated that they were confident about their body shape (M=3.8, SD=1.68), but more than 60% of the female boomers were proud of their age (M=5.19, SD=1.49). The demographic characteristics of the sample are illustrated in Table 4.6.
Table 4.6. Demographics of the Sample

<table>
<thead>
<tr>
<th>Demographics</th>
<th>Frequency</th>
<th>Percentage of Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age</strong> (N=320)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>50-54</td>
<td>71</td>
<td>22.3</td>
</tr>
<tr>
<td>55-59</td>
<td>88</td>
<td>27.7</td>
</tr>
<tr>
<td>60-64</td>
<td>81</td>
<td>25.5</td>
</tr>
<tr>
<td>65-70</td>
<td>78</td>
<td>24.5</td>
</tr>
<tr>
<td><strong>Ethnicity</strong> (N=317)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>272</td>
<td>85.8</td>
</tr>
<tr>
<td>Black</td>
<td>11</td>
<td>3.5</td>
</tr>
<tr>
<td>Hispanic</td>
<td>9</td>
<td>2.8</td>
</tr>
<tr>
<td>Asian</td>
<td>21</td>
<td>6.6</td>
</tr>
<tr>
<td>Other</td>
<td>4</td>
<td>1.2</td>
</tr>
<tr>
<td><strong>Martial Status</strong> (N=309)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single</td>
<td>46</td>
<td>14.9</td>
</tr>
<tr>
<td>Married</td>
<td>192</td>
<td>62.1</td>
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<tr>
<td>Divorced/ Separated</td>
<td>54</td>
<td>17.5</td>
</tr>
<tr>
<td>Widowed</td>
<td>10</td>
<td>3.2</td>
</tr>
<tr>
<td>Other</td>
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<td>2.3</td>
</tr>
<tr>
<td><strong>Education</strong> (N=316)</td>
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<td></td>
</tr>
<tr>
<td>High school graduate, diploma or equivalent</td>
<td>90</td>
<td>28.5</td>
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<tr>
<td>Associate degree</td>
<td>56</td>
<td>17.7</td>
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<tr>
<td>Bachelor's degree</td>
<td>103</td>
<td>32.6</td>
</tr>
<tr>
<td>Masters degree</td>
<td>57</td>
<td>18.0</td>
</tr>
<tr>
<td>Doctorate degree</td>
<td>10</td>
<td>3.2</td>
</tr>
<tr>
<td><strong>Employment Status</strong> (N=313)</td>
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<td></td>
</tr>
<tr>
<td>Employed full time</td>
<td>132</td>
<td>42.2</td>
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<tr>
<td>Employed part time</td>
<td>25</td>
<td>8.0</td>
</tr>
<tr>
<td>Self employed</td>
<td>19</td>
<td>6.1</td>
</tr>
<tr>
<td>Not employed but looking for job</td>
<td>7</td>
<td>2.2</td>
</tr>
<tr>
<td>Not employed and not looking for job</td>
<td>18</td>
<td>5.8</td>
</tr>
<tr>
<td>Retired</td>
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<td>33.2</td>
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<tr>
<td>Working in retirement</td>
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<td>2.6</td>
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<tr>
<td><strong>Region</strong> (N=317)</td>
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<td></td>
</tr>
<tr>
<td>Midwest</td>
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<td>22.4</td>
</tr>
<tr>
<td>Northeast</td>
<td>98</td>
<td>30.9</td>
</tr>
<tr>
<td>Southeast</td>
<td>53</td>
<td>16.7</td>
</tr>
<tr>
<td>Southwest</td>
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<td>10.7</td>
</tr>
<tr>
<td>West</td>
<td>61</td>
<td>19.2</td>
</tr>
<tr>
<td><strong>Annual Income</strong> (N=316)</td>
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<td></td>
</tr>
<tr>
<td>Less than $10,000</td>
<td>15</td>
<td>4.8</td>
</tr>
<tr>
<td>$10,000-$50,000</td>
<td>51</td>
<td>16.1</td>
</tr>
<tr>
<td>$50,000-$100,000</td>
<td>144</td>
<td>45.5</td>
</tr>
<tr>
<td>Over $100,000</td>
<td>57</td>
<td>18.0</td>
</tr>
</tbody>
</table>
Descriptive Statistics of Female Boomers’ Evaluations on Activewear

Before beginning the evaluation of the proposed activewear, the participants were asked about their levels of satisfaction towards current activewear. About 75% (N=241) of the participants agreed that they were dissatisfied with current activewear. Specifically, Table 4.7 shows the frequency and mean values of participants’ levels of dissatisfaction on finding well-fitting, comfortable, aesthetically pleasing, and age-appropriate exercise clothing. Each question was asked on a seven-point Likert-type scale ranging from Strongly Disagree (1) to Strongly Agree (7). The results showed that in general, female boomers had difficulties in finding well-fitting activewear ($M=4.26$, $SD=1.57$), comfortable activewear ($M=4.19$, $SD=1.64$), aesthetically pleasing activewear ($M=4.34$, $SD=1.63$), and age-appropriate activewear ($M=4.59$, $SD=1.68$).
Table 4.7. Descriptive Statistics of Participants’ Dissatisfaction on Finding Activewear

<table>
<thead>
<tr>
<th>Dissatisfaction</th>
<th>Frequency</th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. It is difficult to find well-fitting</td>
<td>21 26 35 10 60 50 24</td>
<td>317</td>
<td>4.26</td>
</tr>
<tr>
<td>exercise clothing.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. It is difficult to find comfortable</td>
<td>26 27 40 92 60 48 25</td>
<td>318</td>
<td>4.19</td>
</tr>
<tr>
<td>exercise clothing.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. It is difficult to find aesthetically</td>
<td>21 30 25 96 65 48 32</td>
<td>317</td>
<td>4.34</td>
</tr>
<tr>
<td>pleasing exercise clothing.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. It is difficult to find age-appropriate</td>
<td>18 26 27 79 60 64 44</td>
<td>318</td>
<td>4.59</td>
</tr>
<tr>
<td>exercise clothing.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The participants were further asked to evaluate the prototypes after reviewing the products’ visual and text descriptions. The prototypes were evaluated on their perceived comfort, age appropriateness, perceived aesthetic attributes, lengths, slimming effects, technology, and female boomers’ attitudes and wearing intentions towards the prototypes. All of the questions were asked with seven-point Likert-type scale ranging from *Strongly Disagree* (1) to *Strongly Agree* (7), except perceived comfort, each measured on a seven-point scale with bipolar adjectives (uncomfortable (1)/comfortable (7), difficult to move in (1)/easy to move in (7), unsatisfactory fit (1)/satisfactory fit (7), hot (1)/cool (7)).

Results showed that the prototypes were perceived to be comfortable (*M* ranging from 4.44 to 4.95), age appropriate (*M* ranging from 4.58 to 5.35), and aesthetically appealing (*M* ranging from 4.69 to max. 5.27). Specifically, the participants liked the simplistic designs of the clothing (*M*=5.27, *SD*=1.37) and thought the slimming effects are fashionable (*M*=5.25, *SD*=1.32). In terms of lengths, participants liked the lengths of the leggings because the lengths cover the knees (*M*=5.14, *SD*=1.72), the lengths of the raglan shirts because it covers the hips (*M*=5.57, *SD*=1.36), and the lengths of the 2-in-1 shorts over the leggings (*M*=4.03, *SD*=1.86). The participants felt that overall, the proposed activewear covered imperfections.
of body parts well ($M=5.02$, $SD=1.41$). Table 4.8 shows the mean and standard deviation values for each evaluated criteria.

Table 4.8. Descriptive Statistics of Participants’ Evaluations on Activewear

<table>
<thead>
<tr>
<th>Female Boomers’ Evaluations</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Perceived Comfort</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overall, wearing the exercise clothing in the image would be comfortable.</td>
<td>4.95</td>
<td>1.54</td>
</tr>
<tr>
<td>Overall, wearing the exercise clothing in the image would be easy to move in.</td>
<td>4.87</td>
<td>1.52</td>
</tr>
<tr>
<td>Overall, wearing the exercise clothing in the image would be satisfactory fit.</td>
<td>4.68</td>
<td>1.56</td>
</tr>
<tr>
<td>Overall, wearing the exercise clothing in the image would be cool.</td>
<td>4.44</td>
<td>1.46</td>
</tr>
<tr>
<td><strong>Age Appropriateness</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wearing the clothing in the image would be age appropriate.</td>
<td>5.35</td>
<td>1.34</td>
</tr>
<tr>
<td>Wearing the clothing would not draw attention to me.</td>
<td>4.58</td>
<td>1.50</td>
</tr>
<tr>
<td>I will not be embarrassed when wearing the clothing outside in public.</td>
<td>4.63</td>
<td>1.72</td>
</tr>
<tr>
<td>The overall design of the clothing is age appropriate.</td>
<td>5.16</td>
<td>1.39</td>
</tr>
<tr>
<td><strong>Perceived Aesthetic Attributes</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The overall appearance of the clothing is aesthetically appealing to me.</td>
<td>4.79</td>
<td>1.45</td>
</tr>
<tr>
<td>The overall designs of the clothing is fashionable.</td>
<td>4.88</td>
<td>1.44</td>
</tr>
<tr>
<td>I like the simplistic designs of the clothing.</td>
<td>5.27</td>
<td>1.37</td>
</tr>
<tr>
<td>I like the colors of the clothing.</td>
<td>4.69</td>
<td>1.61</td>
</tr>
<tr>
<td><strong>Lengths</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I like the length of the leggings in the image because they covers the knees.</td>
<td>5.14</td>
<td>1.72</td>
</tr>
<tr>
<td>I like the length of the raglan shirts because it covers the hips.</td>
<td>5.57</td>
<td>1.36</td>
</tr>
<tr>
<td>The 2-in-1 shorts over the leggings is a good idea because it covers the hips.</td>
<td>4.03</td>
<td>1.86</td>
</tr>
<tr>
<td>Overall, these outfits cover imperfections of body parts well.</td>
<td>5.02</td>
<td>1.41</td>
</tr>
<tr>
<td><strong>Slimming Effects</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I like the slimming effects of the shirt A.</td>
<td>4.72</td>
<td>1.53</td>
</tr>
<tr>
<td>I like the slimming effects of the shirt B.</td>
<td>5.15</td>
<td>1.38</td>
</tr>
<tr>
<td>I like the slimming effects of the shirt C.</td>
<td>4.79</td>
<td>1.56</td>
</tr>
<tr>
<td>Overall, the slimming effects of the shirts are fashionable.</td>
<td>5.25</td>
<td>1.32</td>
</tr>
<tr>
<td>Wearing the shirts A, B, C, would make me look slimmer than wearing the plain shirts in the image.</td>
<td>5.16</td>
<td>1.60</td>
</tr>
<tr>
<td><strong>Technology</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I am interested in monitoring heart rates in exercise clothing.</td>
<td>3.62</td>
<td>1.80</td>
</tr>
<tr>
<td>I am interested in tracking steps in exercise clothing.</td>
<td>4.00</td>
<td>1.92</td>
</tr>
<tr>
<td>I am interested in cooling tech that lowers body temperature in exercise clothing.</td>
<td>5.11</td>
<td>1.65</td>
</tr>
<tr>
<td>I am interested in odor-resistant fabrics for exercise clothing.</td>
<td>6.00</td>
<td>1.52</td>
</tr>
</tbody>
</table>
Table 4.8. (continued)

<table>
<thead>
<tr>
<th>Female Boomers' Evaluations</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Attitude</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I like the 2-in-1 camisole.</td>
<td>4.94</td>
<td>1.95</td>
</tr>
<tr>
<td>I like the raglan sleeve shirts.</td>
<td>5.16</td>
<td>1.62</td>
</tr>
<tr>
<td>I like the 2-in-1 shorts over the leggings.</td>
<td>3.94</td>
<td>1.92</td>
</tr>
<tr>
<td>I like the 3/4 length leggings.</td>
<td>5.1</td>
<td>1.74</td>
</tr>
<tr>
<td><strong>Wearing Intention</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I would wear the clothing if they become available.</td>
<td>4.35</td>
<td>1.45</td>
</tr>
<tr>
<td>I intend to try this type of clothing.</td>
<td>4.61</td>
<td>1.68</td>
</tr>
<tr>
<td>It is likely that I will be wearing the clothing while exercising.</td>
<td>4.38</td>
<td>1.75</td>
</tr>
</tbody>
</table>

**Factor Analysis and Evaluation of Assumptions for Multiple Regression Analysis**

The relationship between female boomers’ perceptions on FEA needs and wearing intention were further examined. Before examining reliabilities of the constructs for internal consistency of the scales, an Exploratory Factor Analysis (EFA) was conducted for two constructs: *age appropriateness* and *wear intention*. These two constructs were developed based on the findings from the qualitative interview data. A principal component method with Varimax rotation was employed to obtain the factor loadings and to ensure construct validity of the developed constructs. Age appropriateness was measured on four items and the factor loading ranged from .80 to .93 with an eigenvalue of 3.01. Wearing intention was measured on three items and the factor loadings ranged from .88 to .95 with an eigenvalue of 2.53. Items were considered to belong to a factor if they had loadings of .05 or higher (Nunnally, 1978) and factors with eigenvalues of 1.0 or greater were considered for interpretation of factors.

Next, a confirmatory factor analysis (CFA) using maximum likelihood estimation was conducted to assess the convergent and discrimination validity of all the research constructs: *perceived comfort* (PC) from functional need, *age appropriateness* (AA) from expressive needs, *perceived aesthetic attributes* (PA) from aesthetic needs, and *wearing*
intention (WI). CFA for the model provided a good fit (CFA: $\chi^2 = 265.19$, $df = 84$, $p < 0.00$, CFI = 0.95, TLI = 0.94, SRMR = 0.04, and RMSEA = 0.06) and with the standardized factor loadings ranging from .62 to .94, convergent validity was satisfied (Hair, Anderson, Tatham, & Black, 2010). After running the factor analysis, the reliabilities for all of the research constructs were analyzed to determine internal consistency of the scales. Cronbach’s standardized alpha was used in determining the internal reliability of measures. All of the constructs’ Cronbach’s alpha values ranged from .88 to .91, indicating an acceptable internal consistency (Nunnally & Bernstein, 1994). The standardized factor loadings of each items and the reliability of each construct are reported in Table 4.9.

Table 4.9. Factor Loading and Reliability of Measurement Items

<table>
<thead>
<tr>
<th>Constructs and measurement items</th>
<th>Standardized factor loading</th>
<th>Cronbach’s alpha</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Functional</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Perceived Comfort</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overall, wearing the exercise clothing in the image would be comfortable.</td>
<td>0.85</td>
<td>0.90</td>
</tr>
<tr>
<td>Overall, wearing the exercise clothing in the image would be easy to move in.</td>
<td>0.80</td>
<td></td>
</tr>
<tr>
<td>Overall, wearing the exercise clothing in the image would be satisfactory fit.</td>
<td>0.89</td>
<td></td>
</tr>
<tr>
<td>Overall, wearing the exercise clothing in the image would be satisfactory cool.</td>
<td>0.76</td>
<td></td>
</tr>
<tr>
<td><strong>Expressive</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age Appropriateness</td>
<td></td>
<td>0.88</td>
</tr>
<tr>
<td>Wearing the clothing in the image would be age appropriate.</td>
<td>0.86</td>
<td></td>
</tr>
<tr>
<td>Wearing the clothing would not draw attention to me.</td>
<td>0.70</td>
<td></td>
</tr>
<tr>
<td>I will not be embarrassed when wearing the clothing outside in public.</td>
<td>0.77</td>
<td></td>
</tr>
<tr>
<td>The overall design of the clothing is age appropriate.</td>
<td>0.94</td>
<td></td>
</tr>
<tr>
<td><strong>Aesthetic</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Perceived Aesthetic Attributes</td>
<td></td>
<td>0.90</td>
</tr>
<tr>
<td>The overall appearance of the clothing is aesthetically appealing to me.</td>
<td>0.92</td>
<td></td>
</tr>
<tr>
<td>The overall designs of the clothing is fashionable.</td>
<td>0.91</td>
<td></td>
</tr>
<tr>
<td>I like the simplistic designs of the clothing.</td>
<td>0.85</td>
<td></td>
</tr>
<tr>
<td>I like the colors of the clothing.</td>
<td>0.72</td>
<td></td>
</tr>
</tbody>
</table>
Prior to conducting the multiple linear regression analysis, tests of the regression assumptions and multicollinearity diagnostics were performed. First, a Pearson correlation coefficient was calculated for the relationship among the research variables (see Table 4.10). Results of correlation analysis revealed that all variables were significantly related to each other and the correlations between the independent variables were below .70, indicating that all of the independent variables can be retained in the study (Pallant, 2001). The correlations of all the variables regarding wearing intention were from .54 to .70. The highest correlation ($r=.70$) was between perceived aesthetic attributes and wearing intention, indicating if female boomers perceive activewear to be aesthetically pleasing, their wearing intention of the clothing would be greater. Table 4.13 also shows mean values and standard deviation of each construct. The mean value was 4.80 for perceived comfort ($SD=1.32$), 4.93 for age appropriateness ($SD=1.28$), 5.00 for perceived aesthetic attributes ($SD=1.28$), and 4.45 for wearing intention ($SD=1.50$).

Next, the collinearity among the independent variables for the model was also examined through variance inflation factors (VIF) and eigenvalues (see Table 4.11). The VIF for each independent variable was less than the standard comparison score of 10, and the variables had low eigenvalues ranging from .02 to .03 with relatively equal magnitudes, indicating that multicollinearity is not serious.
Table 4.10. Correlation Matrix and Descriptive Statistics of the Constructs

<table>
<thead>
<tr>
<th>Variable</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Perceived Comfort</td>
<td>1.00</td>
<td>.52</td>
<td>.47</td>
<td>.54</td>
<td>4.80</td>
<td>1.32</td>
</tr>
<tr>
<td>2. Age Appropriateness</td>
<td>.52</td>
<td>1.00</td>
<td>.62</td>
<td>.64</td>
<td>4.93</td>
<td>1.28</td>
</tr>
<tr>
<td>3. Perceived Aesthetic Attributes</td>
<td>.47</td>
<td>.62</td>
<td>1.00</td>
<td>.70</td>
<td>5.00</td>
<td>1.28</td>
</tr>
<tr>
<td>4. Wearing Intention</td>
<td>.54</td>
<td>.64</td>
<td>.70</td>
<td>1.00</td>
<td>4.45</td>
<td>1.50</td>
</tr>
</tbody>
</table>

*Note.* All correlations are significant at the .01 level (2-tailed).

Table 4.11. Variance Inflation and Eigenvalue Analysis

<table>
<thead>
<tr>
<th>Variable</th>
<th>Variance Inflation (VIF)</th>
<th>Eigenvalue</th>
<th>Condition Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Constant)</td>
<td>3.90</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>Perceived Comfort</td>
<td>1.45</td>
<td>0.03</td>
<td>10.2</td>
</tr>
<tr>
<td>Age Appropriateness</td>
<td>1.86</td>
<td>0.03</td>
<td>10.47</td>
</tr>
<tr>
<td>Perceived Aesthetic Attributes</td>
<td>1.75</td>
<td>0.02</td>
<td>12.93</td>
</tr>
</tbody>
</table>

*Note.* Dependent variable is Wearing Intention

**Regression Analysis**

A linear regression analysis was conducted to examine female boomers’ evaluations on functional, expressive, and aesthetic needs identified from the qualitative analysis and the relationship between their evaluations and wearing intention. Table 4.12 shows the summary of a regression analysis for the model.

Table 4.12. Summary of Regression Analysis for Variables Predicting Wearing Intention

<table>
<thead>
<tr>
<th>Variable</th>
<th>Unstandardized coefficients</th>
<th>Standardized coefficients</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B</td>
<td>SE</td>
</tr>
<tr>
<td>(Constant)</td>
<td>-.96</td>
<td>.23</td>
</tr>
<tr>
<td>Perceived Comfort</td>
<td>.19</td>
<td>.04</td>
</tr>
<tr>
<td>Age Appropriateness</td>
<td>.22</td>
<td>.05</td>
</tr>
<tr>
<td>Perceived Aesthetic Attributes</td>
<td>.65</td>
<td>.05</td>
</tr>
</tbody>
</table>

*Note.* R^2 = .67; adjusted R^2 = .67
F(3, 287) = 193.16, *p* < .00
**p < .00
This analysis was used to develop a model for predicting female boomers’ wearing intention based on their FEA needs that included: perceived comfort (PC), age appropriateness (AA), and perceived aesthetic attributes (PA). The results found that all of the three FEA variables, PC ($\beta=.17$, $t=4.00$, $p<.00$), AA ($\beta=.18$, $t=3.90$, $p<.00$), and PA ($\beta=.50$, $t=12.00$, $p<.00$), had positive effects on female boomers’ wearing intention. A significant regression equation was found for the model predicting wearing intention ($F(3,287)= 193.16$, $p<.00$) with an $R^2$ of .67. Participants’ predicted wearing intention is equal to $-.96+.19(\text{PC})+.22(\text{AA})+.65(\text{PA})$. 
CHAPTER 5. DISCUSSION AND CONCLUSIONS

This chapter summarizes and provides interpretations of the research findings presented in chapter 4. Conclusions, implications, limitations, and recommendations for future research are also presented.

Overview

The emerging phenomena of active aging brought new challenges for professionals to respond to baby boomers’ demands on special needs for fit and styling of apparel that are difficult to find in today’s marketplace. Especially, female boomers are more frustrated than other generations when shopping for apparel items and are dissatisfied with current activewear. However, a very limited number of studies have examined apparel design requirements for female boomer consumer. Since this market is not well understood, a holistic research that integrates both consumer behavior and product development is needed. Thus, this study explored and analyzed design requirements for female boomer activewear for indoor fitness through a sequential exploratory mixed methods research.

Examining design requirements for female boomer activewear could not be adequately addressed by the use of either inductive or deductive approaches by themselves. Combining both qualitative and quantitative research, provides more insights and an expanded understanding of research problems. Specifically, the purpose for mixing methods for this study was both developmental and complementarity (Green, 2007), so a sequential exploratory strategy has been adopted. A Qualitative method was used to inform the development of the prototyping for an instrument construction and further informed the development of the online survey.
Specifically in the first phase, in-depth interviews were conducted to explore female boomers’ functional, expressive, and aesthetic needs based on FEA Consumer Needs Model (Lamb & Kallal, 1992). In the second phase, themes and preferences found in the first phase were translated into garment engineering details in terms of design features and textile properties: interaction matrix and design problem-approach analysis were conducted. The fit issues were addressed by comparing two avatars of missy and female boomer figures and the data were further transferred to visual representations by 3D virtual prototyping process. In the third phase, online survey was conducted where female boomers across the United States evaluated the prototypes by reviewing images and text descriptions. Specifically, FEA attributes of the activewear were evaluated and the relationship between FEA needs and wearing intention were examined. This study presented a model for female boomers’ FEA needs for activewear, visually compared fit issues of a missy and female boomer body figures, developed prototypes of female boomers’ activewear, and confirmed the applicability of FEA model in the context of female boomers as a target consumer.

**Conceptual Model**

The knowledge gained from the interviews from the first phase provides the foundation for the emergence of a conceptual model: A Model of factors influencing design requirements for female boomer activewear (see Figure 5.1). This conceptual model was based on the results from the analysis of interviews with female boomers with the integration of FEA Consumer Needs Model (Lamb & Kallal, 1992) along with the analysis of 3D prototyping. Specifically, the model was developed to illustrate the interrelationships of factors influencing design requirements for female boomer activewear. By using a sequential
exploratory strategy, this offers an insight into understanding female boomers’ needs and preferences for designing activewear that influence the prototyping phase.

Figure 5.1. A model of factors influencing design requirements for female boomer activewear.

Aging factors are located at the bottom of the model, which include *body changes* and *body shape*, *attitudes toward aging*, and *changes in social status*. The varying degrees of
female boomers’ individual experiences of aging process require well-designed garments that determine functional, expressive, and aesthetic design attributes of activewear. In the model, female boomers are located at the core of the model as a target customer or intended user that guide the three major consumer needs criteria (Lamb & Kallal, 1992). These three dimensions of clothing are essential in assessing consumer wants and needs for innovative design because the intended user is the foundation of the model (Lamb & Kallal, 1992). These factors further influence female boomers wearing intention and each dimension of the model is discussed in-depth below.

**Aging Factors**

The three FEA dimensions are influenced by *aging factors* that include *body changes and body shape, attitude towards aging, and changes in social status*. Female boomers’ physical body changes such as joint problems, low energy, and fat distributions may influence their motivation for exercising, which requires satisfaction in activewear. These body changes due to aging move mature women away from the cultural ideals of physical attractiveness of being thin and fit (Halliwell & Dittmar, 2003). The changes in posture, body shape, or varicose veins required functional needs to cover imperfections or wearable technology that monitor the physical activities as a proactive approach. The findings also confirm previous literature (Paulson & Willig, 2008) that body change, due to aging, is one of the major factors that influence female boomers’ functional needs when wearing clothing.

Female Boomer’s *attitude towards aging* is one’s overall feeling towards getting old. Some women achieve gerotranscendence, the ability of the active mind and sense of self-rising above the aging body (Clarke, 2001). Depending on their attitude toward aging, women may be proud and confident about their physical appearance even when choosing
activewear. Especially their quality of life would not be influenced by their chronological age. Rather, their functional age or individual’s functional fitness level, compared to others of one’s same chronological age (Jones & Rose, 2005), is more important than mere chronological age. The results of the first phase also confirm that mature women of today are educated, employed, and self-confident about themselves (Silverman, 2000), and their attitudes towards aging influence their preferences on product attributes such as desire to look fit or look good. As discussed by previous studies, today’s mature group is not sedentary and frail, but they are leading varied healthy lifestyle (Borcherding & Bubonia, 2015). Both qualitative and quantitative results supports that female boomers are very health conscious and working hard to have proactive lifestyle, confirming that boomers are interested in things that make them better such as being health-conscious and working out frequently (Wray & Hodges, 2008). Importantly, the clothing should be also compatible with the wearer’s self-image since clothing makes visual statements about their individuality (Damhorst, 1990).

Along with female boomers’ attitude towards aging, the last aging factor includes changes in social status, a person’s standing or importance in relation to other people within a society. Changes in social status may refer to both achieved and ascribed status and for female boomers there are natural changes of social roles as they age. These changes are important FEA factors in activewear for retired female boomers who want to maintain a professional appearance while exercising. Female boomers’ changes in social status may relate to the age appropriateness factor which plays a big role in determining clothing requirements as Lee (2005) suggested.
**Functional, Expressive, and Aesthetic Attributes for Female Boomer Activewear**

As shown in the model of factors influencing design requirements for female boomer activewear, the *functional* dimension includes *comfortable fit, thermal comfort, athleisure of dual function*, and *covering imperfections*. Especially, physical comfort in terms of garment fit (tightness/ease, lengths, and support) and thermal comfort of balancing body temperature were major factors that influence functional attributes of activewear. This aligns with previous studies (Frith & Glesson, 2004; Sontag, 1985) that physical comfort is an important factor influencing overall evaluation of the product. Specifically, confirming Eckman et al. (1990) and Gardyn (2003), apparel fit is related to physical comfort and a major factor when consumers made intention to wear. Unlike expressive and aesthetic dimensions, functional dimension is more related to physical prosperities and the body-garment relationship. Especially for female boomers, lengths of the leggings (hem and crotch lengths) and tightness around hip areas influence comfortable fit of activewear. Female boomers acknowledge their body changes and actively seek for design attributes that enhance their needs. This finding contradicts with Tongren (1988) that mature women do not want specially designed elderly garment comfort features, since they do not want reminders of their chronological age.

Covering imperfections or body parts with clothing attributes is another important factor for functional dimension. As women age, they naturally tend to increase in weight by between five to ten pounds especially around waist and hips. Female boomers indicated that they identified themselves with pear shape and this finding supports Sorkin (2004) that boomers’ figures change from an hourglass shape to a more pear shape over the years. This study also confirms age-related female physical changes supported by other studies.
(Borcherding & Bubonia, 2011; Ashdown & O’Connell, 2006). Thus, female boomers expect activewear to work around their body shape and cover their imperfections such as waist, hips, and knees. Consumers perceive activewear as a tool to fulfill their physical needs. Athleisure is another style that requires dual functions and is an important factor for functional dimension. It is a style of clothing suitable for both functions of athletic apparel and casual, everyday wear, and the participants highlighted inclusion of both internal and external pockets and garment items should be part of layering system. Further, integration of body mounted technologies such as monitoring activities and other fiber integrated technology such as odor resistant, tracking steps or UV protection was another important functional dimension for activewear. Activewear achieves goals of functional clothing that Watkins and Dunne (2015) describes since it improves a wearer’s efficiency on the job, which is exercising and increases body function. Integrating technologies should not interfere the physical comfort and body-garment relationship. Thus, technologies such as biosensing fibers that are integrated to fabric are perceived to be more useful. This aligns with Hwang, Chung, and Sanders (2014) that comfort is related to perceived usefulness of technology-integrated clothing, which has direct impact on purchase intention.

The expressive dimension includes *age appropriateness* and *body consciousness*. The physical looks of being appropriate and suitable for boomer age group is the important factor influencing expressive needs for activewear. As suggested by Twigg (2013), mature women are fully aware of traditional norms in relation to dress and age and acknowledge the pressure to be modest with age. The finding also supports Farr (2009), in that the goal as one gets older is to look effortless and current. Especially as the participants agreed that it is about not looking too young or like one has given up, as female boomers in this study referred it as
“grandma” look. The participants tended to distinguish themselves from “the old ladies” and suggested that they did not mind looking similar to their age group but would not want to look older since it portrayed the image of “messy” and “old-fashioned.” This aligned with previous studies (Branchik, 2010; Milliman & Erffmeyer, 1989) that mature women had a cognitive age where they saw themselves about 75 to 80% of their chronological age and people’s belief of age appropriateness influenced their preferences and how they wanted to be perceived in the society. The female boomers in this study indicated that they had difficulties finding age-appropriate activewear in comparison to comfortable or aesthetically pleasing activewear. They often related age appropriateness to well-fitting activewear. Age appropriate activewear is appropriate for body shape, not looking too young, being modest and not revealing skin in terms of lengths, tightness, colors, and materials of clothing. As Lamb and Kallal (1992) suggested, expressive consideration related to the communicative aspects of clothes and age appropriateness and body consciousness are based on the socio-cultural and psychological aspects of wearing clothes.

Body consciousness or body image plays a significant role in human interactions (Garner, 1997). Previous research argue that an individual’s view of their body image may be influenced by media images that idealize slim and young while providing negative stereotypes of boomer figures (Halliwell & Dittermar, 2004; Stice & Shaw, 1994). Thus, body consciousness influence female boomers’ attitude towards aging (Halliwell & Dittmar, 2003) as well as body image and self-or aspirational image and further impact their preferences on design attributes of activewear.

The aesthetic dimension includes simplicity in design attributes, slimming effects and fashion consciousness. Even though activewear is more considered to enhance physical
activities and concerned with body-garment relationship, aesthetic criteria is an important factor for consumers’ evaluations of the clothing, supporting Chattaraman (2006). One important attribute is simplicity in design where the intrinsic attributes that are inherent in the product such as colors, lines, and fabric should be generic and modern, not drawing attention. Intrinsic color attributes were important factors since it also influences slimming effects of wearing activewear. Most of the female boomers preferred generic colors such as shades of gray, black as main fabric with adding hints of colors even though the nature of activewear portrays active movements with energetic patterns and bold colors. The aesthetic attributes are more related to female boomers expressive needs since the design attributes influence how other people view their appearance.

**Female Boomer Body Figure in the Apparel Industry**

One of the important differences between the female boomer and missy consumer group is differences in body shapes, which influence design requirements. As shown in the Chapter Four, the visual representation of the body shapes based on the ASTM sizing system for missy and female boomer figures were inverted triangle and pear, respectively. The pear or triangle body shape, has wider and lower body parts in the hip areas. Also, the hips are larger than the bust. On the other hand, the inverted triangle body shape has hips that are narrower than the shoulders. Most of the apparel industry targets the missy body figure, which has inverted triangle or hourglass shapes in general. Thus, conventional garment patterns for activewear tops do not usually include enough ease around the waist and armholes. The tension map testing supports the findings that when the conventional missy size top is placed on the female boomer avatar, much tightness was found around waist and
hip areas where no tightness was found in missy figure. The tension map visually represented female boomers complaints on fit issues of currently available activewear tops.

Even though some of the body circumferences seemed similar, the missy figure had a longer waist to hip length resulting a slimmer appearance than the boomer figure. Confirming previous findings (Borcherding & Bubonia, 2011; Ashdown & O’Connell, 2006), body differences were visually found such as shoulder slope of the boomer women was higher and the back hunched, changing the posture of the figure. Also, there was difference in the shape of the breasts, where female boomers were smaller and sagging. The findings indicate that fit strategies are needed when developing activewear tops and bottoms by placing ease, the difference between garment measurement and body measurement in each garment area (Watkins & Dunne, 2015), on crotch, hips, and underarms. Thus, the distinguished body shape of female boomers warrant attention to garment lengths and line placement by designers.

Female Boomers’ Evaluations and Effects of FEA Attributes on Wearing Intention

The study measured the extent to which the prototypes corresponded to female boomers’ FEA needs as well as participants’ general satisfaction and wearing intention of the prototypes. Specifically, female boomers evaluated the prototypes that involved numerical ratings, and they were satisfied with the proposed activewear in terms of perceived comfort, age appropriateness, aesthetic attributes, and slimming effects. In general, female boomers perceived that wearing the proposed activewear would not draw attention to them and would be satisfactory fit. Most of all, female boomers were satisfied with the garment torso lengths and especially liked the lengths of the raglan shirts that covered the hips. When examined the relationship between female boomers’ perceptions on FEA needs and wearing intention, all
of the three dimensions of FEA attributes were found to be significantly influencing female boomers’ evaluation of activewear. Aligning with previous studies (Frith & Glesson, 2004; Hwang 2014), this study found that perceived comfort from functional dimension and perceived aesthetic attributes had a positive effect on one’s overall evaluation of activewear. Age appropriateness from expressive dimension also positively influenced female boomers’ wearing intention. Supporting the results from the first phase of this study, aesthetic attributes was an important factor that determined female boomers intention to wear the activewear. It is also notable that perceived aesthetic attributes is highly correlated with wearing intention ($r = .70$), indicating that improving aesthetic attributes would increase positive intention to wear the clothing.

The participants also evaluated the product in subjective manner by providing opinions on the prototypes. Interestingly, many of the female boomers appreciated the research itself along with expressing positive attitude toward the products. Many of the women appreciated the researcher for “the fact that someone is appealing to all sizes and ages in exercise clothing” [P25], and for “giving this matter some attention” [P142]. The participants were delighted about the topic of the study and left comments such as “I’m delighted to see this focus on my age group!” [P203], “this [the prototypes] fits as age appropriate and thank you for your time and study” [P111] and “it is important for older women to not attempt to look like younger women in their exercise wear and thank you for realizing this” [P71]. In terms of evaluating the prototypes, the women noted that the design “is a good idea”[P126], “would be perfect given my age love it” [P6], and [looks very age appropriate and appealing” [P29], and further indicated that “lots of women would appreciate the option” [188]. The findings of this final evaluation phase along with model testing
confirm the importance of the three FEA dimensions and indicate that the proposed prototypes meet the needs of female boomers that have positively effects on wearing intention.

**Implications**

This present study has both theoretical and practical implications and contributes to the growing body of research on examining female boomers as a vital consumer sector in the apparel industry. The research explored multiple dimensions of female boomers needs based on FEA Consumer Needs Model (Lamb & Kallal, 1992) and the framework provides a satisfactory end product that help to collect direct information about their specific demands for activewear. Thus, the present study provides theoretical implications by confirming the appropriateness of the model and further validating the efficacy of the model in explaining female boomers needs and preferences on activewear. Even though this framework has been successfully used for developing a variety of functional clothing (Cho, 2006; Stokes & Black, 2012), limited study has further applied the model for evaluation and validation stage.

This study also brings increased conceptual clarity to the concepts of age appropriateness. As part of expressive needs within the model, age appropriateness had many dimensions that are related to aesthetic attributes of activewear and wearing intention. As shown in the proposed model, age appropriateness describes wearing clothing that are appropriate for body shape, not looking too young, being modest or not revealing skin. The needs for physical appearance to be appropriate and suitable for baby boomer age group were categorized and translated to engineering details in terms of length, tightness, colors, and fabrication of clothing. These design elements should cover imperfection of body parts, be
modest in terms of revealing skin as well as looking neat that uphold female boomers’ individual social status.

This study further confirms the applicability of using mixed methods research in the discipline of textiles and clothing. Currently, there is dearth of research on product development integrating both inductive and deductive approach to answer research questions. This study shows a holistic process of user-oriented product development based on a theoretical framework and the synergistic effects of having both qualitative and quantitative data. Such interactive approach to research is needed to bridge the gap between consumer behavior and product development research that addresses both consumer need and end-user analysis. Thus, this present study may be a good example of a mixed methods research that adds value to research and strengthens the understanding of a phenomenon in the apparel and textile discipline.

Moreover, this study has practical implications for product developers and retailers on product development and commercialization strategies for female boomer consumers. It is recognized that most of the apparel retailers offer merchandise designed for consumer groups below the age 45 (Anon, 2002) and female boomers are not offered the same range of choices compared to younger consumers especially in activewear market. Thus, product developers should first develop a target body figure that distinguishes from a conventional missy body figure. This should highlight major body changes due to aging, such as differences in posture, sagging breasts, and fat distribution towards hip areas, which influence female boomers’ tendency to have pear body shape instead of inverted triangle. Reflecting these body changes, the design elements such as lengths, tightness/ease, colors
and materials should be arranged based on body shapes that cover imperfections of body parts.

Since exercising is a big part of female boomers, design attributes of activewear should be athleisure styles that is suitable for both functions of athletic apparel and casual, everyday wear. Thus, as McCann (2009) stated, layering system is important that offers versatile appearances as well as balances thermal comfort. Especially, product developers should also focus on sports bras since female boomers had the most issues with fit, ease of wearing, and comfort when exercising. The participants acknowledged that they prefer 2-in-1 camisoles that integrate sports bras since it fits better, are more comfortable, are easier to wear, and keep their body temperature cooler since it eliminates a layer of wearing sports bras. Integrating smart textiles, such as odor resistance and wearable technologies such as monitoring exercise routines (heart rates, steps) could be motivational tools for female boomers that encourage them to exercise and monitor their routines. Other design attributes such as having raglan sleeves and pockets are important factors that satisfy female boomers.

Further, corresponding commercialization strategies are necessary. Since most consumers buy brands that project their self-image or the image to which they aspire, the models should represent older with various body shapes rather than being young and slim figures. Even though female boomers’ cognitive age is a bit younger, about 10 years younger than their chorological age (Szmigin & Carrigan, 2000; Birtwistle, 2005), the current market projects 20-30 years old, which is too young for them to identify with. Thus, female boomers can easily identify with mature models and correspondingly select sizes in shops they can fit. In addition, marketers should explicitly inform and highlight the features of the products and the relationship between body shapes and the clothing such as covering imperfections. Since
message explicitness, the degree of precision, and specificity provided in a communication influence consumers’ attitudes and purchase intention (Hyllegard, Yan, Ogle, & Lee, 2012). E-retailers could provide a virtual avatar on their websites so female boomers can virtually try on garments to visualize the products before purchasing.

**Limitations and Future Research**

There are several limitations to this study. The first limitation relates to sampling and the convenience sampling method limits the generalizability of the findings. The qualitative findings were based on the responses of a convenience sample of 15 participants in the Midwest. Especially, 14 participants identified themselves as White, and future research may use a sample that is more heterogeneous in terms of ethnicity and geographic location to confirm the findings. Even though, about 320 people were sampled for the quantitative phase with a good distribution of geographic locations, the researcher recognizes that both samples in the study were not representative of all female boomers in the United States.

Another limitation includes the discrepancies between visualized fit and actual fit when working with the 3D simulation of the virtual prototyping. The developed parametric avatars in the digital environment may not be a perfect representation of the real world. The virtual environment does not share the same physical characteristics as bodies in the physical world as they are rigid shells that are not able to compress in the same way as flesh (Dunne, 2012). Even though, there is a fabric parameters where fabric properties can be adjusted in terms of stretch, friction, thickness and bending, there may be some errors representing all the relationship between body and a garment such as representing the body fat distributions when wearing supporting waistbands.
When female boomers evaluated the prototypes during online survey, the developed prototypes were presented with text descriptions and images. The information page may not fully have represented all the features, since the participants could not actually touch the fabrics. Further, the current researcher developed some of the items used in the questionnaire. Although these items were proven to demonstrate acceptable reliability and validity in the present study, future studies should be conducted to test the external validity of this measurement scale.

Future studies may employ wear testing to examine any discrepancies between visualized fit and actual fit of the prototypes. Particularly, researchers should examine the function of tension map testing so the quantitative data can be transferred to the degree of how the wearer in the real world feel the tightness of the garment. In addition, future research can validate the proposed FEA models with all of the research variables included. Other factors such as price, purchase intention, or the effects of cognitive and chronological age may be included in the model and tested. An experimental study may be also conducted where female boomers can actually feel and interact with the prototypes. Future research may seek partnering with apparel industry to execute a production process with smart textiles for further wear testing.
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APPENDIX A: INSTITUTIONAL REVIEW BOARD APPROVAL LETTER

IOWA STATE UNIVERSITY
OF SCIENCE AND TECHNOLOGY

Institutional Review Board
Office for Responsible Research
Vice President for Research
3190 Pearson Hall
Ames, Iowa 50011-2207
515-294-4566
FAX 515-294-4707

Date: 5/10/2016

To: Charmi Hwang
31 MacKay Hall

CC: Dr. Eulanda Sanders
31 MacKay

From: Office for Responsible Research

Title: Design requirements for female boomer's smart activewear: A sequential exploratory mixed methods study

IRB ID: 16-108

Study Review Date: 5/10/2016

The project referenced above has been declared exempt from the requirements of the human subject protections regulations as described in 45 CFR 46.101(b) because it meets the following federal requirements for exemption:

- (2) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey or interview procedures with adults or observation of public behavior where
  - information obtained is recorded in such a manner that human subjects cannot be identified directly or through identifiers linked to the subjects; or
  - Any disclosure of the human subjects' responses outside the research could not reasonably place the subject at risk of criminal or civil liability or be damaging to their financial standing, employability, or reputation.

The determination of exemption means that:

- You do not need to submit an application for annual continuing review.

- You must carry out the research as described in the IRB application. Review by IRB staff is required prior to implementing modifications that may change the exempt status of the research. In general, review is required for any modifications to the research procedures (e.g., method of data collection, nature or scope of information to be collected, changes in confidentiality measures, etc.), modifications that result in the inclusion of participants from vulnerable populations, or any change that may increase the risk or discomfort to participants. Changes to key personnel must also be approved. The purpose of review is to determine if the project still meets the federal criteria for exemption.

Non-exempt research is subject to many regulatory requirements that must be addressed prior to implementation of the study. Conducting non-exempt research without IRB review and approval may constitute non-compliance with federal regulations and/or academic misconduct according to ISU policy.

Detailed information about requirements for submission of modifications can be found on the Exempt Study Modification Form. A Personnel Change Form may be submitted when the only modification involves changes in study staff. If it is determined that exemption is no longer warranted, then an Application for Approval of Research Involving Humans Form will need to be submitted and approved before proceeding with data collection.

Please note that you must submit all research involving human participants for review. Only the IRB or designee may make the determination of exemption, even if you conduct a study in the future that is exactly like this study.

Please be aware that approval from other entities may also be needed. For example, access to data from private records (e.g., student, medical, or employment records, etc.) that are protected by FERPA, HIPAA, or other confidentiality policies requires permission from the holders of those records. Similarly, for research conducted in institutions other than ISU (e.g., schools, other colleges or universities, medical facilities, companies, etc.), investigators must obtain permission from the institution(s) as required by their policies. An IRB determination of exemption in no way implies or guarantees that permission from these other entities will be granted.

Please don’t hesitate to contact us if you have questions or concerns at 515-294-4566 or IRB@iastate.edu.
APPENDIX B: INVITATION FLYER

Help us to design smart activewear for female baby boomers!

Invitation to participate in a research study by a doctoral student in Apparel, Merchandising, and Design Program.

Any body shapes/ sizes are welcomed!

Please participate in this research if you:
✓ Are a female aged 51-70 years old
✓ Exercise at least once a week at a fitness center, such as walking on a treadmill or participating in yoga/Pilates classes etc.

The interview will take about 40 minutes to complete. You will receive $10 Target gift card!

If you are interested, please contact Gloria Hwang at chanmigh@gmail.com
APPENDIX C. INFORMED CONSENT DOCUMENT

Design requirements for female boomer’s smart activewear:
A sequential exploratory mixed methods study

Dear participant:

This study is being conducted by Chanmi Hwang and Dr. Eulanda Sanders in Apparel, Merchandising, and Design program at Iowa State University. This is a research study. Please take your time in deciding if you would like to participate. Please feel free to ask questions at any time.

The purpose of this study is to explore design requirements and develop prototypes for female boomer’s smart activewear for indoor fitness. Baby boomers in this study is a group born between the years 1946 and 1964, with the youngest being 52 years old and the oldest being 70 years old as of 2016. You are being invited to participate in this study because you are a female, in the age bracket of baby boomers, and exercise at least once a week at a fitness center.

If you agree to participate, you will be asked to participate in a face-to-face interview and discuss on your thoughts on current activewear and any design attributes to satisfy your needs. You will be also asked to fill out a short paper-based survey for some demographic information. Your individual responses will be kept in strict confidence. Your personal information will not be associated with your response. The researchers will use a protected password, to access data from the web-based survey. If the results are published, your identity will remain confidential.

There are no foreseeable risks from participating in this study. Your participation in this study is completely voluntary. If you do not feel comfortable answering the questionnaire, you are free to discontinue at any time. There is no penalty or loss to you for not completing the interview or if you begin interview but wish to withdraw and discontinue. You can skip any questions that you do not wish to answer. By participating, you give the researchers your consent. The interview will take about 40 minutes of your time.

If you have any question, you are encouraged to ask at any time during this study. For further information about the study contact Chanmi Hwang (chanmih@iastate.edu) or Dr. Eulanda Sanders (sanderse@iastate.edu). If you have any questions about the rights of research subjects or research-related inquiry, please contact the IRB Administrator, (515) 294-4566, IRB@iastate.edu, or Director, (515) 294-3115, Office of Research Assurances, 1138 Pearson Hall, Iowa State University, Ames, Iowa 50011.

Your efforts in participating in this research project are deeply appreciated.

Do you agree to participate in this survey?

Sign __________________________  Date_______________________
APPENDIX D: INTERVIEW QUESTIONS

Exercise Routine/ Lifestyle
1. I would really like to hear about your exercise routine/ What types of exercise do you do (where, when, why)?
2. Do you workout by yourself or with your friends/family?
3. What do you wear when you exercise? (brands, types etc.)
4. Do you wear the activewear only when you exercise or any other time such as going out to grocery, gardening, or cafe etc?
5. Do you workout more compared to when you were younger?
6. What are your most current health concerns if any?

Difficulties/ Dissatisfaction with Current Activewear
1. What is it about the current activewear/ exercise clothing that you find dissatisfactory if any? (fit, aesthetic, ease of wearing and movement etc)
   a. Is it easier to find bottom or top? Why?
   b. Are there any specific areas where you are dissatisfied with the activewear that you have worn before?
2. What is it about the current activewear/ exercise clothing that you find satisfactory if any?
3. Do you have any difficulties in shopping activewear? Do you shop online or in store?

Additional Questions
1. What is your priority when selecting clothing for exercising? Why?

Functional Needs
1. What are some features or attributes for activewear you recommend that can improve your exercise and lifestyle? (it can be more supports on waist or adding more paddings to certain areas etc.)
2. What designs or functions would make you more comfortable both physically and mentally?
   a. Covering imperfection? - is it important?
3. Have you heard about Athleisure? It is about dual functionality of wearing activewear when exercising but also transform or designed for other purposes too. Is it something you might be interested?

Aesthetic Preferences
1. Could you describe your preferences on design attributes of activewear for aesthetic needs? (colors, silhouettes- lengths, fashion trends)- refer to paper survey.
2. What do you think about slimming effects through design?
3. What do you think about layering system from sports bra to cover-ups?

Expressive Needs
1. When you wear activewear, do you want to appear similar to other people of your
1. Your age, or younger? If younger, how old?
2. What kind of body changes do you feel the most? (body shapes, physical attributes)
3. Do you want to see more older models in the apparel industry?
   Do you think it will help you when you shop?
4. How do you view the market for female-specific mature (baby boomers) activewear? (e.g., petite, plus size)
5. What do you think about age appropriateness?

**Smart Technologies**
1. This is some example of smart clothing for activewear (refer to paper survey). Which one do you find it more helpful and willing to wear?

2. Do you think wearing good activewear would motivate you to exercise more?
   (increase satisfaction, enjoyment)

Final Question. Is there anything else that you would like to add?
APPENDIX E: PAPER-BASED SURVEY QUESTIONS

Demographic Questionnaire

Date: 
Participant Number:

The following questions will help us gain a better understanding of you as a participant in this study. Your information will remain completely confidential.

Part I. Demographic Information

1. What is your age? ______

2. What ethnic group(s) do you consider yourself to be a member? Please check all that apply.
   [ ] White/European American  [ ] African American/Black
   [ ] Native Hawaiian and Other Pacific Islander [ ] Asian
   [ ] American Indian/Alaska Native   [ ] Hispanic American
   [ ] Other? (please specify)______________

3. Martial Status:
   [ ] Single   [ ] Married
   [ ] Divorced/separated   [ ] Widowed   [ ] Other

4. How often do you exercise (walking, jogging etc.) per week? ______

5. Employment Status
   [ ] Employed full time   [ ] Employed part time
   [ ] Self employed   [ ] Not employed but looking for job
   [ ] Not employed and not looking for job   [ ] Retired

6. Education Level
   [ ] High school graduate, diploma or the equivalent [ ] Associate degree
   [ ] Bachelor’s degree [ ] Masters degree
   [ ] Doctoral degree

7. Perceived Health/ Physical Status
   [Poor] [Fair] [Good] [Very Good] [Excellent]

8a. I normally wear [XXS] [XS] [S] [M] [L] [XL] [XXL] [3XL] for top

8b. I normally wear [24] [25] [26] [27] [28] [29] [30] [31] [32] for bottom

9. Please indicate your degree of satisfaction with your current exercise clothing.
Part II. Design Preferences

10. Please rank the factor that you consider the most when shopping for activewear:

- [ ] fabric content
- [ ] care instructions
- [ ] construction (e.g., seam finishes, straight top stitching)
- [ ] brand of clothing
- [ ] fit
- [ ] comfort
- [ ] aesthetic (e.g., color, prints)
- [ ] age appropriateness design
- [ ] special functions (wicking, dri-fit etc.)

11. Please check for each box if you think the described function is useful/helpful for you.

- [ ] Track calories burned
- [ ] Track steps taken
- [ ] Monitoring heart rate
- [ ] Monitoring respiration (breathing)
- [ ] Monitoring muscles movements: reduce risk of injury
- [ ] UV protection: Block UVA and UVB rays to help prevent sunburn and long-term skin damage.
- [ ] Temperature Control
  - [ ] Cooling tech: Reacts with your sweat to lower the material’s temperature and keep you cool during dynamic aerobic activity in the heat.
  - [ ] Heat tech
- [ ] Glow in the dark
- [ ] Monitoring locations (GPS)

12. Which body shape do you identify yourself with?

![Body Shapes Diagram]

[Choose the appropriate shape]
13. Please indicate “X” on the body parts/ imperfections you want to hide (if any) when exercising. You can indicate multiple parts.
14. Please rank the silhouette you prefer to wear when exercising.

15. Please draw a necklines you prefer to wear when exercising (you can draw multiple necklines).
16. Please rank the silhouette you prefer to wear when exercising.
APPENDIX F: INTERVIEW PROTOCOL

Interview Protocol

- Thank participant for meeting today
- Introduction
  - Name: ___________
  - Standing: Graduate student in ___________
  - Subject: Smart Activewear for Female Boomers
- Informed Consent
  - Has the participant had time to look it over?
  - Clarification
    - You must be over 18 years of age (female boomers)
    - You have the right to refrain from any questions or to stop the interview at any time.
    - You may ask us to withhold any or all of the previous questions
    - Your identification will remain confidential and your name will not appear on any forms or in the research
  - Any questions?
- Have the participant sign the consent form
- Have the participant fill out the survey
- Is it ok if this interview is recorded?
  - Check recording device
- Let’s begin.
- Refer to Interview Questions
  - Thank participant after each main question is answered
  - Make sure to take notes on body language and how participant responds to questions
  - Ask clarifying questions and a few follow up questions, but not more than necessary.
- When interview is over, thank participant for his/her time
- Allow participant to contact researcher if he/she has any questions
APPENDIX G: CODING GUIDE

- Aging
  - Attitudes towards aging
    - Distinction of self to “old”
    - Age-no differentiation
    - Self acceptance
    - Self Esteem/ confidence
  - Body Changes due to aging
    - Low energy
    - Tone/ elasticity
    - Body composition/ fat
    - Sagging
    - Fuller breasts
    - Natural stiffness
    - Joints issues
    - Changes in body shape
      - Weights gain
      - Weights loss
  - Health Concerns

- Exercising as a lifestyle
  - Current exercise details
    - Individual exercise
      - Weight training
      - Biking
      - Walking
    - Group exercise
      - Yoga
      - Aerobic
      - Pilates
      - Tai-chi
      - Cycling
      - Zoomba
      - Swimming
    - Outdoor activities
      - Biking
      - Hiking
      - Walking
    - Variety
    - Consistent

  - Reasons for exercising
    - Socializing & community support
    - Being proactive
• Mental benefits
• Physical benefits
  o Doing more exercise than before
  o Activewear as daily wear outfit
  o Current clothing details
  o Have more money to buy activewear
  o Shopping habits
    • In-store shopping- variety of shopping venues
    • Online shopping- past experience
    • Being a royal customer
    • No shopping enjoyment

■ Dissatisfactions with current activewear
  o Design issues
    • Horizontal lines
    • Complicated styles
    • Showing bras
    • Fold-down waist
    • Short lengths of top
    • Not strong seams
    • Tags
  o Fit issues
    • Low waist/ tight crotch
    • Tight top
    • Fit and support of sports bra
    • Not enough support at waist- leggings
  o Being hot and sweaty
  o Materials
    • Materials that increase body temperature
    • Thin fabrics- showing underwear
  o High price
  o Availability of products offered
  o Difficulty in garment care

■ Female boomers preferences: Functional attributes
  o Athleisure of dual functionality
  o Sports bra
    • Combining bra and a camisole
    • Easier to wear
    • Good support and fit
  o Shapewear effects
  o Durability
  o Comfort
  o Fit
  o Smart functions
o Covering imperfection
o Cooling effects
o Having internal/external pockets

- Female boomers preferences: Expressive attributes
  - Age appropriateness
    - Not revealing body
    - Appropriate for body type
    - Looking not too young
    - Looking not messy
    - Appropriate colors
  - Body conscious- imperfections to hide
    - Varicose Veins
    - Wrinkles
    - Saggy breasts
    - Knees
    - Stomach
    - Hips
    - Under arms
  - Social norms
    - Want to look nice & attractive
    - Want to look healthy and fit
    - Don’t want to draw attention
    - Don’t want to be embarrassed outside
    - Not trying to look younger
    - Trying to look younger
    - Don’t care what other think
  - Comfort- feeling covered
  - Being modest
  - Vanity
  - Body conscious

- Female boomers preferences: Aesthetic attributes
  - Materials
    - Cotton/ cotton blend- top
    - Heavier fabrics- bottom
    - Spandex/ blends- bottom
    - Organic/ natural
  - Slimming effects
    - Camouflage
    - Curved vertical lines
    - Support system like shapewear
    - Darker colors
  - Colors
    - Dark- black/ greys
    - Conservative
- Mixing colors
- Mixing abstract prints
- Brighter top vs. bottom

  o Length preferences
    - Longer crotch
    - Higher waist
    - Shorter sleeve
    - Longer top for covering imperfections
    - Below knee to cover imperfections
    - Not revealing neckline

  o Design details
    - Simplicity
    - Generic styles- don’t want a baggy tshirt
    - Wider elastic waistbands
    - Built-in short pants
    - Back details to cover bra straps
    - Wider straps for camisole
    - Seamless
    - Layering loose/fit
    - No hood

  o Fashion conscious- trends
  o Body-garment relationship
  o Layering clothing items

- Use of technology
  o Apps
    - Monitoring exercise routine- report (heart rate, steps, calories etc.)
    - Diet monitoring
  o Google watch
  o Fitbit
  o Cooling tech
  o GPS tracking data
  o Parametric avatars on website for online shopping

- Attitudes towards labeling female boomer
  o Categorizing mature women
  o Categorizing by body shapes
  o Categorizing by functionality- design specific
  o Do not want
Subject: Survey on smart activewear for female boomer

Dear Participants:

You are invited to participate in a research study by completing a short survey. This study aims to examine design requirements of smart activewear for female boomers. The survey will take about 10 minutes to complete the questions. This study was approved by the Institutional Review Board at Iowa State University (IRB ID: 16-188).

You can participate in this research only if you are female born between the years 1946 and 1964 (age 52-70 as of 2016). You must exercise (walking, elliptical, yoga, aerobics etc.) at least once a week at a gym/ fitness center.

If you decide to participate, you may enter your name in a drawing for TEN $10 Target gift cards as an incentive for participation in the study.

Please feel free to ask any questions at any time. For further information about the study, contact Chanmi Hwang, (419) 410-9410, chanmih@iastate.edu, or Dr. Eulanda A. Sanders, sanderse@iastate.edu. If you have any questions about the rights of research subjects, please contact the IRB Administrator, (515) 294- 4566, IRB@iastate.edu, or Director, (515) 294-3115, Office of Research Assurances, 1138 Pearson Hall, Iowa State University, Ames, Iowa 50011.

By clicking the survey link below, you agree to participate in this research study:
“insert Qualtrics link”

Your efforts in participating in this research project are deeply appreciated.

Sincerely,
Chanmi Hwang
Ph.D. Candidate
Apparel, Merchandising and Design
College of Human Sciences
Iowa State University
APPENDIX I: ONLINE SURVEY QUESTIONS

Dear participant:

This study is being conducted by a doctoral student in apparel, merchandising, and design program at Iowa State University. This is a research study. Please take your time in deciding if you would like to participate.

The purpose of this study is to explore design requirements and develop virtual prototypes for female boomer’s smart activewear or exercise clothing for indoor fitness. The findings of this study can make a contribution to increase an understanding of the aging population and have practical implications for fashion retailers and researchers to improve female boomers’ needs for current activewear market. Further, this research can inform and teach design students how to better understand the needs and design requirements of a different demographic where current fashion design and product development predominately target toward the young and professional-female consumer market.

If you agree to participate, you will be asked to participate in an online survey with demographic information. Your individual responses will be kept in strict confidence. Your personal information will not be associated with your response. If the results are published, your identify will remain confidential.

Your efforts in participating in this research project are deeply appreciated.

Q2 Are you a female between the ages of 50-70 years old and agree to participate in this survey?

- Yes
- No

Condition: No Is Selected. Skip To: End of Block.

Q3 The following questions will help us gain a better understanding of you as a participant in this study. Your information will remain completely confidential.

You can always go back and change answers at any time by clicking a back arrow button on the bottom of the survey page.
### Q4. What is your age?

```

```

### Q5. What ethnic group(s) do you consider yourself to be a member of? Please select all that apply.

- White/European American
- African American/Black
- Hispanic American
- Asian
- Native Hawaiian and Other Pacific Islander
- American Indian/ Alaska Native
- Other

### Q6. What is your marital status?

- Single
- Married
- Divorced/ Separated
- Widowed
- Other

### Q7. What is your employment status?

- Employed full time
- Employed part time
- Self employed
- Not employed but looking for job
- Not employed and not looking for job
- Retired
- Working in retirement
- Other

### Q8. What is the level of your education?

- High school graduate, diploma or the equivalent
- Associate degree
- Bachelor’s degree
- Masters degree
- Doctorate degree
<table>
<thead>
<tr>
<th>Q9</th>
<th>What is your yearly personal income?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Less than $3,000</td>
</tr>
<tr>
<td></td>
<td>$3,000 to $10,000</td>
</tr>
<tr>
<td></td>
<td>$10,000 to $25,000</td>
</tr>
<tr>
<td></td>
<td>50,000 to $75,000</td>
</tr>
<tr>
<td></td>
<td>$75,000 to $100,000</td>
</tr>
<tr>
<td></td>
<td>More than $100,000</td>
</tr>
<tr>
<td></td>
<td>Choose not to answer</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Q10</th>
<th>Which region of the country do you live in?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Midwest</td>
</tr>
<tr>
<td></td>
<td>Northeast</td>
</tr>
<tr>
<td></td>
<td>Southeast</td>
</tr>
<tr>
<td></td>
<td>Southwest</td>
</tr>
<tr>
<td></td>
<td>West</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Q11</th>
<th>Please choose types of exercises you do (choose all that apply)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yoga</td>
</tr>
<tr>
<td></td>
<td>Walking</td>
</tr>
<tr>
<td></td>
<td>Aerobics</td>
</tr>
<tr>
<td></td>
<td>Pilates</td>
</tr>
<tr>
<td></td>
<td>Weight training</td>
</tr>
<tr>
<td></td>
<td>Biking</td>
</tr>
<tr>
<td></td>
<td>Cycling</td>
</tr>
<tr>
<td></td>
<td>Zumba</td>
</tr>
<tr>
<td></td>
<td>Running</td>
</tr>
<tr>
<td></td>
<td>Hiking</td>
</tr>
<tr>
<td></td>
<td>Swimming</td>
</tr>
<tr>
<td></td>
<td>Other- please specify</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Q12</th>
<th>Please select a body shape that you most identify with from the image below.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Full hourglass</td>
</tr>
<tr>
<td></td>
<td>Apple</td>
</tr>
<tr>
<td></td>
<td>Pear</td>
</tr>
<tr>
<td></td>
<td>Inverted triangle</td>
</tr>
<tr>
<td></td>
<td>Rectangle</td>
</tr>
</tbody>
</table>
Please choose types of body changes you have experienced during the last few years (choose all that apply):

- Varicose veins
- Gaining weights
- Being hot - increasing body temperature
- Sagging breasts
- Changes in posture
- I did not experience any body changes
- Other - please specify

How often do you exercise (walking, indoor fitness, yoga etc.) per week?

- 0-1 times
- 1-2 times
- 2-3 times
- 3-4 times
- 4-5 times
- 5-6 times
- 6-7 times
- more than 7 times

Please indicate your degree of agreement or disagreement with the statements shown below.

<table>
<thead>
<tr>
<th>Strongly disagree</th>
<th>Disagree</th>
<th>Neutral</th>
<th>Agree</th>
<th>Strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

I am dissatisfied with current exercise clothing.

It is difficult to find well-fitting exercise clothing.

It is difficult to find comfortable exercise clothing.

It is difficult to find aesthetically pleasing exercise clothing.

It is difficult to find age-appropriate exercise clothing.

Exercising is a big part of my life.

I enjoy group exercising.
Please indicate your degree of agreement or disagreement with the statements shown below.

<table>
<thead>
<tr>
<th></th>
<th>Strongly disagree</th>
<th>2</th>
<th>3</th>
<th>Neutral</th>
<th>5</th>
<th>6</th>
<th>Strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>I am dissatisfied with current exercise clothing.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>It is difficult to find well-fitting exercise clothing.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>It is difficult to find comfortable exercise clothing.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>It is difficult to find aesthetically pleasing exercise clothing.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>It is difficult to find age-appropriate exercise clothing.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Exercising is a big part of my life.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>I enjoy group exercising.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Please review the information page below that include descriptions and images of exercise clothing. The questions below refer to the exercise clothing that are shown in the image. You can always go back to any questions by clicking the back arrow button on the bottom of the survey page. To see an enlarged image of the information page, you can click HERE and a new window will be opened.

**Benefits**

- **2-in-1 Camisole**
  - Extra supports at bust line
  - Breathable micro mesh
  - Monitoring heart rate
  - Built-in biosensing fibers

- **2-in-1 Leggings**
  - 2-in-1 Shorts over leggings
  - Wider waistband
  - Capris 3/4 length
  - Hidden waistband
  - Curved lines & back

- **Raglan Shirts**
  - Longer curved hem
  - Raglan sleeves fit
  - Curved sides fit
  - Relaxed fit for comfort
  - Cooling performance

- **Leggings**
  - Capris 3/4 length
  - Wider waistband
  - Hidden waistband
  - Black vertical line
  - Medium weights
  - Odor resistant fabric
Q19

Please indicate your response by clicking the number that best describes your opinion:

Overall, wearing the exercise clothing in the image would be...

<table>
<thead>
<tr>
<th>Uncomfortable</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>Comfortable</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Difficult to move in</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>Easy to move in</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Unsatisfactory fit</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>Satisfactory fit</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Hit</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>Cool</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Q20

Please indicate your degree of agreement or disagreement with the statements shown below about the exercise clothing in the image.

<table>
<thead>
<tr>
<th>I like the length of the leggings in the image because they cover the knees.</th>
<th>Strongly disagree</th>
<th>Neutral</th>
<th>Strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 2 3 4 5 6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I like the length of the raglan shirts because it covers the hips.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1 2 3 4 5 6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>The 2-in-1 shorts over the leggings is a good idea because it covers the hips.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1 2 3 4 5 6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overall, these outfits cover imperfections of body parts well.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1 2 3 4 5 6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I like the 2-in-1 camisole.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1 2 3 4 5 6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I like the raglan sleeve shirts.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1 2 3 4 5 6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I like the 2-in-1 shorts over the leggings.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1 2 3 4 5 6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I like the 3/4 length leggings.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1 2 3 4 5 6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>When I exercise, I do not wear a sports bra because it is uncomfortable.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1 2 3 4 5 6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>The idea of combining a sports bra and camisole seems comfortable to me.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1 2 3 4 5 6</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Please click HERE to enlarge the image and a new window will be opened.

Please indicate your degree of agreement or disagreement with the statements shown below about the exercise clothing in the image.

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly disagree</th>
<th>Neutral</th>
<th>Strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wearing the clothing in the image would be age appropriate.</td>
<td>•</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Wearing the clothing in would make me look young.</td>
<td>•</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Wearing the clothing would make me look healthy.</td>
<td>•</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Wearing the clothing would not draw attention to me.</td>
<td>•</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>I will not be embarrassed when wearing this clothing outside in public.</td>
<td>•</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>The overall design of the clothing is age appropriate.</td>
<td>•</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>

- **Benefits**
  - 2-in-1 Camisole
  - 2-in-1 Compress
  - Extra supports a
  - Breathable microfiber
  - Monitoring heart biosensing fiber
  - 2-in-1 Leggings
  - 2-in-1 Shorts over
  - Wider waistband
  - Capris 3/4 length
  - Hidden waistband
  - Curved lines & b

- **Raglan Shirts**
  - Longer curved h:
  - Raglan sleeves f:
  - Curved sides f:
  - Relaxed fit for cc:
  - Cooling perform:

- **Leggings**
  - Capris 3/4 length
  - Wider waistband
  - Hidden waistband
  - Black vertical line
  - Medium weights
  - Odor resistant fa
Please indicate your degree of agreement or disagreement with the statements shown below.

<table>
<thead>
<tr>
<th>Strongly disagree</th>
<th>Disagree</th>
<th>Neutral</th>
<th>Agree</th>
<th>Strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

1. I like to show off my body when exercising.
2. I like revealing my skin when exercising.
3. For me, exposing too much of my skin when exercising is **not** age appropriate.
4. For me, exposing my hips when wearing leggings is **not** age appropriate.
5. I am confident about my body shape.
6. I am proud of my age.

The image above shows a plain shirt and three other shirts labeled A, B, C. Please indicate your degree of agreement or disagreement with the statements shown below about the exercise clothing in the image.

<table>
<thead>
<tr>
<th>Strongly disagree</th>
<th>Disagree</th>
<th>Neutral</th>
<th>Agree</th>
<th>Strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

1. I like the slimming effects of the shirt A.
2. I like the slimming effects of the shirt B.
3. I like the slimming effects of the shirt C.
4. Overall, the slimming effects of the shirts are fashionable.
5. Wearing the shirts A,B,C would make me look slimmer than wearing the plain shirts in the image.
Please click HERE to enlarge the image and a new window will be opened.

Q28

Please indicate your degree of agreement or disagreement with the statements shown below about the exercise clothing in the image.

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly disagree</th>
<th>Disagree</th>
<th>Neutral</th>
<th>Agree</th>
<th>Strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>The overall appearance of the clothing is aesthetically appealing to me.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The overall designs of the clothing is fashionable.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I like the simplistic designs of the clothing.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I like the colors of the clothing.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The clothing would coordinate well with the other clothing I own.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The clothing would be compatible with my current needs than clothing I already have.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The clothing would be appropriate for my lifestyle.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Q29

Benefits
- 2-in-1 Camisole
- 2-in-1 Compression
- Extra support at the bust
- Breathable microfiber
- Monitoring heart rate
- Biometric biosensing fiber

Benefits
- 2-in-1 Leggings
- 2-in-1 Shorts over Capris
- Wider waistband
- Capris 3/4 length
- Hidden waistband
- Curved lines & bl

Raglan Shirts
- Longer curved hem
- Raglan sleeves
- Curved sides for flexibility
- Relaxed fit for comfort
- Cooling performance

Leggings
- Capris 3/4 length
- Wider waistband
- Hidden waistband
- Black vertical line
- Medium weights
- Odor resistant fabric
Please indicate your degree of agreement or disagreement with the statements shown below about the exercise clothing in the image.

<table>
<thead>
<tr>
<th>Q30</th>
<th>Strongly disagree</th>
<th>Neutral</th>
<th>Strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Wearing the clothing would make my workout more pleasant.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I would wear this type of clothing while running errands.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I would wear the clothing if they become available.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I intend to try this type of clothing.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>It is likely that I will buy the clothing when they become available.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I would purchase the clothing in the image.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Please indicate your degree of agreement or disagreement with the statements shown below about technology integrated exercise clothing.

<table>
<thead>
<tr>
<th>Q32</th>
<th>Strongly disagree</th>
<th>Neutral</th>
<th>Strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Are you interested in monitoring heart rates in exercise clothing?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Are you interested in tracking steps in exercise clothing?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Are you interested in cooling tech that lowers body temperature in exercise clothing?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Are you interested in odor-resistant fabrics for exercise clothing?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wearing technology integrated clothing would increase my productivity when exercising.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overall, I find technology integrated clothing useful.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I like technology.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Final (Optional) Question:
Do you have any comments that might help us to improve exercise clothing?

Any opinions on age appropriate exercise clothing?