

A user-centred approach to modest sportswear design for Cape Town Muslim women

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Declaration

I, Rushdeen Rose, declare that the contents of this design research report represent my own/group's unaided work, and that the report has not previously been submitted for academic examination towards any qualification. Furthermore, it represents my/our own opinions and not necessarily those of the Cape Peninsula University of Technology.

A handwritten signature in black ink, appearing to be 'Rushdeen Rose', written in a cursive style.

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Date

15/02/2022

Dedication and Acknowledgements

To Mummy – I miss your unconditional love - my only solace, knowing that you've returned to the sweet-smelling garden underneath which rivers flow.

I want to thank my supervisor Dr Elsabe Pepler. Thanks, Doc, for your reassuring words, continuous motivation, and precious time. This process has been made less stressful through your sound advice, guidance, and wisdom.

I want to thank my co-supervisor, Dr Alettia Chisin. I appreciate the third set of eyes and for availing time to read and offer insightful suggestions.

I appreciate those who have helped me realise this research -Mr Shamil Isaacs, Prof Michael Ernst, Mr Dave Mason, and all the participants in this study.

Note: Initially, my research aimed at producing physical prototypes to compare the performance against the existing garments through a field test study. However, the Covid-19 pandemic and its criteria for social distancing meant that I had to change the research content and title. Furthermore, all physical gatherings were prohibited, and athletes were not willing to participate. As a result, I changed the process to focus on 3D prototype development.

Finally, to my wife Imaan and my children Jasmin, Layla and Daniyaal – I thank Allah that you are the coolness of my eyes.

Abstract

There is limited peer-reviewed research investigating the incline amongst Muslim women who enter road running and athletic events. However, it is undoubtedly a trend perceived through international sportswear sales (Hwang & Kim, 2020), popular media articles (Hamilton, 2018), and visually noticeable by the increased frequency of Muslim women running in the streets of Cape Town. In addition, it is noteworthy that Nike and Adidas have launched ranges for Muslim women runners, confirming that Muslims have become a strategic growth market for well-established brands. However, the requirements for modest athletic sportswear that align with the prescribed hijab pose specific challenges for Muslim women, especially those who want to participate in long-distance road running.

Physiological studies confirm that female competitors found modest athletic sportswear (MAS) cumbersome and uncomfortable (Davis & Bishop, 2013). Furthermore, the research underlined that MAS adversely affected an athlete's physical, physiological, and ergonomic experiences related to comfort or discomfort. Therefore, an opportunity exists to complement previous studies and further investigate how a user-centred design approach, supplemented by contemporary fashion technologies in South Africa, may enhance athletic comfort and MAS performance through a virtual design process. Consequently, in addition to its functional design objectives, this study will explore this trend through qualitative interviews with experts on the hijab and a qualitative focus group with women participating in road running.

The primary research and design phase starts with interviews with an open and qualitative approach derived from a semi-structured interview schedule with two prominent women in Islam to establish the styling parameters for female Islamic clothing. Next, a focus group session engages athletes from running clubs in the Western Cape to understand their experiences with current products to establish elements for design improvement. Next, selecting suitable textiles through expert consultations and laboratory testing to present a scientifically tested range of sportswear for Muslim women. Finally, the data gathered provides insight into the

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development of three 3D prototypes: a long-sleeved top, a pair of pants, and a head covering.

Keywords: Islamic clothing, modest sportswear, comfort, fashion, Muslim, user-centred design, functional clothing.

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Chapter 1

Introduction and background

1.1 Introduction

Modest dressing is a cultural and religious code for Muslim women across the globe. Wearing modest clothing is also practised by non-Muslim women from various faiths and cultures in countries worldwide. At the current time, athletic clubs and Muslim-focused sportswear suppliers produce and sell clothing that aesthetically portrays modesty through loose, long, unrevealing, and reserved clothing.

Modest athletic sportswear (MAS) inherently possesses design and fit characteristics that are oppositional to the technically designed functional sportswear worn in warm weather conditions during competitions. In addition, modest dressing requires a high percentage of concealment, whereas performance-focused, comfort-promoting sports clothing most often results in minimum covering. Thus, the regulation of heat and comfort versus complete concealment poses an incongruous design dilemma for Muslim athletes and designers alike.

As more modest dressing women aspire to live healthier lifestyles, user-centred technical design becomes the medium for improving their sports experiences while still adhering to religious, moral, and cultural guidelines at the same time. However, the creation of such sports clothing needs to be considered carefully not to broach the line of modesty and still yield a semblance of an athletic adventure and feeling optimally fitting for the runner to ensure good performances.

1.2 Background to the problem

After September 11, 2001, there has been a reluctance by the fashion industry to be associated with Muslim people and their habits (Lewis, 2015; Hwang & Kim, 2020). More recently, however, there has been a steady shift towards focusing on human rights and

diversity through initiatives such as the United Nation's Sustainable Development Goals – with the core principle of "leaving no one behind" (United Nations, 2015). In addition, the World Economic Forum's promotion of diversity in business (World Economic Forum, 2020) and the recent anti-racism movement, Black Lives Matter (Black Lives Matter, 2020), made headlines in thinking about topics like this. Society is clearly demanding the consideration of human rights and diversity in fashion lifestyle brands, as was evident after the controversial Clicks black hair products (Chikaonda, 2020) and the H&M "Coolest Monkey" hoody adverts (Bjerre, 2018).

Globally, retailers noted the increased commitment to the pro-hijab movement represented by an explosion of niche apparel businesses on social platforms and the increased frequency at which modest wear fashion shows are hosted (Lewis, 2015; Hwang & Kim, 2020). There has been a consequent noticeable increase in the supply of products for the Muslim lifestyle. However, the hijab remains a contentious and politicised religious symbol, continuously experiencing resistance in liberal countries such as France and Denmark where there is a ban on wearing the headscarf.

Decathlon, a major sportswear brand, attempted to launch a MAS range for Muslim women athletes. However, the company experienced resistance through violent threats and opposition from French citizens and government officials (Chrisafis, 2019). Marks and Spencer experienced the same backlash for including the headscarf in their girl school uniform line (Zatat, 2018). Such incidents have contributed to the delay of sales and marketing of hijab by mainstream retailers, which may explain MAS's limited supply and availability. The headscarf is sold in small offerings by brands such as Nike and Adidas but has been in abundance supply through niche retailers (Hwang & Kim, 2020). As a result, leisure MAS is accessible to the Muslim demographic, but no significant research has developed professional MAS for performance and utility, particularly not in South Africa.

The idea for this study originated through various discussions with club athletes who acknowledged the need for the development of better MAS. The athletes also perceived the upward trend of Muslim women participating in road-running in recent years.

Evidence alluding to this phenomenon became apparent in a preliminary investigation at various Cape Town training sessions and the Two Oceans Marathon of 2016.

During such conversations and discussions, the women athletes acknowledged that they experienced discomfort with the clothing available on the market. They confirmed the sportswear they owned was mostly bespoke and produced by informal small businesses. Large retailers, these runners confirmed, are not stocking appropriate MAS conducive to participation in major running events.

Clothing fulfils three dimensions: expressive attributes, functional requirements, and aesthetic demands (Hwang & Kim, 2020). Even though some people perceive the hijab/Islamic covering as an object that invokes prejudice, racism and a barrier to comfort during sport, it remains an immutable necessity for many Muslim women athletes. This study aims to apply an ideal user-centred approach to understand the critical cultural-religious expressiveness of hijab and clarify the parameters and significance of modest styling as a user-requested essential. Furthermore, the research study will explore the functionality and performance limitations in modest athletic sportswear available to female Muslim athletes residing in Cape Town. Finally, the research extracts the users' aesthetic preferences and, in the end, incorporates all the expressive, functional and aesthetic needs in 3D designed concept prototype products.

1.3 Statement of the problem

Research has substantiated the fact that there is a lack of any sports range, specifically designer collections, for Muslim women who want to participate in road-running events and be comfortable but still desire to be respectful of the requirements for modest clothing. This design challenge thus became one of developing women's sports clothing that maintains modesty and achieves sports performance requirements to be still considered professional MAS. Following a user-centred approach, the task was to evaluate the needs and expectations of female Muslim runners of MAS. The primary exploration was to determine what female runners expect from MAS in the sports realm and then refine those remarks and suggestions into data that can support the design process and produce user-friendly hijab to benefit female runners in various ways.

1.4 Literature review

The literature review aims to clarify the developments and issues in the realm of Muslim women participating in road running. Various objectives must be explored and addressed: the growth of the road running amongst Muslim women; dressing guidelines for Muslim women participating in sport; the performance standards and requirements for MAS; the user-centred methodologies used to determine women needs for clothing design; the use of 3D technologies, and finally, the conditions explicitly related to Muslim women.

1.4.1 The growth in road running amongst Muslim women

MAS has become a popular matter in various mediums, including online retailing, social media, traditional media and academic literature. As discussed in section 1.2, mainstream retailers such as Decathlon, Nike and Adidas have shown interest in the halal sports market in recent years. However, for a long time in the East, MAS has been sold in niches by many non-mainstream companies such as Ahida, Raqtive, LiaWear, Asiya Sport, Sukoon Active and Capsters (Abraham, 2021).

Primary research on the growth of road running amongst Muslim women wearing hijab could not be found during the review period. However, global road running is growing amongst this demographic. This growth is evident through various indicators such as sales numbers of MAS in countries like Indonesia and the United States (Husna, 2020; Hwang & Kim, 2020), which have the largest Muslim population and the largest economy, respectively. In addition, Muslim women in various sports categories increasingly feature in news articles and magazines.

For example, in the politically charged Islamophobic United States, six-time marathon athlete Rahaf Khatib encourages Muslim women to do road running – and this article featured on the cover of *Women Runners* magazine (Hassouri, 2016). Besides this headlining of Muslim women in a prominent global running magazine, female Muslim running clubs in countries like the United Kingdom have also increased. Literature attributes the UK's growth to diversification projects and health promotion in Muslim-rich communities (Bakkar, 2019; Dutch, 2021). Moving east, Hamilton (2018) states that Saudi Arabia, the most gender-segregated country globally, has recorded growth in female running clubs in Jeddah, Riyadh, and Khobar.

Another indicator is the increased interest in product development of MAS, such as research studies by Yazid (2016) and Yusof, Ahmad, Yusof, Yahya, Hussain, Azidin and Muhamed (2020), which look at the functionality and performance of textiles and MAS. For example, Yazid's study utilised fashion design, Islamic principles and sports textiles to develop new MAS products. Hence, the growth in this sports demographic is accompanied by a perpetually growing range of products in the market with various styling features and integrated hijab elements in multiple degrees.

1.4.2 The guidelines for hijab worn by Muslim women entering road running

The definition of hijab is 'to cover'. Therefore, the hijab is mandatory for men and women. Some define and understand the headscarf to be "the hijab". However, the hijab (with or without the preceding 'the') should refer to headscarves and loose garments worn by Muslims as prescribed by Shariah (Islamic law). For men, the hijab is to cover from above

the navel to below the knees. For women, the hijab covers everything except the face and the hands up to the wrists. Hijab also includes protecting the way one conducts oneself, which should be righteous, moral and with good intention (Sumarliah, Li and Wang, 2020).

Hijab guidelines are applicable when unrelated men and women interact, and this includes sporting events. The primary source of prescription for hijab originates in ancient Quranic literature. Yazid (2016) extracted the translated verses from the Holy Quran, which speaks to female dress etiquette and refers to directives in Chapter 24, Verse 31, stating that women should not display their beauty and "ornaments" except to a specified group of people. The verse mentions the Khimar, a head-covering that covers the head and the breasts. In Chapter 33, Verse 58, the Quran advises that loose garments and concealment of the body shape afford women distinction and protection against harassment. Hwang and Kim (2020) echo Yazid but add that clothing must never be transparent, and designs must not be fancy or attention-seeking.

The following verse is extracted from the Holy Quran, Chapter 7, Verse 26, where God reveals the following:

O children of Adam, we have bestowed raiment upon you to cover yourselves (screen your private parts) and as an adornment; and the raiment of righteousness, that is better. Such are the Ayat (proofs, evidence, verses, lessons, signs, revelations, etc.) of Allah, that they may remember (i.e., leave falsehood and follow truth) The Quran 7:26.

The revelation of this verse is the instruction to dress and act modestly and use modest dressing as a personal visual reminder of one's required behaviour and to remain focused on truth and righteousness.

In the above verses, the Quran clarifies the intention and characteristics of the hijab but with no specific indication about the design elements. The style of hijab will thus inevitably differ due to diverse global cultural norms, experiences, age, mood, textile availability, weather, and a host of other aspects. In this research, styling accommodates the performance of hijab in warm weather conditions, which influences the design process.

1.4.3 Considering high-performance hijab for female Muslim road runners

To compete professionally and maintain the hijab criteria, MAS should meet high-performance apparel standards. High-performance apparel performs specific functions over and above the body's usual covering (McLoughlin & Sabir, 2018). For example, in sportswear for warm weather conditions, clothing keeps the individual cool, dry, comfortable, and protected.

Sportswear's primary function is to allow the body's natural processes, such as heat regulation and sweating during sports activities. The thermos-regulating properties of clothing are affected by various factors such as fibre type and composition, the method used to construct textiles, and the type of finish applied to the textiles or garment (McLoughlin & Sabir, 2018). Nadirah Mohd Yusof et al. (2020) studied the thermal properties of MAS supplied by retailers in Indonesia. A questionnaire presented to 100 participants validated that common hijab did not meet the comfort or thermal performance requirements during sports activities, corroborating the sentiments of the Cape Town athletes.

Another property that affects comfort is fit. Running requires a wide range of exaggerated movements. Therefore, there must be enough ease in the garment-to-body-fit ratio to allow room for the repetitive mechanical motion of running to be experienced as acceptable or unintrusive (Yazid, 2016; Zhang & Little, 2018). Even though stretch fabrics require a reduced ease allowance because of their flexibility, limitations can still result from incorrect patterns. Therefore, one must consider pattern design and ease allowance for the static and dynamic positions. Static ease refers to the allowance of ease in the stationary stance and dynamic ease, based on the body when it is in full motion or performing an exaggerated action. Yazid (2016) designed some of these products using sports textiles which incorporated allowances for movement to improve performance in MAS.

In addition to facilitating the body's physiological processes and freedom of movement, sportswear should protect the user against environmental elements (Ziemele, Šromab,

and Kakarānec, 2018) . Other functions are identity-giving and recognition as well as durability. Sportswear products endure elevated physical activity levels and are prone to degradation due to environmental issues such as weather, friction and sweating (Elmogahzy, 2019). Sports garments must therefore be user, activity and environment-centric to perform optimally.

1.4.4 User-centred design to determine women's needs and use 3D program software

A significant part of the comfort functionality is the correct fit of a garment. To understand how technology can assist with obtaining the proper fit, Hou (2018) tested real pants on living people using a film pressure sensor to record garment pressure to body measurements. The garments were then simulated in 3D and fitted on avatars with the exact body dimensions of the actual participants. Numerical values entered the program represent fabric properties. The result showed that virtual products realistically predicted fit improvements in physical products. To confirm the effectiveness of virtual garment fitting, Liu et al. (2021) designed 2D yoga suit patterns and analysed them for fit in CLO 3D, a virtual clothing design program. Suggestions for improving the fit through visual analyses of the garments in the static and dynamic (motion) states and applied in the 3D program resulted in 60.39% optimisation.

Interrogating users to provide design input remains a vital tool to determine functional garments' expected aesthetics and utility. However, virtual prototyping is becoming more popular and offers a more scientific and quantitative method of analysing garment fit, whether static or whilst moving.

1.4.5 The aspects to consider for the user-friendly design of modest sportswear for female runners.

Modern clothing production must consider various aspects as the process involves design, science, technology, sociology, and psychology (McLoughlin & Sabir, 2018). An influential designer will possess in-depth knowledge of the textiles, technologies, and production techniques available to produce a solution-based product. In sportswear design, one must

consider the wearer's needs, the environment and the fabric properties that will accommodate said environment (McLoughlin & Sabir, 2018; Ziemele et al., 2018; Elmogahzy, 2019). For example, the garments utilised for extreme winter sports would need to conserve heat whilst allowing moisture to move away from the body as a liquid build-up could freeze, resulting in hypothermia. In comparison, garments used in sweltering summer sports need to maintain the body's core temperature and control moisture during strenuous activities. In addition to the standard expectations for fashion such as appearance, comfort and fit, sportswear requires additional considerations such as optimising mobility and not being a barrier to the body's physiological processes.

As mentioned previously, the primary considerations relating to modest wear are the indicated requirements for a looser, longer fit that covers the whole body except the eyes and hands up to the wrists. These design elements are not conducive to warm weather running clothes. Yazid (2020) incorporates sports textiles intending to enhance the performance of MAS.

This research aims to build on such developments by combining sourced research on female-specific physiological data such as the female sweat regions; laboratory analysed textiles, and modern design tools to develop virtual prototypes.

1.5 Research questions

1.5.1 Primary research question

The primary question for this research is: **How can a modest sports fashion range be designed for Muslim women athletes guided by Islamic norms in Cape Town to improve comfort and performance during road-running?** This question aims to determine the design elements to successfully create a product that fulfils all the religious, sports, and fashion expectations. In addition, the inquiry seeks to elucidate research methodologies, garment design processes and materials used in the product development process.

1.5.2 Secondary research questions

The main question divides into three sub-questions. The first secondary question is focused to answer the question: **What are the current parameters of modest Islamic dressing for Muslim women in Cape Town in everyday life and when participating in sports events?** The question aims to determine the dress norms amongst Muslim women in Cape Town. This question focuses on a specific demographic, and it considers that regionally cultures differ. For example, people's perspectives on Islamic appropriate clothing will vary from Cape Town to Dubai. This research aims to apply a user-centred approach and design products applicable to female Cape Town users' specifications and expectations.

The second question unfolds as such: **How do a growing group of female Cape Town Muslim athletes participating in road running experience the Islamic prescribed sportswear (MAS) when they are competitive?** This question considers the current MAS available and how the women perceive its performance. The question aims to determine design improvements and elements for MAS.

The third question probes the following matter: **How can the athletes' needs, and experiences be included in the design, using processes and products available in South Africa, which will result in sports clothing that is more comfortable and performance optimal for Muslim women?** This question aims to discover traditional and contemporary design tools, materials, processes, and methods to optimise the design result. So, the question of how it is done requires knowledge about the available technologies. Technology will provide the solution to developing a product with incongruent design features such as loose, flowy clothing that requires optimal thermos-regulation and moisture management.

1.6 Aim and objectives

This research explores the minds and feelings of Muslim women in Cape Town about modest sportswear's expressive, functional, and aesthetic requirements. The research questions seek to use the female Muslim athletes in the focus groups' feedback to develop

a potential hijab range for those interested in sports and road running. In developing and producing the MAS hijab with 3D software, the user-centred design methodology includes participant suggestions and needs in product development.

The objectives of the research design and methods are manifold. Interviews are to be conducted with two prominent Muslim women activists and an athlete focus group to determine parameters for MAS, religious etiquette, and expectations for performance. In the focus group, participants are to be 3D-scanned for accurate sizing. Sports textiles sold in South Africa will be laboratory tested and selected based on suitability. Virtual prototypes aim to incorporating female perspiration study findings to determine vent placement to maximise cooling and drying. The aim is to include an evaluation of pattern fit and ease in static and dynamic positions employing 3D design technologies. The final goal is to improve the professional appearance of MAS through 3D design.

1.7 Research design and methodology

1.7.1 Research design

The epistemological approach is subjective and consists primarily of qualitative methods for data gathering, namely interviews and a focus group. However, data from the survey, fabrics testing, and 3D prototype analysis are all objectively acquired and based on quantitative (but non-extrapolated) data. The research is, therefore, a mixed-method design.

1.7.2 Research methodology

The methodology, detailed in the third chapter, solves the primary question and secondary sub-questions and explains the interviews, the focus group, textiles testing, and 3D design processes applied for data extraction. An explanation of how the data is secured and interpreted will be offered. The method utilised qualitative and quantitative research tools to extract data for prototype development. The final section focuses on the 3D evaluation of the prototypes.

1.8 Assumptions for the study

The assumptions that follow here, were posed at the beginning of the research, and focused on the technical aspects and performance of sportswear. Comfort is a subjective topic, and not all study participants/athletes feel that current and available MAS is uncomfortable. Therefore, the assumption is that research can still improve MAS comfort even if the wearer is satisfied with current comfort levels.

Modern technologies are a means of improving technical clothing design. Technical clothing improves when user needs, and expectations are evaluated by consultation with experts about technical issues. In other words, applying a modified functional design process would undoubtedly result in a better functioning product.

Sports and moisture management textiles are made from synthetic/man-made polyester fibres incorporated in the existing products worn by the study participants. The main cause of discomfort was a result of moisture management fabrics used without sufficient venting. Moisture management fabric performs when it has skin contact and facilitates wicking through moisture displacement due to the fibre and fabric structure design (Troynikov & Wardiningsih, 2011). The existing product's fabric had an increased ease allowance, distanced away from the skin and it thus trapped moisture. Appropriate venting would enable the body to regulate its physiological processes.

Using natural fabrics or blends, proper venting, and ergonomic considerations could improve comfort by decreasing heat, moisture retention and ease movement.

1.9 Theoretical context for the study

User-centred functional clothing design is the major motivation for the existence of clothing. The first animal hides offered protection against the natural elements in prehistoric times; later, the medieval protective metal-armoured suits used by knights, and more recently, camouflage clothing worn in wars to evade the enemy by blending in with the terrain during combat. There are many examples where the user and environment are the combined basis for clothing design and functionality.

The history of user-centred design theory is discussed has been appearing in academia for decades (Bayazit, 2004; Pacheco, 2019; Wallisch & Paetzold, 2020), and originated in the second of two design generations in academics during the 1960s and 1970s. The first generation of design developments was concerned with conveying design processes in terms of systems and processes and focussed on a designer inspired solution or creation. This type of design can be compared typical high fashion design practices that still take place today where designs are manifestations of the designer and her/ his imagination, creativity, capability, and knowledge. In contrast to the first generation of design, the second phase focused on the impact of design and its relation to humanity (Rittel, 1972). It is from this second generation of design that the user-centred design approach originates. The second generation concluded that design had to be relevant, impactful, and empirically acceptable. In maintaining relevancy, it is logical to accept that only the wearer of specific clothing, as they partake in specific daily routines and functions of their lives, can offer insight into what is optimally "user-friendly" and comfortable. The processes for the second generation of design require research methods to establish what humanity needs. This is, of course, a far distance from high fashion design, where aesthetics and beauty only often inspire design for humans, and rarely comfort and optimal functionality.

Qualitative data-gathering techniques such as interviews, surveys, focus groups and other tools empirically support user-centred ideas. There are a vast number of citations in literature from Dejonge (1984), Huck and Kim (1996) and LaBat and Sokolowski (1999). They highlight multiple models for the design of functional clothing, which indicates the prominence of user-centred clothing design. These methods assess aesthetic, expressive and functional requirements through user consultation and evaluate performance after prototyping. Communication with the end-user about the product design will always be the optimal way to design functional products. The exponential growth in digitisation has resulted in modern technologies that can augment traditional practices by simplifying the design and prototyping through immediate visual evaluation and correction (Hou, 2018). With the end user's input, designers can create virtual clothing products based on those aesthetic, expressive and functional requirements stipulated by the end-user.

A valuable explanation of user-centred theory and the purposes thereof by Gupta (2011) can be read in the literature review chapter (under point 2.3, User-centred design),

1.10 Delimitations of the study

The scope of the study depended on accessibility to interviewees and participants, and the availability of resources in Cape Town.

The study includes interviews with two prominent Muslim female activists and a focus group of thirteen Muslim athletes who participate in road running and need MAS running outfits. All the chosen athletes reside in Cape Town to ensure accessibility and maintain consistency in their experiences with climatic conditions.

The study focuses on clothing for warm weather conditions and all fabrics purchased from local suppliers and tested by the Technology Station Clothing and Textiles testing lab.

The research would result in three 3D conceptualised modest sports products: a head covering, a top, and a pair of tights.

1.11 Ethical adherence

I was acutely aware that this study was related to the culture of a very particular group (young Muslim females pursuing athletic participation in marathons and road events) and the sensitive area of religious beliefs and convictions. The females/women were informed ahead of selection and the different phases of the study that this topic may involve potential discussion about values, religion, and culture. This study was vital since the subject may have intimidated other researchers from other cultures and religions. I benefit from being Muslim, young, and married with children, and deep background deep knowledge and experience about the gender expectations around Muslim culture.

In addition, I was aware that many perceive the hijab as a patriarchal instrument of oppression, and being a male, developing a hijab may seem unethical. I therefore cover the various topics in the literature review where Muslim women have provided their

opinion about their roles in Islam and the function of hijab. I have also used ensured that all co-designers were Muslim women.

I thoroughly explained the original motivation for the study and the potential value for female Muslim candidates. Their participation and respect for their culture, religion, values and ethics are naturally crucial due to the title, topic and envisioned outcomes of the study, and it was explained as such to all participants. I also shared the information gained from female Muslim activists who provided insight into the research and the design and methodology. The option was always open to any respondent or participant to stop any proceedings along the way.

At all times, the four ethical categories or conditions, according to Leedy and Ormrod (2015:120), will be respected and communicated:

- 1) protection from harm;
- 2) informed participation;
- 3) privacy, and
- 4) unconditional honesty.

Privacy during the scanning phase was to be discussed with participants, although no physical touching was involved in the process. They did not have to get undressed or put on revealing clothing.

Maree (2016:44) states that one must familiarise oneself with the institutional rules on ethics and further mention issues on consent, permission for interviews and disposal of audiotapes. Thus, this study has an even more pronounced need to respect ethics from both CPUT and the Muslim culture and religion.

Babbie and Mouton (2016:546) list various ethical considerations with critical value: protect your subjects, be honest in the research and data evaluation, and maintain awareness of potentially biased findings. All findings must be available to all respondents to ensure that the research remains ethical. In addition, the results may interest the

women themselves to know that the designed range is designed to improve their comfort, appearance, and happiness and that it still adheres to the Muslim culture, religion, and values upheld in Islam. Therefore, as a researcher, one has to think the process through, protect all subjects (whether animate or inanimate), be honest and transparent to those participating, and scientifically evaluate the data.

Participants in the research were recruited with complete information about the origin and intended outcomes of the study. Participation was voluntary and free of coercion, and the researcher never had any relationship with the participants (except for a familial sister who participates in road running).

A formal written information page followed by a request for consent of participation will be provided to all participants. Then, I will explain the data collection method, purpose, and end-use, allowing participants to reject or accept being part of the study. Records will be kept in safe conditions in both hard and electronic copies.

Utilising numbers or alphabetical representations instead of actual names protect participant privacy, and when required, faces are blurred in images. The participants will thus be confident that they are not recognised and would suffer no potential cultural or religious consequences for their participation. Assurance is given to athletes that the research contributes to their future achievements, comfort, and recovery after events.

Cape Peninsula University is the sole funder and organisation involved in the research and engaged participants in their personal capacity. All above included a disclaimer, signed off and accepted before the participants could participate in the study.

1.12 Significance of the research

A study in 2015 that involved 163 556 participants from thirty-eight Muslim Countries determined that 35.5 % of all adults were inactive women, and 28,8% were inactive males (Kahan, 2015). The study's overall conclusion found that physical inactivity was higher in Muslim countries than in non-Muslim countries. The research adds to the knowledge of the impact of culture on sports clothing design. This understanding improves the

products and the likelihood that more women may consider healthier lifestyles and participate in sport. In addition, the redesigned products could enhance the comfort and physiological experiences during sport and therefore enhance competitiveness and performance.

The rapid growth of Islam is an essential factor that will impact business sustainability globally (Pew Research Centre Religion and Public Life, 2015; Thomson Reuters, 2015). Globally, there has been a conscious move towards marketing for the Muslim demographic across various industries, including finance, fashion, tourism, food, media and recreation, pharmaceuticals, and cosmetics (Thomson Reuters, 2015). Major brands in the fashion industry have indicated their inclinations towards Muslim-focused fashion through their online marketing campaigns, confirming the Islamic demographic and its importance to business sustainability (Sarkar, 2016; Net-A Porter, 2017; Operandi, 2017). According to the Pew Research Centre (2015), the global Islamic population will increase by 6.5% (\$1.16 t) to an estimated 30% (\$2.7 t) by the year 2050.

The research has utilised user-centred design methodology in Fashion Design which is not solely about aesthetics but is scientifically guided. If South Africa aims to compete globally, user-centred functional designed products offer more value and intellectual property than traditional fast fashion. Furthermore, focusing on technically designed fashion products in universities could provide an effective pedagogical method to promote innovation or a design–engineering focus instead of fashion with a design-art focus.

1.13 Summary

In this chapter, I gave a broad and general overview of this study and dissertation. I have explained the subject under investigation and my initial background exploration. I have clarified the aim and objectives of the research and conveyed the relevance of the topic. The following chapter will examine available literature on the subject and research problem.

Chapter 2

Literature review

2.1 Introduction

Some may be described the hijab as having an infamous reputation. Therefore, it is essential to examine the reasons and validity of the negative perceptions of the hijab. Designers have a profound responsibility to design ethically and create products that are not oppressive or repressive but rather benefit humanity (Rittel, 1972) . In the first section on modest wear, I extensively investigate the cultural background of Islam in Cape Town, hijab politics and the narrative around the hijab as a tool of oppression. Next, I examine the literature on the user-centred approach to fashion design. In addition, I review literature related to aspects that influence sportswear comfort. Finally, I investigate the capabilities of 3D technologies and their use in fit and ergonomic assessment.

2.2 Modest wear expressiveness

The expressiveness of modest dressing relates to the sub-question, "**how do Cape Town Muslim women athletes currently experience prescribed sportswear as guided by Islamic norms when they are competitive?**" This question relays to their physical and the social experiences while expressing their religiosity. The latter requires ethical consideration from a design perspective as the hijab has been considered a vice of oppression over Muslim women.

Muslim women persist in wearing MAS during sport. They express their Islamic identity as a timeless tradition and as a connection to the Divine. In this section, I will investigate the origin of Islam in Cape Town, the political influence on the perception of Islam, Muslim women's rights, the display of religiosity through dress, hijab as a symbol, and the theoretical reasons for wearing hijab.

2.2.1 Islam in Cape Town, South Africa

Islam has existed in South Africa for more than six hundred and eighty years, is heterogeneous and multicultural, and has taken residence in different regions at different times. For example, Muslims with Malay and Indonesian origins first populated the Western Cape, and those with Indo-Pakistani ancestry occupied the then Natal and Transvaal regions two hundred years later. Mayson (1865) and Theal (*n.d.*) in Mahida (1993:1) and Tayob (1996:730), estimate that Islam was established in the Western Cape around 1652 to 1658.

Slaves and political exiles trafficked from Malaysia, Bengal, Madagascar, and the Malabar Coast, fulfilled colonial ambitions in the Western Cape. Among those were prominent Muslim scholars such as Tuan Guru and Sheik Yusuf of Macassar. These scholars were pioneers of Islam in the Cape and built the Islamic foundation that exists today. In 1860, about two hundred years after the first Muslim arrivals, Indian workers from Calcutta, Madras, Bombay, and Gurujat were brought to South Africa to work on the plantations in Natal and Transvaal.

Besides the Muslim diaspora, many non-Muslim Malaysians in the Cape converted to Islam (Günther, 2018). Cape Town consists of a heterogeneous Muslim community established by the inflow of the various cultural groups from the other parts of South Africa and the world. Muslims have had a notable impact on the socio-political fabric of South Africa. The effect is evident in the influence of Arabic in the formation of the Afrikaans language (Muhammed, 2012). Tuan Guru was the first political prisoner, and Imam Haroun martyred in the apartheid struggle in politics. Hundreds of mosques were established in South Africa, of which the first was the 1978 Auwal mosque in the Bo-Kaap.

Islam in South Africa is synonymous with liberation politics, and therefore, Muslims have had the freedom to express their religiosity. However, in recent times the occurrence of intolerance has started to surface. With the advent of social media, increasing gentrification in Muslim community areas, generational change, and the fading of Apartheid struggle memories, South Africa is experiencing sporadic anti-Muslim

sentiments. Evidence of these sentiments are complaints against the call to prayer, anti-halal food campaigns, and the banning of the hijab in workspaces (Adriaanse, 2019).

2.2.2 Political influence on the perception of Islamic dress

The hijab is an identifier of Muslim presence in Western society and a visual marker for marginalisation. The religious dress code, its association with emotions like fear and resentment and its status with terrorism and oppression need to be understood to render this design endeavour ethical. To understand the image of the hijab, one must comprehend Islam's association with terrorism. Esposito (2015) explains how the lines between religious Islam and political Islam are intentionally blurred to promote political agendas of Western publics, sectarian interests, and those labelled as "jihadists" or extremists. Islamic proponents of the anti-west movement have legitimised actions like the September 2001 attacks on the World Trade Centre by quoting the Quran. Quranic scripture that revealed tribal wars in the year six hundred and twenty-two (622) has been taken out of their historical context and used to motivate present conflicts. The extremists' sinister interpretation of the Quran ignores rules on chivalry towards women, children, the elderly, and priests. This ignorance over Quranic texts is not simply an inability to interpret the revelation. It is about the intentional recruitment of soldiers to fight political battles, not religious ones.

Fighting by groups such as Al Qaeda, Hamas, Hezbollah, and other groups are comparable to liberation movements opposed to the occupation of Arab territories by Western forces. It is about the occupation of Israel in Palestine and the support provided by America to the authoritarian Saudi regime and is therefore politically motivated. Islamic State (IS) is a "mafia-like" movement whose primary goal is to conquer territories, killing anyone, religious or not religious, and opposing their newly formed "caliphate" and version of Sunniism.

The Quran defines the rules for war. War is for defence only. In battle, all innocent citizens are to be protected – these include Jewish and Christian holy leaders and their places of worship. There is no compulsion in religion. Esposito (2015), a practising Catholic Christian, juxtaposes Quranic text to the actions of extremists and provides a logical

assessment confirming that Islam does not advocate violence. In the same way, Western forces have selected verses of the Quran to legitimise war on Muslim countries, quoting verses of war as an indicator of the violence propagated by Islam but ignoring the passages on genocide in the Bible (Haggerty, 2010). Recognising the actions of IS, Al-Qaeda, and Boko Haram and linking it to Islamic norms while not recognising the activities of the Christian groups like the Catholic and Protestants of Northern Ireland, Serbian Orthodox and the Croat Catholics in the Balkans and not linking those religious associations, is illogical.

The effect of political ambitions on the reputation of Islam affects the perception of Muslims and their traditions. The narrative that Islam promotes violence, oppressiveness, and repressiveness has led to the hijab becoming the identifying sign of danger when worn in western societies.

2.2.3 The display of religiosity

In June 2018, Major Fatima Isaacs received an instruction to remove her headscarf after twenty years of donning it in her career as a South African National Defence Force member. Isaacs proceeded with successful court action and continues to wear the scarf on duty (Adriaanse, 2019). As witnessed in the case of Bilqis Abdul Qadir, the anti-hijab trend is global. United States basketball rules prevented Qadir from wearing the scarf while playing, which resulted in her fighting the non-hijab policy through the International Basketball Federation (Munu, 2017). Marwa Al Sherbini pursued an Islamophobia and racism lawsuit against a 28-year-old Russian-born German, named Alex W., because of verbal attacks he had cast over her wearing the hijab. Al Sherbini was stabbed and killed by Alex W. in front of her son during the trial. If Islam has been around for over fourteen hundred years (1400+), the question can be asked why is there still such intense resistance to the display of the hijab?

To make sense of such actions, one must view the situation through a socio-cultural lens. The word 'chronotope' is a combination of two Greek words, χρόνος and τόπος, which translates as 'time-space'. As Göle (2018) explains, the secular scene represents spaces of modernity (time) in the regions of colonialism (space). As a result, the public display of

religion in the colonial areas has been denigrated through legislation and media to promote secularity, modernity, and progressiveness. All who exist in secular spaces must adapt and conform to those spatial norms. Those who do not adapt are resistant, non-conforming and an alterity. Through their dress and appearance, Muslims depict a different time (outdated), another space (from the east), and thus portray a different chronotope. Therefore, Islam is conveyed as backward, non-progressive and a threat. The secular chronoscope feels fear and resentment when witnessing the Islamic chronotope, which is publicly displayed through Islamophobic acts. In other words, in the case of hijab, the display of an anachronous dress culture is obtrusive in a "modern" secular society. It has resulted in a public expression of hostility and fear of the entrenchment of a culture that belongs in the eastern, "backward civilisations" (Brayson, 2019; Göle, 2018)).

The fear of societal change is not the only aspect that has influenced the hostility towards Islamic religiosity. Through entertainment, news, politics and academic literature, media have successfully developed, to a degree, the generalised perception that Islam perpetuates the oppression of women (Goodwin, 2016). Even though the generalised perception or stereotyping of a particular group defines racism, it is essential to establish whether such accusations are true.

2.2.4 Muslim women rights

Besides terrorism, there is a notion that Islam is a religion of oppression and regression (Goodwin, 2016). A featured point of this oppression is the narrative on the treatment and women's rights in Islam. The United States, which many consider the flagship of democracy, has yet to elect a women president. The country with the largest Muslim population, Indonesia, had already appointed Megawati Sukarnoputri as their first female president in 2001. Bangladesh, a Muslim majority country, has elected two consecutive female presidents, namely, Khaleda Zia in 1991 and Sheikh Hasina in 1996. Regarding regression, the first university in the world, al-Quarawiyyin University, was established by a Muslim female, Fatima al-Fihri, in 859 Finally, a Muslim woman, Halimah Yacob, has been president of Singapore since 2017, a country with one of the best-performing education systems.

Abu Lughod (2012) explains how religion is often intentionally blamed for political injustice. The hijab has become a perfect connector of the progressivists and the far right and Western feminists. On the one hand, you have the Western feminists rushing to save "incapable Muslim women" from their patriarchal prisons. For the far-right, Islam contaminates foreign culture infiltrating what Westerners perceive to be the only perfect way to experience life, so-called democracy. Abu-Lughod explains how all Egyptians, male and female, face corruption, persecution, and extortion by police and how an avid businesswoman survives in a challenging political and social environment. Her strength and the way she lives deflate the image of the imprisoned women damned by her faith. Her faith connects her to God, her identity, strength, and hope under an oppressive and corrupt government.

Many Muslim women that Abu-Lughod, a renowned ethnographer, has studied come from different walks of life. Educated and uneducated, rich and poor, living in Muslim and non-Muslim countries all react similarly and take offence by suggesting that Islam is the cause for any trepidation or adversity that they may be experiencing. Western feminists believe that all Muslim women are cut from the same cloth, possess the same faculties, and are weak or brainwashed to the extent that they cannot choose what they wear, which conveys hypocrisy (Khan, 2019)

2.2.5 Hijab

The topic of the hijab is often contentious, filled with various gender, political, and cultural/religious debates. This study investigates those issues through secondary and primary research to understand the innate motivation and importance of donning the hijab and establish the design elements acceptable to participants. Hijab is incumbent on practising women and men, but the latter's investigation is not part of this thesis.

There is extensive research on the definition, origination, and parameters of the hijab. Bhuiyan (2018) references the Quranic verses and the Prophetic Prescriptions and has highlighted several specific requirements. Those requirements summarise that woman should draw their head-coverings over their chests but that the face and hands may be exposed. The garments must be loose and not define the shape of the body or be

transparent. Clothing must be modest. Dress style should not imitate the clothing of the opposite sex and applies to apply to men and women. Finally, clothing must be an adornment covering the private parts, clean, decent, and not worn for admiration or sympathy.

2.2.6 Theoretical motives for wearing hijab

Islamic knowledge collection has been systematic and treasured according to the authenticity of its links to the Prophet Mohammed (PUB) or/and his companions. In the generations to follow Prophet Mohammed (PBUH), four revered scholars became the custodians of the message of Islam due to their lifelong dedication to religious studies and their status as saintly figures. These religious scholars – or Imams – were the originators of the four primary Sunni schools of thought, also known as the Madhabs of Shafi, Hanafi, Maliki and Hanbali. These schools have some minor differences in practices, but all remain within the bounds of Sharia law. For an in-depth analysis of hijab prescriptions, Bhuiyan (2018) provides a detailed study of Islamic literature sources.

Abu-Lughod (2002:4) conveys the universality of modest dressing and highlights that many societies worldwide, such as the Hasidic Jewish women in New York, the Amish in Pennsylvania, the Hindu in the North of India, Catholic women, Christian nuns and Muslim women worldwide, don modest clothing.

Endelstein and Ryan (2013: 255) compare the intentions around modest dressing by the Jewish community and state that even though the Jewish community and Muslims dress modestly for religious purposes, their underlying motives vary. The Jewish people dress to portray unity and for the preservation of their religion. On the other hand, Muslims dress to show affiliation to the pioneers of Islam and the re-composition of that identity. Endelstein and Ryan state that to be a true Muslim, one must emulate the characteristics and examples of the pioneer Muslims and strictly obey Quran texts, which agrees with Bhuiyan (2018).

A study examining the impression-management choices of individuals belonging to collectively stigmatised groups revealed that the hijab was used as a form of resistance,

negotiating public presence, maintaining modesty, purity, and creating acceptance of religious differences in public spaces. Such symbolic actions continue during the onslaught of verbal and physical attacks (Tress, 2009; Endelstein & Ryan, 2013) . The hijab is more than a dress code. It is a tool for negotiation in times of stigmatisation, racism, and anti-multiculturalism. As mentioned in the display of religiosity section, the hijab has become a symbol of human rights instead of a simple dress code.

As Tayob (1999)defined, religious symbols manifest the metaphysical reality and communicate the social identity of a group or a community. Without the symbols, the identity will cease to exist. Religious symbols are powerful in that they enable personal direction, allowing for alignment to a social structure and a guide on living. The way to live is connected to an absolute, thus providing a sense of belonging, direction, peace, and coherence. The headscarf would be defined as a modest dress code in specific regions and situations and is not unique to Islam. However, the Islamic headscarf has become a symbol of faith and principles, manifested by the hyper and controversial attention as a characteristic of Islam.

When designing clothing for the Muslim market, it is vital to understand how the study's participants interpret Islamic dressing. Therefore, this investigation will define the local Islamic dress norms, clarified through interviews with prominent Muslim females.

2.3 User-centred design

The user-centred theory (see 1.9 for theory for the study) is crucial to successful functional clothing development.

In traditional fashion design, designs are symbolic of the designer's self-expression released into the market with the expectation of creative recognition and sales success. In contrast, the user-centred method incorporates the user experience and the environment in which the products are utilised and focuses on functionality and protection(Naesgaard et al., 2017)

Gupta (2011:321) provides a definition that explains the user-centricity in clothing development and defines functional clothing as

... clothing or assemblies that are specifically engineered to deliver a predefined performance or functionality to the user, over and above its normal functions. It can ... protect individuals who are exposed to life threatening or hazardous environments during work or during sporting activities; or ... facilitate movement and body balance in physically challenged individuals or that enhance stamina or reduce fatigue in sportspeople. It can also be clothing that performs a purely aesthetic function like enhancing body shapes ... Functional clothing assemblies are ergonomically designed ... [to] provide maximum comfort and performance to the user ... aesthetic considerations are often overridden in favour of performance.

When developing user-centred functional clothing, the process formulated in the design situation depends on accessibility to materials, technologies, facilities, etc. In general, developed countries lead technological advancements, and therefore developing countries cannot replicate advanced product development processes, including specialised equipment and specific resources. Consequently, it is worth examining literature while considering technological availability – especially for applied research – to formulate design solutions in line with resources available in South Africa.

Therefore, although dated, the principles for technical clothing design by Huck and Kim (1996) (also see 1.9) still apply and are a comprehensive example of a user-centred approach that uses a mixed-method to assess mobility and comfort of firefighter coveralls. The research used primary data extracted through an experimental process, with the variables being the range of motion/mobility and the users' subjective evaluations. The researchers used observations and interviews, respectively. The data extracted were on comfort, mobility, utility, and wearer acceptability. The study by Huck and Kim (1996) is an example of a low-tech method for designing functional clothing with a primary focus on user experience and user feedback.

Naesgaard et al. (2017) applied a user-centred approach to develop protective clothing for off-shore petroleum workers by interrogating participants in interviews and assessments through field tests. In addition to user input, prototyping and an iteration

process allowed additional user feedback and improved later prototypes. As a result, the study proved an enhanced user satisfaction and better performing clothing.

Yazid (2016) applied a traditional fashion design approach to develop experimental prototypes for MAS. Users were provided with prototypes designed by the designer and evaluated the products' performance, shortfalls and suggested improvements.

In the above examples, users evaluated various performance metrics. Hwang and Kim (2020) specified these metrics into three categories, proposing modest sportswear to be functional, expressive and aesthetically pleasing (FEA). Products such as fire, hazmat and boiler suits/overalls conform to legal and technical standards, and such products lack expressiveness and aesthetics. Aspects relating to expressiveness and aesthetics are restrained in technical clothing design because they are not related to performance or utility. The FEA attributes confirm that, in some instances, cultural norms influence the acceptability of a product. Culture falls under the expressive category.

Previous studies describe MAS as cumbersome and uncomfortable (Davis & Bishop, 2013; Yazid, 2016). The research by Davis and Bishop had shown that MAS certainly affected performance and recovery during exercise by adversely influencing physical, physiological, and ergonomic experiences – experiences that confirm discomfort. The human body was the subject of the investigations, which focused on the resultant physiological reactions caused by wearing MAS during exercise. Being conducted by sports scientists, the research is more creditable when evaluating the physiological impact of MAS. Therefore, the study confirmed the need for further studies to develop technically sound functional MAS to improve user experience, physiological function and sports performance.

2.4 Sportswear functionality

2.4.1 Comfort

Besides affiliation to a particular sporting genre or club, the primary function of sportswear is to promote comfort during sport. Therefore, comfort-enhancing textiles

and technologies, initially designed for sportswear, are incorporated into fashion items dubbed leisure sportswear – ideally creating two categories, professional and leisure sportswear (also known as activewear). Professional sportswear requires optimal performance designed to a predefined set of criteria such as wear time, wear frequency, weather conditions, participant age, and participant gender. On the other hand, leisure sportswear is produced for everyday comfort, not for professional performance (Elmogahzy, 2020).

Perceptions of comfort vary due to subjective experience that users perceive from a range of physical and non-physical processes. The three components affecting comfort are the body, clothing, and environmental conditions. Of these, the only controllable component is the clothing system, and the technical objective is to design non-intrusive clothing for the body's physiological processes. In addition, the system needs to consider both sensory experiences and mobility requirements. Therefore, comfort aspects for apparel are categorised into thermo-physiological, skin sensory, ergonomic and psychological effects. Thermo-physiological properties relate to the ability of clothing to maintain a comfortable core body temperature. Skin sensory relates to the perceived comfort during skin and textile contact. Ergonomic properties refer to the design, construction, fabrics, and ease of movement due to these factors. Lastly, the psychological impact refers to the overall perception of comfort by the wearer due to experiences in the previously mentioned categories (Wang, 2015; Yazid, 2016; Kurniawan, 2017).

2.4.2 Fabric

Fabric is the barrier and component directly in contact with the skin, and therefore strategic fabric selection is key to obtaining clothing comfort. Fabrics used for sports textiles can contain natural, synthetic, or blended fibres processed into yarns. The yarns are constructed into fabrics using specific techniques and may have a finishing process to enhance performance. However, certain synthetic fabrics contain mono or a single extruded filament. Fabric comfort and performance is enhanced by manipulating fibre cross-sectional shape, filament content, construction techniques, and chemical finishes (Wang, 2016).

Natural fibres such as cotton and bamboo generally used in leisure sportswear are fine, soft and flexible, and are synonymous with comfort due to their skin sensory properties. Natural fibres, however, tend to absorb and trap moisture within the fibre structure, which can cause discomfort during strenuous exercise due to clinginess or hyper-cooling (Ziemele et al., 2018). For this reason, synthetic moisture-management fabrics have become the dominant textile for sportswear and are specifically engineered to improve comfort due to their quick-dry properties. For example, Simile (2004) states that polyester, a synthetic fibre filament, does not have in-to-fibre absorptive properties but utilises fibre and fabric structure to channel moisture. Simultaneously, the inability to absorb moisture allow synthetic textiles to possess quick-drying properties.

The ability of a fabric to absorb moisture is defined as wetting which has three categories: dispersion wetting, infiltration wetting and adhesion wetting. Simile (2004) explains that dispersion wetting diffuses the moisture across the surface. Infiltration wetting absorbs water with towel-like saturation. Adhesion wetting is when water is held onto a solid surface by tension. Contemporary synthetic fibres aim to utilise wetting actions to control and move moisture away from the body. Sweat travels into crevices in the fibre, which causes dispersion and infiltration wetting. The use of alkali treatment and the shaping of the fibre influence surface tension, which disperses, absorbs and releases the moisture to the external environment (Hussain et al., 2015). An example of a well-known moisture management brand is DuPont's Coolmax® which is a "propeller" shaped yarn made from recycled plastic bottles (Invista, 2017). Even though synthetic textiles have excellent moisture management categories, they also do possess some negative qualities. Synthetic textiles tend to retain body odour and become static. Therefore, in recent years, natural options for moisture management fabrics such as Transdry® and Wicking Windows® have been developed to accomplish the favourable properties of both natural and synthetic fibres (Frumkin et al., 2012; Cotton Inc, 2017).

2.4.3 Fabric testing

Testing standards provide instructions to ensure that laboratories control all the variables to ensure a calibrated environment and standardised methods for testing.

A range of organisations such as the American Association of Textiles Chemists and Colourists (AATCC), Australia and New Zealand Standards (AS/NZS), American Association for Testing and Materials (ASTM), British Standards Institute (BS), International Organisation for Standardization (ISO), International Wool Textile Organisation (IWTO), European Standards/ European de Normalization (EN) and Oeko-tex Association (Oeko-tex) exist to evaluate and set performance standards (Wang, 2016).

Sportswear fabric comfort testing predominantly focuses on thermo-physiological factors such as thermal insulation, skin sensorial, stiffness, moisture absorption, wicking, surface index, wet cling, dry rate, air permeability and mass (Elmogahzy, 2020).

The evaluation of the fabric component must precede the decisions on garment fit as physical properties of fabrics influence pattern development. Therefore, designers must allow for fabric drape, handle, shrinkage, and stretch/ elasticity when developing patterns (Hosseini Ravandi & Valizadeh, 2011).

2.4.4 Fit

Globally, we are experiencing exponential technological advancements driven by multiple macro-environmental factors such as the Covid-19 pandemic, launching the 5G network, the Fourth Industrial Revolution, the United Nations' Sustainable Development Goals, and the current techno-political landscape. Over a short period in 2020, Covid-19 has become a catalyst to the economising of bricks and mortar facilities, and investments and growth in online facilities have leapfrogged (Cullinane, Carlson and Wang, 2017). There are perpetual improvements in product development technologies in the clothing industry to optimise the one hundred per cent online experience, including the virtual fitting of garments. Although the percentage related to size and fit issues is not readily available, online garment returns have been estimated to be as high as sixty per cent. In the online space, contemporary product development requires global anthropometric surveys and the utilisation of 2D and 3D tools to ensure that sizing and fit are correct for the targeted market.

Fit/garment cut is how the garment shapes to one's silhouette. During mobility, garment fit comfort improves by adjusting clothing to body distance/ease, adding stretch fabrics, manipulating limiting fit points such as waistbands, and correctly allocating fullness into patterns. Besides the importance of correct fabric choice, engineering clothing patterns to match body dimensions for the appropriate fit is fundamental to achieving comfort(Zhang & Little, 2018).

2.4.4.1 Anthropometrics

Measurements of the targeted group are the primary step in product development. Anthropometrics is the scientifically measured numerical data of the body relating to size, shape, and other physical characteristics utilised to develop the sized patterns for a target group(Pheasant & Haslegrave, 2005). Anthropometrics, which is the scientific study of the measurements and proportions of the human body, is critical in developing clothing that is ergonomic in terms of comfort and safety. 3D body scanning technology has become the standard tool for doing size surveys due to its efficiency and comprehensive recording of measurement and the 3D shape, which can later integrate into 3D design software (Rissiek & Trieb, 2010). In addition, 3D software enables the analysis of garment ergonomics through fit assessment in different poses and motions to improve functional comfort.

2.4.4.2 Ease allowance

Ease allowance is the additional volume provided in the pattern design process to accommodate mobility, breathing and comfort. Ease is incorporated into clothing patterns by using a linear index that adds fabric allowance to linear measurements. The more accurate method for adding ease is through a cross-sectional index. A cross-sectional ease allowance considers regional areas such as the shape and volume of the back versus the front of the body. In addition, it allows for the volume changes that occur during breathing (Fan, Yu and Hunter, 2004). Ease allowance may also be utilised as a design tool in relaxed, oversized loose or “baggy” clothing. Patterns conform to body shape for knitted fabrics, compression/medical clothing, or sports applications. Additional adjustments, such as altering the contours of designs, seam placements, and

vents placements, can help reduce the drag on garments, ultimately improving performance and comfort(Dai & Havenith, 2009).

2.4.5 Ventilation

Research on ventilation in clothing occurs either through fabric permeation, bellowing or pumping through openings such as cuffs, collars, and other vents. Ventilation or air pressure fluctuation is affected by the gap between the body and the fabric. A rare experiment on venting by Dail and Havenith (2009) tested two identically constructed jackets made of different fabrics using an articulated thermal manikin. The purpose was to measure the effect of clothing ventilation on thermal insulation and vapour resistance. They concluded that using other materials in the experiment resulted in a 76% difference in ventilation when there was no movement involved, which was related to the air permeability of the selected materials. However, the experiment also determined that ventilation increased whilst walking in the wind, which decreased the difference in ventilation between the two fabrics. In other words, fabrics play an essential role in comfort by allowing air permeability, but movement combined with loosely worn garments and appropriate venting improves ventilation and thermoregulation. Tian et al. (2020) suggested further studies on venting as a heat release mechanism.

Smith and Havenith (2012) measured sweat zones for females across the body through a sponging technique and collecting sweat at moderate and intense exercises. The thirteen (13) aerobically trained females participated in moderately warm conditions (25°C, 45% relative humidity, two MPs air velocity). Figure 2.1 below depicts the results of this study. The mid-upper back and the lowest point towards the extremities and the front below the breasts and sides showed the highest sweat regions. No correlation occurred between local skin temperature and sweat rates. The study reveals that the data has applications for gender-specific clothing design in terms of thermo-physiological modelling. The study elucidates where the strategic placement of venting or air-permeable fabrics may facilitate effective cooling and drying. These identified sweat regions will be utilised in the design of the final prototypes in Chapter 5.

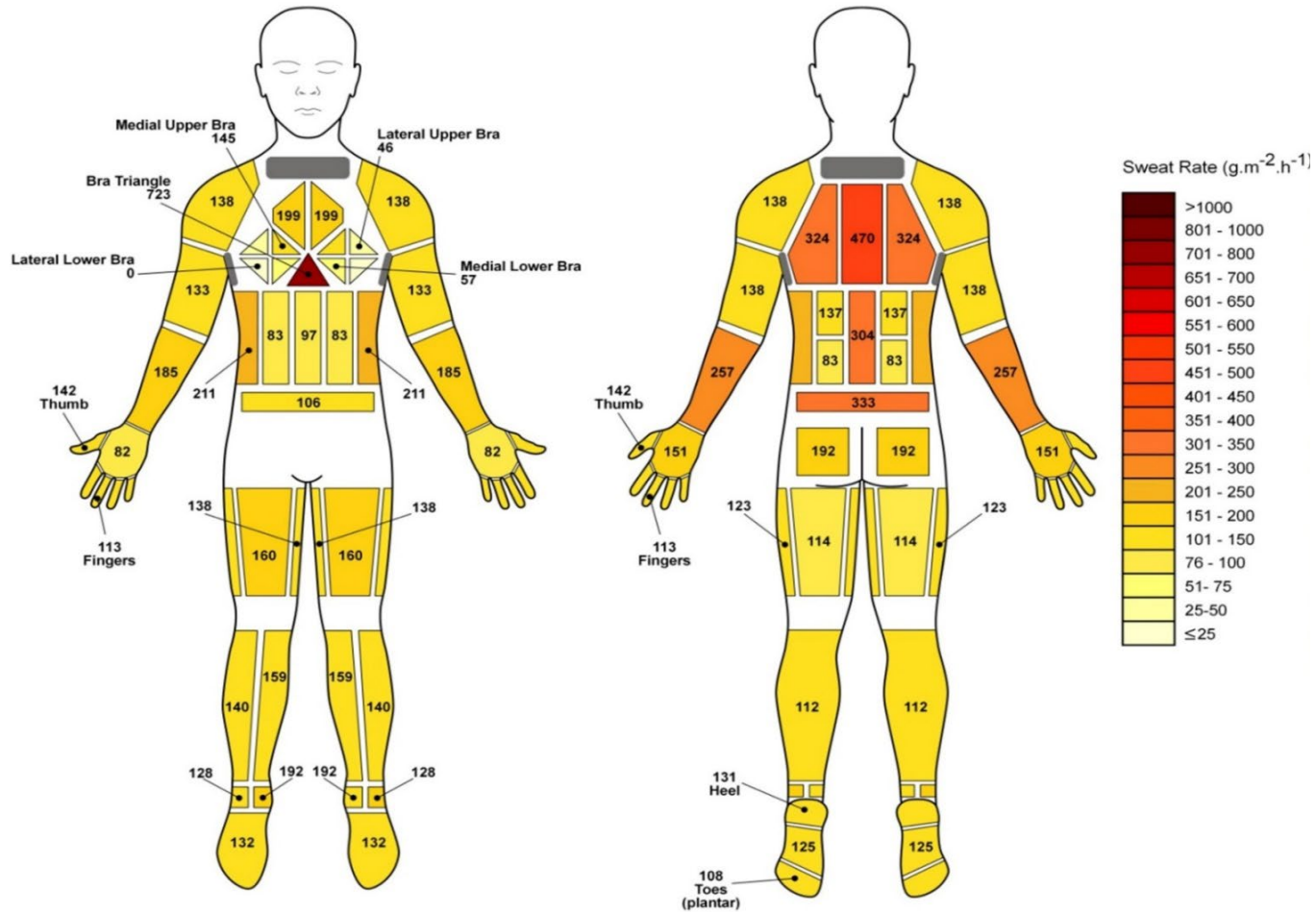


Figure 2. 1 Sweat maps for female athletes (Smith and Havenith, 2012)

2.4.6 Utility

Clothing provides specific functions such as modesty through concealment of the body, providing adornment, and protecting the body from harmful elements. The degree of each of these functions will vary according to the initial intended application for the clothing. Conversely, clothing is a barrier between the body and its access to the external environment and can cause amplified hindrances when accompanied by extreme exercise activities. Well-designed functional sportswear for warm weather conditions reduces barriers and allows the body to perform its natural functions. Functional clothing design aims to meet the user requirements in four areas: physiological, biomechanical, ergonomic and psychological conditions or needs (Das & Aliagirusamy, 2010; Gupta, 2011; Beringer, 2019).

According to market research, Beringer (2019) states that the main requirements for contemporary sportswear are wear-comfort, fit, sustainability, performance enhancement, integrated microtechnology (Smart Textiles), bio-based raw materials, and multi-functionality. Sportswear should be light and fit well for easy movement; it should be durable, resist abrasion, be protective, and should absorb and evaporate sweat quickly to keep the body dry. Technical sportswear should maintain the body's temperature around the 36.8 degrees' Celsius range. This regulation of temperature is made possible by using the appropriate design elements viz. fabrics, fit and functionality to minimise the barrier created.

Gupta (2011:324), pertaining to functionality, further mentions that certain professional sportswear is scientifically designed for compression and to improve blood flow, aerodynamics and drag reduction – thus, enhancing athletic performance. Therefore, compression, aerodynamics and other enhancements are key factors in improving the athlete's performance and recovery.

Literature on sportswear include studies on physiological and physical performance, but there is a distinct lack of research on the utility features of road running sportswear. Running long distances often require extra gear to carry goods such as keys and cell

phones. Muslim women athletes also have more clothing to don whilst running. The number of pieces worn simultaneously can be as many as seven: the peak cap, headscarf, T-shirt, faux sleeves, skirt, pair of pants, and a moon bag. The main objective for MAS is to optimise the utility, reduce the number of clothing items worn, improve comfort, and improve protection whilst maintaining religious expressiveness.

2.5 3D Design (CAD)

Digitisation of the product development process has changed the ‘designscape’ in clothing by converting a previously physical production-heavy process into a design-focused process. The traditional design process includes a range of labour-intensive tasks. Tasks include the execution of technical drawings, taking measurements, selecting fabrics, pattern draughting, grading, cutting, sewing prototypes, fit sessions, presentations to clients, evaluation and adjusting until the designer arrives at the desired product. 3D CAD systems have revolutionised designer capabilities by allowing control over product development in a virtual space.

Software companies such as CLO3D, Gerber Accumark, Browzwear, Tukatech, Lectra and others have changed the competition by enabling creativity, allowing for on-the-spot adjustments. As a result, it is possible to design one virtual product and create endless varieties through colour and textile libraries without purchasing actual fabrics or producing any physical garments.

It is important to note that I will be focussing on the literature utilising CLO3D software as this is the software available for the research at CPUT’s fashion and textile station.

2.5.1 3D design process

Wang and Liu (2020) describe the process of 3D design as follows:

- obtaining data indicators through 3D anthropometric technology,
- digital fitting of clothing pieces onto a 3D mannequin (also referred to as an avatar), and

- stitching the pieces to form a 3D display of the product.

Wang and Liu (2020) further proposed a virtual garment fitting system that includes a 3D design process using CLO3D as the leading design software. The 3D steps included in the process are as follows:

- making virtual clothing,
- mannequin building,
- importing 2D patterns,
- arranging the sample positions,
- generating the 3D samples,
- fabric processing, and
- final adjustments.

2.5.2 Automated 3D body scanning

Automated body scanning gathers anthropometric data and generates a full-scaled digital representation of the shape and size of the human body (Apeagyei, 2010; Wang & Liu, 2020). The coordinates recorded through scanning displays as a 3D avatar upon which 2D patterns will be fitted and sewn to create 3D garments. The Human Solutions scanner (Figure 2.2), the scanning technology available for this research at CPUT, utilises portable laser scanning. Portable laser scanners in a triangulated position measure the various planes of the body through the light displacement of the body. The scanner records one hundred and forty (140) body measurements in twelve seconds (Wang & Liu, 2020).

2.5.3 Creating an avatar

Wang and Liu (2020) elucidate the importance of selecting or creating the correct avatar. The avatar size, body shape, and capabilities regarding posture and movement are essential, especially if one intends to utilise the avatar to analyse functional clothing such as sportswear. Different avatars in the CLO system have various physical features in terms of anthropometrical dimensions and appearance. Avatar capabilities in terms of

poses and motion also vary. Avatars may have static or dynamic states. Static states are mannequin-like poses used to view the fit and drape of clothing. Dynamic states are helpful to analyse clothing performance in terms of sizing and fit whilst in motion.

Dynamic states expose the effects of movement on comfort in the form of tension maps, stress maps and pressure points. The dynamic actions and poses allow for the alteration of ergonomic functionality. Therefore, selecting the avatar with the correct capabilities and movement range is crucial when designing sportswear, as ergonomic testing occurs later in the process.

Avatars imported and obtained using 3D scanning equipment, as in Fig 2.2, would need to be capacitated with movement-using rigging. Rigging adds a skeleton to the scanned image, providing the joints for movement, allowing the designer to create different poses. The easier option is to utilise the existing avatars within the system and adjust the avatar dimensions to the data extracted through the 3D scan, as in Figure 2.3. Wang and Liu (2020) suggest using dimensions/parameters such as height, weight, chest circumference, waist circumference, hip circumference, and head circumference as the critical measurements for customising an avatar. The avatar dimensions correlate to the scanned body; the arrangement of the fabric pattern pieces shapes on the mannequin with blue dotted guides known as arrangement points (Fig 2.3).

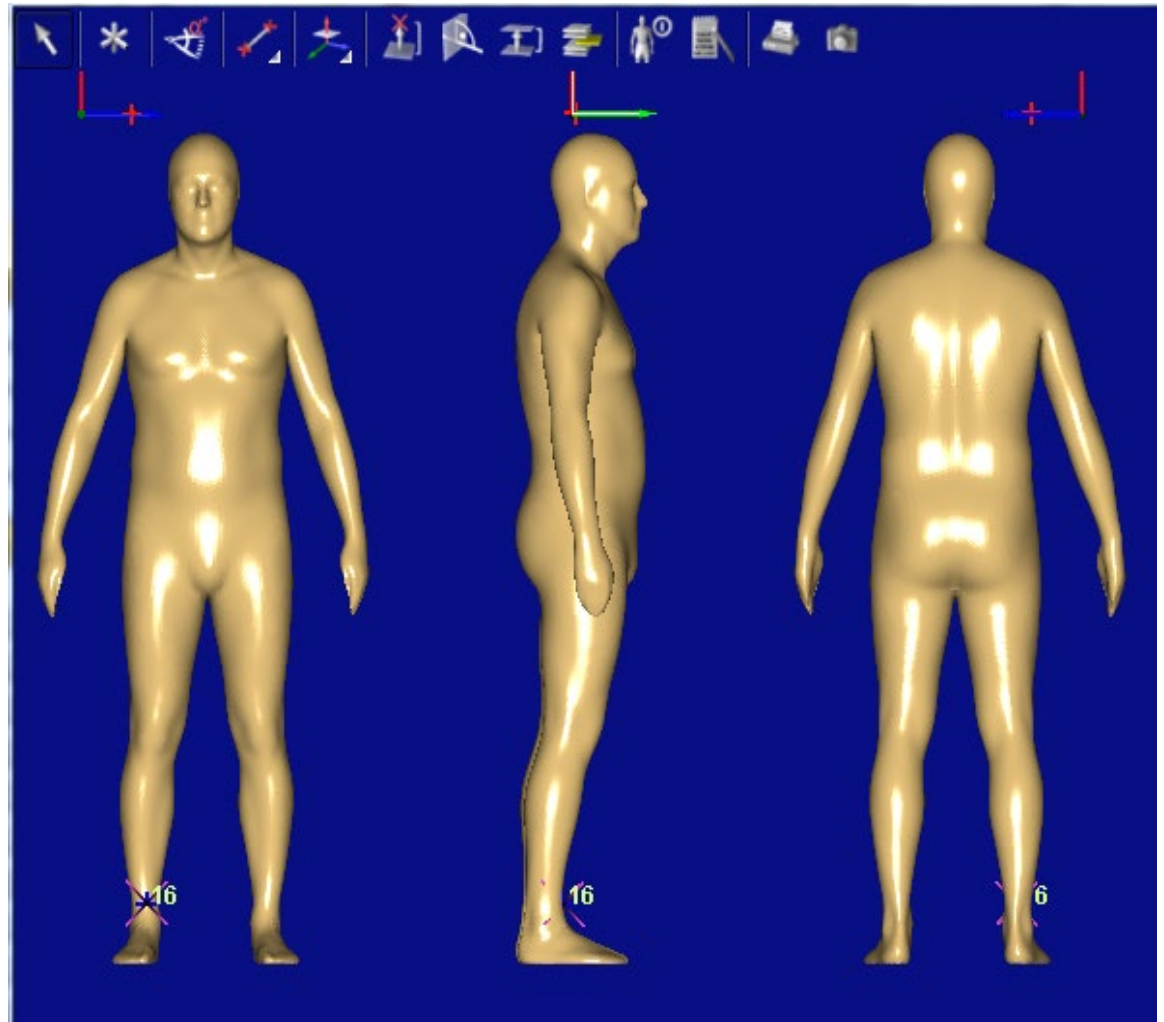


Figure 2. 2 Human Solutions Anthroscan 3D scanner (Author, 2018)

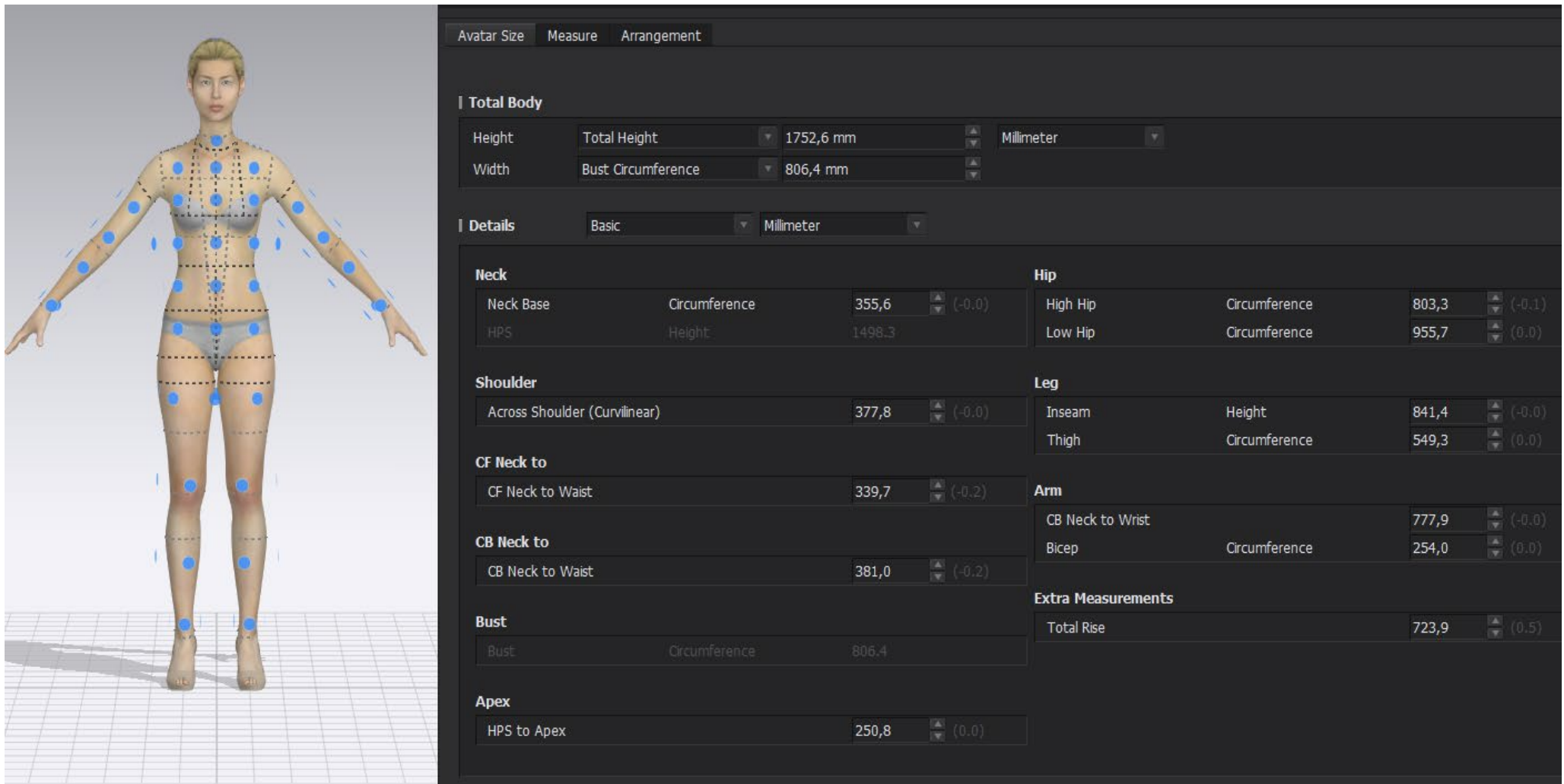


Figure 2. 3 Arrangement and measure points (left) and measurement input interface for avatar adjustment (right) in CLO programme (Author; 2020)

2.5.4 Comfort and fit assessment

As simulations, 3D garments are assessed for comfort and fit visually. Just as actual yarns undergo the process of weaving or knitting to become the interconnected network of fibres known as fabric, so are the coordinates and lines in a 3D program interconnected through parametric equations and algorithms used to mimic the properties of textiles (Greder, Pei, Shin and Jooyoung, 2020). The accuracy of the simulation enables the virtual evaluation of comfort and fit through four maps, namely, a stress map, strain map, fit map and a pressure map (Fig 2.4). The colour red indicates the heavy stress and strain of the avatar on virtual fabric. Green will mean a looser fit, and red, a tighter fit. The fit map utilises two colours, yellow and red, to indicate a close fit or inability to wear. Finally, the pressure map displays skin contact using blue dots. Programmes such as Marvellous Designer, a CLO3D product, have been used to virtually and scientifically assess the drape performance of textiles (Miguel et al., 2020). To follow is an explanation of the rating indicators for the various fit maps.

2.5.4.1 Stress rating

The stress map (Fig. 2.4) indicates the amount of pressure applied to the avatar's garment. The program measures the force on the garment instead of the avatar as the software cannot calculate physiological skin pressure. The stress rating properties measure four stress levels indicated by green, yellow, orange, and red. The colours in the order mentioned showing pressure (kPa) ranges of 0 to 33.32, 33.3 to 66.65, 66.66 to 99.99 and 100 kPa, respectively.

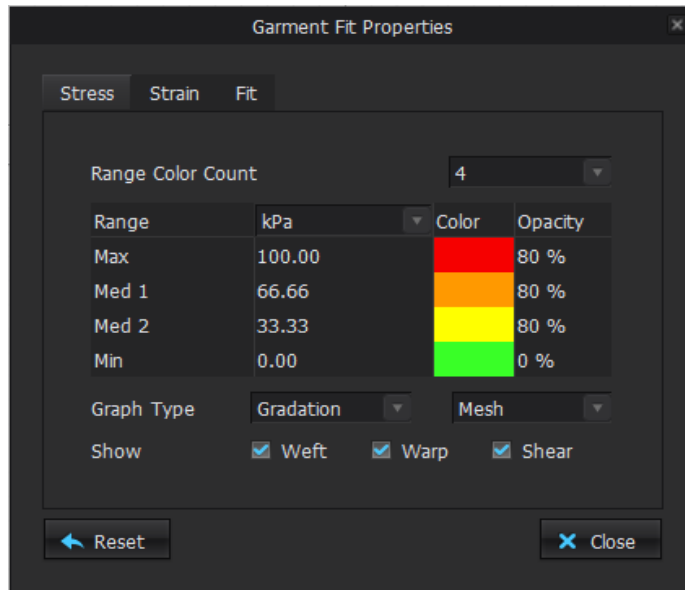


Figure 2. 4 Stress map indicators (CLO, 2020).

2.5.4.2 Strain rating

The strain map (Fig. 2.5) indicates the stretch that the avatar exerts on the garment. The rating reads four levels of stress exhibited by the colours green, yellow, orange and red. The colours in the order mentioned indicate the fabric's stretch on percentages from 100 to 105, 106 to 113.32, 113.33 to 119 and 120 %, respectively. A one hundred per cent reading indicates no stretch, and a reading above one hundred per cent indicates stretch.

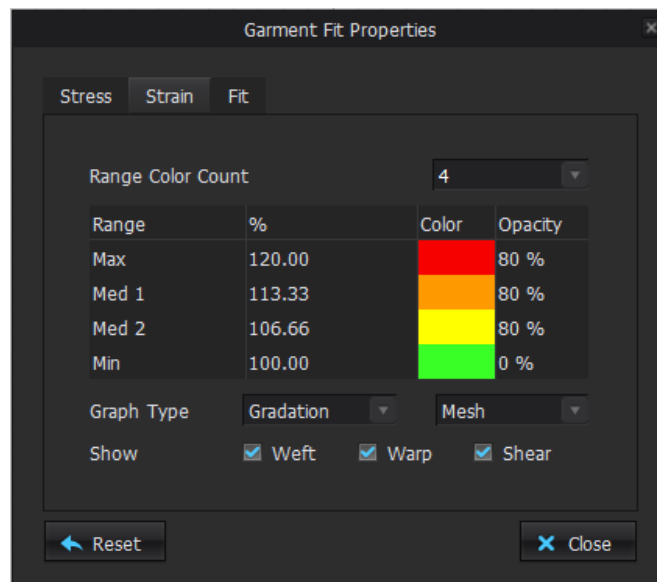


Figure 2. 5 Strain map indicator (CLO, 2020).

2.5.4.3 Fit rating

The fit map (Fig 2.6) indicates which garment parts are un-wearable because of pattern construction. The colours indicate the amount of constriction, with yellow representing tight at eighty to eighty-nine per cent and red indicating that that specific sized person cannot wear the garment.

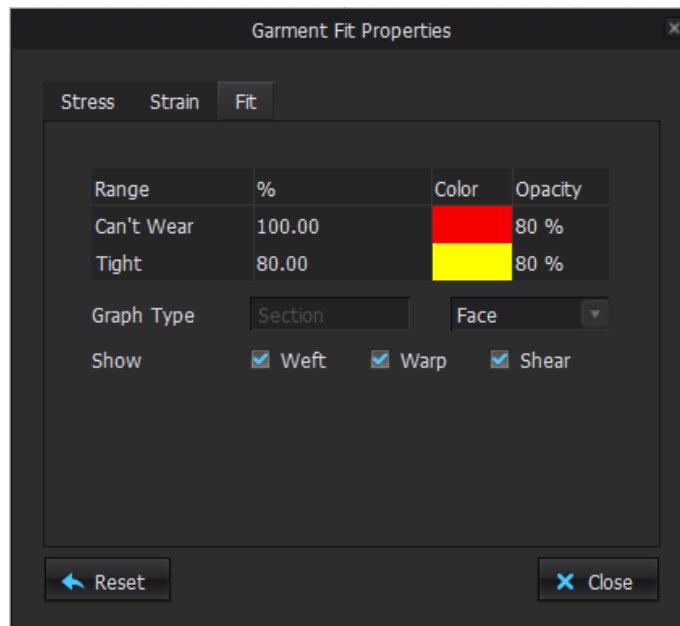


Figure 2. 6 Fit map indicator (CLO, 2020).

2.5.4.4 Pressure rating

The pressure map indicates the points of contact that the garment has with the avatar. This indicator is helpful, especially for MAS, as it allows control over the looseness or ease of the garment. Figure 2.7 shows the various fit maps utilised for the assessment of the ergonomic performance of MAS. The method of evaluation and correction is discussed in Chapter Three (3).

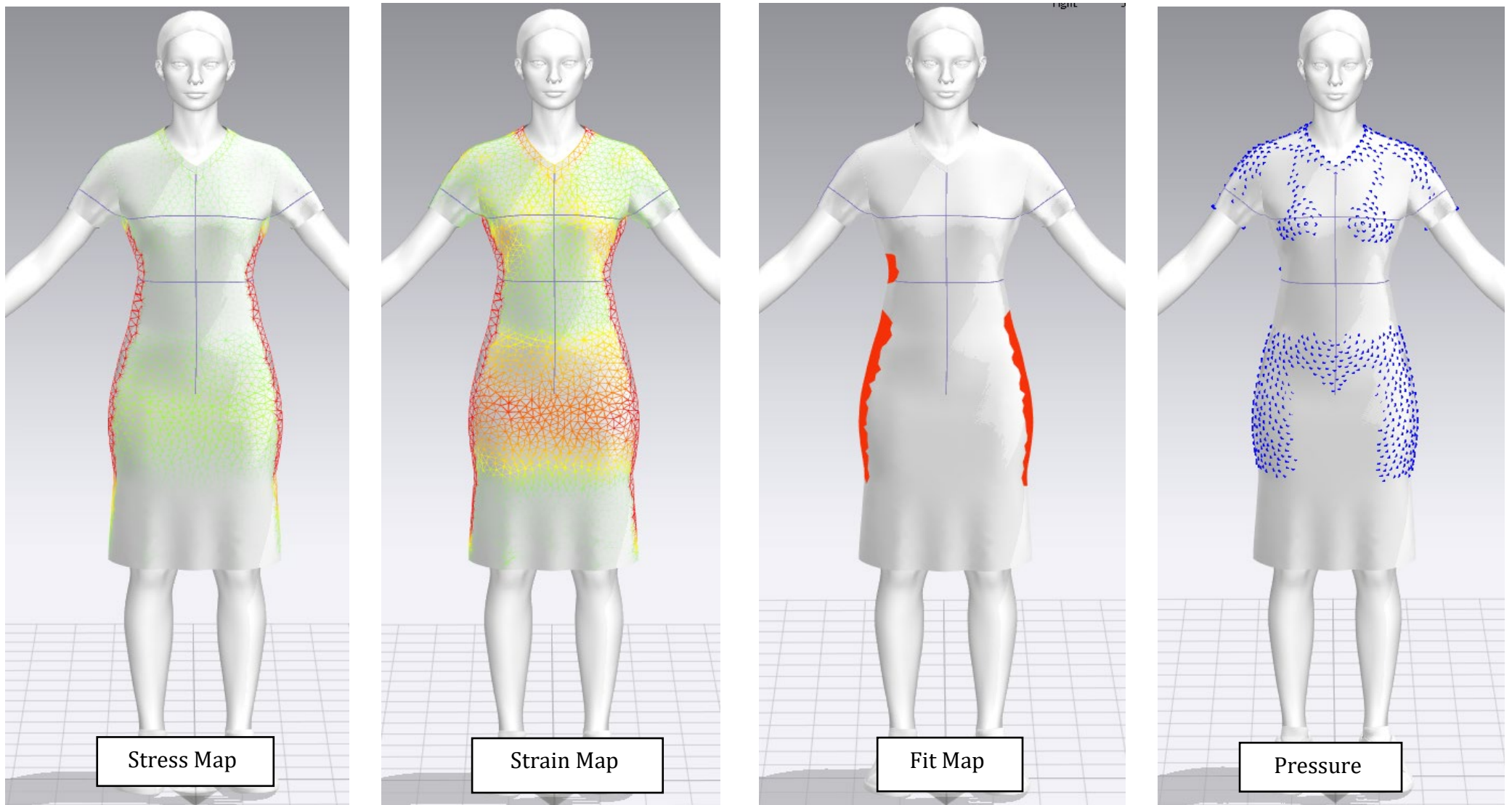


Figure 2. 7 Fit maps to analyse garment fit and comfort in CLO 3D (Author, 2020).

2.6 Summary

The literature looked at the socio-religious aspects and the technical aspects of sports hijab/MAS. I have explored four main areas in the literature review: modest wear, user-centred design, sportswear, and 3D Design. In the section on modest wear, a better understanding of the ethical aspects of modest Islamic dressing was achieved by delving into the socio-political reputation of Islam. We also investigated the factors affecting the perception of the hijab as a symbol. It was ascertained that reasons for Muslim female stereotyping are unfounded, as many women wear hijab as a personally motivated act.

The importance of a user-centred approach in functional design was investigated, proving its centrality to effective product development. I explored various models for the user-centred process. I unpacked the factors that affect functionality, such as comfort, fabric, fit and the utility of technical sports clothing. Finally, I looked at the virtual design process, its various steps, its capabilities, and usefulness in evaluating products in the design process.

Chapter 3

Research design and methodology

3.1 Introduction

When one compares the purpose of innovation to academic research, the two realities reveal different goals and intentions. Innovation seeks practical improvement, whereas academia generally targets the growth of knowledge generation and contribution to science. Leading universities and companies both understand that research for innovation can lead to world-changing developments. Such research is purposeful as it is applied to improve actual lives and experiences of people in the real world. For example, the research on performance MAS can improve the experiences of athletes who prefer to dress modestly during sports activities. This chapter explains the research design I chose, the methods applied, and its reasoning for collecting data that will develop the eventual answers to the research problem and questions.

3.2 Research design and methodology

This study aims to find the best solutions for the fundamental problem of Muslim female athletes or simply those who enjoy physical exercise and prefer to dress modestly. As explained in the rationale of choosing a contextual theory for this research (in Chapter 1 and Chapter 2), the research problem and answering the research questions were approached within a user-centred and functional clothing design paradigm. A valuable explanation of user-centred theory as applied in fashion and the purposes thereof by Gupta (2011) can be read in the literature review chapter (under point 2.3, User-centred design).

Leedy and Ormond (2016) define research design as “the general structure guiding the data collection and analysis to address the research problem”. The structure of this study aims to use qualitative exploration sections comprising two interviews and a focus group session. In addition to the qualitative components are three quantitative analytical areas.

In the quantitative section, I aim to include fabrics testing, 3D body scanning, and 3D CAD design. The combination of methods, I hope, will allow me to design a hijab that fulfils all the participants' aesthetic, ethical, and physiological needs in terms of a range of clothing for female road runners. Therefore, the most optimal way to gather scientific data on the research problem would be a mixed-method approach (Maree, 2020).

3.2.1 Qualitative research

Qualitative data-gathering techniques are typically empirically referenced as interviews, surveys, focus groups, and other tools, most of which support user-centred ideas. Researchers use qualitative methods in various research fields, and it is specifically suitable for gathering data in natural or real-world settings (Leedy & Ormrod, 2015; Maree, 2020). Such research aims to yield information that cannot be easily reduced to numbers and typically involves an in-depth examination of a complex phenomenon. More specifically, qualitative user-centred research uses methods that extract perspectives that improve user acceptance of the design objective, obtained by interacting with the end-user of a product, service or system (Shore et al., 2018). For example, design researchers utilise qualitative techniques to understand better the user's expectations in situations influenced by age, health, race, and other cases where only the lived experience can provide relevant data. There are a vast number of citations in literature (Dejonge, 1984; Huck & Kim, 1997; Labat & Sokolowski, 1999; Han et al., 2016; Hwang et al., 2020; Imbesi & Scataglini, 2021), on the use of qualitative research methods for user-centred clothing products. Amongst the qualitative techniques used are focus groups, which Leedy & Ormrod (2015) defines as "a small group of people who are assembled and asked to express their opinions about a particular issue". I view the focus group as the core instrument in this research as it is the manifestation of user-centred design within this study.

The path I intend to take in the qualitative sections of this research would be divided into three phases:

In the first phase, to be exceedingly respectful of the history, requirements, and parameters of modest sports clothing, I would question two women knowledgeable about

the religious, social, and cultural guidelines for wearing modest athletic wear. The interview would be about compliance with the legal and social requirements demands of female dress. Since the participation of South African Muslim women in road running is quite a new and growing phenomenon, the boundaries and guidelines for hijab during sports must be respected. The data extracted in the interviews will be grouped, coded, and presented through thematic analysis in chapter five (Nowell et al., 2017). Concurring answers will be grouped and presented under the themed sub-headings.

The second phase of exploration around what Muslim women would like to change in the hijab while participating in road running would be to talk to the participants themselves. This section presents images for the participants to vote on styling choices. In addition, discussions will be recorded, and responses will be grouped, coded, and presented in a thematic analysis in chapter 5. In addition, I would also make use of this opportunity to extract quantitative data (further elaboration in 3.2.2) to obtain the participants' measurements by scanning them using a 3D body scanner.

For guidance about textiles and other processes that could improve the research and the production and performance of modest sportswear, the third phase would be to consult with industry experts during the process. These qualitative discussions will hopefully also guide the quantitative sections. This data will be presented in a narrative format.

I believe that the most valuable data would come from the participants and their experiences. Therefore, I intend to include individuals with similar attributes in particular: geographical location, religious background, community experience, sense of dress code, gender, road running, and climate experiences – these attributes would cluster participants with similar needs and expectations, which should allow me to develop a group-designed solution. As a result, this part of the study is less analytical and more participatory.

In summary, data collected from the semi-structured interviews and the focus group session will hopefully generate sufficient answers to the main and secondary research questions. The information gathered should supplement existing literature on Muslim dress or expressiveness, Islamic dress parameters, design preferences, and social and

physical experiences while wearing hijab or MAS. I will include visuals of different sports clothing design options to initiate discussions with focus group participants to determine design elements to redesign MAS. Finally, informal consultations with industry experts should provide technical direction for textiles, pattern development, and 3D design.

3.2.2 Quantitative research

The quantitative processes augment the qualitative feedback during interviews and the focus group and is a means to provide inputs and improvements that are measurable. For example, if participants request fabrics that are “breathable”, materials will be tested for air-permeability, of which the results will be the basis for the selection. A visual portrayal of the research journey from the research questions to the eventual answers, please refer to Figure 6.1, which depicts the path taken during this study. The colours in the diagram indicate how the knowledge generated has filtered into new literature on modest wear and the 3D CAD design concept for MAS.

Quantitative research is objective and yields data communicated in numbers which, be used to make a generalised inference about a similar group or subset (Maree, 2020). The second part of the research, based on quantitative analysis, is divided into two main activities.

In the first section, the results of the focus group participants’ need for modest athletic wear will be translated into possible garment designs by means of the 3D body scans and a 3D CAD design programme. This quantitative section of the research will be achieved by entering the preferences and measurements of the focus group participants into the specific 3D programme. Once designed in the 3D programme, I will numerically assess and adjust the garment’s fit and ergonomics by altering the pattern and recording the adjustments in stress, strain, fit and pressure ratings. The data will be presented in a table indicating the change in percentage which would give value to the degree of improvement.

During the qualitative focus group discussion and consequent quantitative process of the garments’ design, the guidelines supplied by the two expert Muslim females on modest dress – the hijab – will be kept in mind as well.

In the second section, I aim to test a selection of textiles for properties associated with performance or sports textiles. Testing will entail using lab equipment to measure the different properties. The results will be used to select textiles based on air-permeability, mass, and drying rate. The data will be presented in a table format indicating how the textiles performed. I will provide reasons for the selecting textiles which will be based on the functional and religious requirements. This part of process, with regards to the selection of textiles and the lab testing, will rely on the guidance from a textile expert.

3.2.3 Mixed methods design: qualitative and quantitative research

By means of the combination of several qualitative research methodologies with 3D CAD quantitative development and process, a mixed methods research design has been achieved. During a research process that employs both qualitative and quantitative methodologies and analysis, triangulation is achieved. Triangulation is described as such by Schoonenboom & Johnson (2017;123)

Mixed methods research is the type of research in which a researcher or team of researchers combines elements of qualitative and quantitative research approaches (e. g., use of qualitative and quantitative viewpoints, data collection, analysis, inference techniques) for the broad purposes of breadth and depth of understanding and corroboration.

According to Greene et al. (1989), some of the first contributors to a definition of mixed methods research design, the combination of methodologies and paradigms strengthens a study because of the following reasons:

Bryman (2006) has built on Greene et al.'s (1989) categories into several respects, and he added a number of additional aspects to explain the benefits of a mixed methodology research study with both qualitative and quantitative methodologies as such:

(a) *Credibility* – suggestions that employing both approaches enhance the integrity of findings.

(b) *Context* – cases in which the combination is justified in terms of qualitative research providing contextual understanding coupled with either generalizable, externally valid findings or broad relationships among variables uncovered through a survey.

(c) *Illustration* – the use of qualitative data to illustrate quantitative findings, often referred to as putting “meat on the bones” of “dry” quantitative findings.

(d) *Utility* or improving the usefulness of findings – a suggestion, which is more likely to be prominent among articles with an applied focus, that combining the two approaches will be more useful to practitioners and others.

(e) *Confirm and discover* – entails using qualitative data to generate hypotheses and using quantitative research to test them within a single project.

(f) *Diversity of views* – two slightly different rationales, combining researchers’ and participants’ perspectives through quantitative and qualitative research respectively, and uncovering relationships between variables through quantitative research while also revealing meanings among research participants through qualitative research (Bryman, 2006:106).

In this study, the qualitative and quantitative processes did not occur simultaneously, but in two different phases of the research. These factors illustrated how this research study benefited in a very real sense from using both qualitative and quantitative methodologies to gather data, and without which the study would have been much poorer in terms of final outcomes. The validity and reliability of the study were enhanced through a combination of the qualitative interviews, focus groups and informal conversations with experts, while the quantitative 3D scans, building on the qualitative data gathered by the former methodologies completed the study, and enhanced the matter of trust and ethics.

3.2.4 The use of secondary data for the quantitative 3D CAD design process

The exponential growth in digitisation has resulted in modern technologies that can augment traditional practices by simplifying the design and prototyping through immediate visual evaluation and correction. With the end user's input, designers can create virtual clothing products based on those aesthetic, expressive and functional requirements and preferences stipulated by the end-user.

Loughborough University has given permission to utilise their research and diagrams (Figure 2.1) on female sweat regions as a basis for vent/ mesh placements. Previous studies provide direction for heat and moisture regulation, sizing and fit, regulatory standards and systems of other types of protective clothing.

In summary, the primary qualitative and quantitative data and the secondary data on female sweat regions provide the basis for combined design specifications in the 3D CAD design process. Tests for fabric mass, air permeability and drying rate would provide equipment readings to select the fabrics for the 3D prototypes. The Human Solutions 3D anthropometric scans provide measurements for sizing and fit. The designs are developed and assessed for fit and ergonomics using CLO3D virtual fashion design programme data.

3.3. Research questions

The primary research question and supporting sub-questions are restated in Figure 3.1 as they answer the main question.

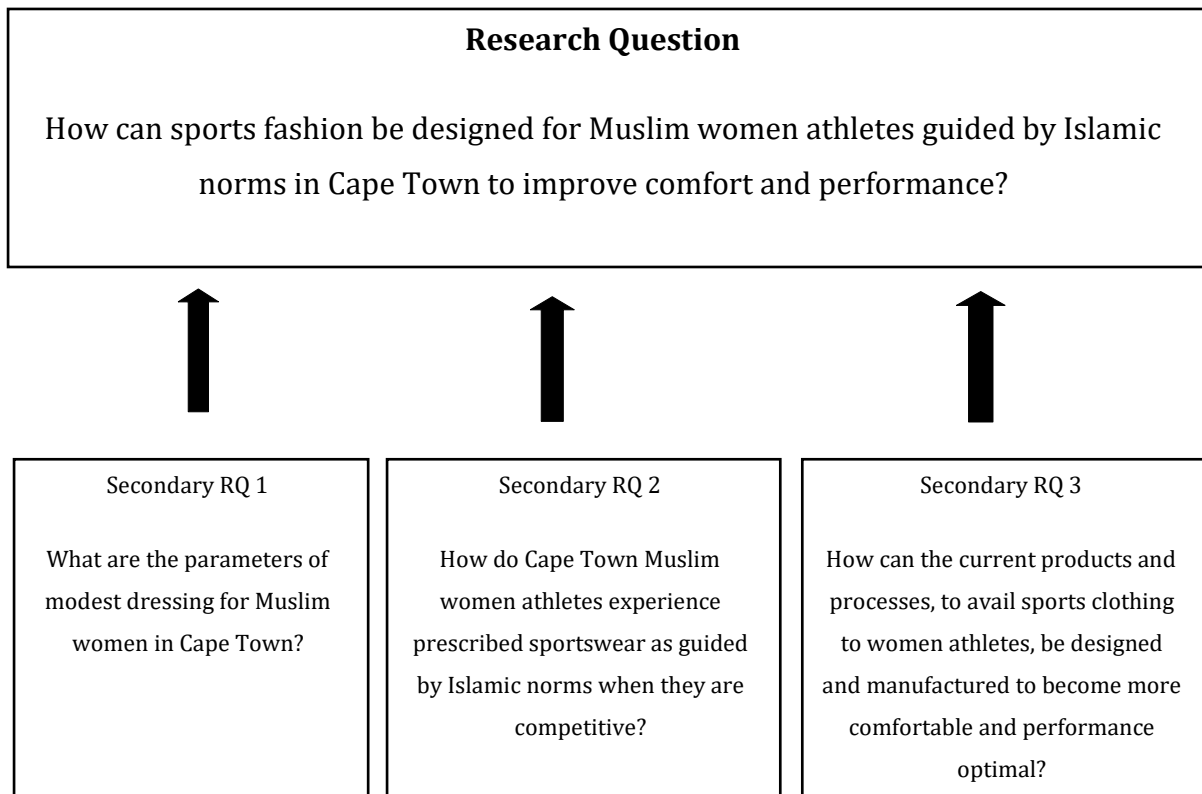


Figure 3. 1 Primary and secondary research questions

3.4 Data sourcing for qualitative and quantitative research phases

This section explains the data compilation in the sub-questions to answer the central question.

3.4.1 First secondary question

What are the current parameters of modest dressing for Muslim Women in Cape Town?

The data needed to resolve this sub-question is likely to originate from literature, the two interviews with religious and academic scholars, videos, journals, books, and other available credible documentation. In addition, the research will investigate the global perspective of Islamic dress and the development of Cape cultural ideology of dressing which plays a part in defining social expectations. During the interviews and focus group, I would pose questions about the participants' perceptions of modest dressing, Islamic law, and etiquette.

3.4.2 Second secondary question

How do Cape Town Muslim women athletes experience prescribed sportswear as guided by Islamic norms when they are competitive?

The data needed to resolve this sub-question should originate from the focus group session. The questionnaire aims to benchmark the comfort level whilst wearing current MAS products and determine the wearer's perception of existing clothing's comfort. In addition, I would initiate discussions around various improvements relating to styling, ergonomics, wearer experience and stereotyping related to wearing MAS.

3.4.3 Third secondary question

How can the current products and processes to avail sports clothing to women athletes be designed and manufactured to become more comfortable and performance optimal?

The data needed to answer this question is in the literature on technical aspects related to comfort. First, I would investigate which processes, textiles and construction available in South Africa are best suited for developing the 3D prototypes. Second, I would research and consult with experts on which testing methods are suitable to assess comfort properties in textiles. Third, fabrics will be tested in an accredited laboratory and selected for 3D prototype development based on their performance. Fourth, I will use the latest locally available technology (Human Solutions TM) scanning equipment to scan participants to obtain accurate fit measurements. I would then design new prototypes

using CLO 3D to assess sizing, fit and movement to establish if this process answers the third secondary question.

3.5 Sampling

This section explains the sampling rationality for the participant selection for the qualitative interviews. The two Muslim women to be chosen for the discussions about Islamic dress etiquette are prominent figures in the Islamic community in South Africa. The sample is biased due to the criteria of prominence. A choice based on reputation may exclude female scholars who may be more knowledgeable about Islamic jurisprudence. However, bias is necessary as these women are leaders and hijab wearers, representing strong Muslim women who choose to wear the hijab. Including these interviewees in the study provides credibility to Muslims around the modesty aspects of the design and shows the thoughts and rationality of strong, educated, outspoken Muslim women for wearing the hijab to non-Muslims. The inclusion of these women will hopefully provide credibility with regards to the modesty aspects as well as the view of women as participants in sports.

The following methodology phase of the research would employ a qualitative focus group. I would select the focus group participants according to their running experience, consistency in training and competition participation. The participants must be committed and dedicated sportswomen who wear hijab. To improve the success level for recruitment and the validity and reliability requirements for the study, I will delegate the selection process to the club management of Ommidraai, the most established Muslim-managed club in the Western Cape. The Ommidraai management network with their competitors to select thirteen participants from different clubs. This sampling technique may be biased as not all Muslim women want to wear the hijab during sports, but the research aims to solve MAS for hijab-wearing athletes. The selection criteria, therefore, required all participants to be hijab-wearing athletes.

3.6 Validity and reliability, and trust as requirements for research

Establishing validity, reliability and truth in qualitative research is especially difficult and a much-debated topic. Theorists explain that where quantitative analysis seeks aggregated evidence, qualitative research seeks depth and breadth to learn life's nuances(Whittemore et al., 2001).

Qualitative research validity for this research should be established by the user-centred approach, which means that truthfulness is determined simply through the correlation of the recorded evidence and what is to be voiced by the participants. The research would contain a pro-religious bias but does not negatively influence the data, as it is the experiences and beliefs we attempt to determine and record. Therefore, the way I will be securing the data is essential and is realised by pure representations of the actual athletes through voice recordings during interviews and the focus group. Copies of the transcripts will be attached in appendices.

On the other hand, the quantitative methods will include testing textiles and the use of 3D technologies. The testing would be performed in an accredited laboratory using internationally and locally approved testing standards. The testing will take place by a third party with accredited lab staff in a conditioned environment. I will include the test results in formal test reports as appendices. Proof of objectivity will therefore be maintained and available.

Literature should provide sufficient scientific evidence (Zhang & Little, 2018; Hou, 2018) advocating for the accuracy of the 3D technology to be used to assess and develop the designs. The results are digital and, therefore, calculated by a computer program.

The overall objective and answering the main question, **how can sports fashion be designed for Muslim women athletes guided by Islamic norms in Cape Town to improve comfort and performance**, could therefore be supported by the stability and truthfulness of the data, the rigor in the recording of the nuances as explained by the participants and the accuracy of technical components such as the testing resources as

well as the 3D technology. Finally, the process will include consulting with experts to advise on technical challenges.

3.7 Ethical clearance and communication

I obtained CPUT's ethical clearance for the execution of the research study, which was particularly vital since the focus group participants had to give their personal views on quite a unique phenomenon, namely the hijab for sporting purposes. The participants, both during the interviews, focus group and informal inquiries about the material for the study, were all informed about ethical guidelines and were ensured that they could withdraw from the study if they did not feel comfortable. These ethical clearing documents can be seen in Appendix E.

3.8 Summary

Chapter Three explained how the research design and methods attempt to answer the research questions and how the evidence would assist in developing MAS. I explained the rationale for all components, including the mixed methods approach, the questions, the sampling of participants, and how the selected qualitative and quantitative tools support the study.

Chapter 4

Data collection and insights

4.1 Introduction

This section explains collecting, recording, and storing the content (data) from the various interviews with experts and leaders, textiles testing, a focus group, and 3D scans/anthropometric data. In addition, the chapter refers to secondary data collected and discussed in Chapter 2, which is crucial to this research.

4.2 Qualitative methodologies

4.2.1 Interviews with two leading experts about Muslim modest wear and the hijab

After identifying the two interview candidates based on their prominence in Islamic society, and religiosity, I contacted them via telephone and email to request their participation and made suitable arrangements.

4.2.1.1 First interview: Interviewee A (Anonymous)

Interviewee A was a member of the Madina Institute Centre for Non-Violence and Peace Studies, and her credentials are a PhD in Occupational Therapy, a bachelor's degree in occupational therapy, a Master's in Business Administration, a master's in sciences and Applied Information Management, employed at Madina Institute- Usul al Din (Foundational Sciences), and International Peace College South Africa - BA Honours - Readings in Maqasid Al-Shariah (objectives of Islamic law).

This interviewee is an educator and an activist who has spoken about religious issues in various public forums, including mosques. Therefore, this doctor's credentials, prominence in society, knowledge about Islam, and view on human rights made her a suitable candidate for this interview.

I conducted the first interview in person at the Cape Town Science Centre in Observatory, Cape Town. The location was convenient as the interviewee had hosted a group panel discussion there on Malcolm X. My interview took place after the event and complied with all ethical requirements that I had put to the respondent beforehand. Before the interview, I forwarded the questions and the consent forms via email. The questions were semi-structured and open-ended, which allowed open and organic responses. However, I anticipated lengthy responses and opted to record the interview and transcribe it later.

I recorded the interview on both a laptop and cell phone to secure a backup. In addition, I took notes to record further questions that deviated from the original schedule to prod additional responses to specific answers or comments. A copy of the recording is stored on a cloud server, transcribed, and analysed.

4.2.1.2 Second interview: Dr Quraysha Ismail Sooliman

Dr Sooliman is a prominent figure with the following credentials: a Postdoctoral Fellow UP Humanities/Mellon Foundation Public Intellectual Project, a PhD at the University of Pretoria, working in the Faculty of Law, has a BA in Journalism, is an Associate Fellow/GovInn and is a freelance journalist/host of Finding Me on Dstv347

The second interview followed the same protocol as the first regarding the briefing, ethics, and consent. Initially, the intention was to have a skype session, but the interviewee opted to answer the questions via email. Dr Sooliman is an academic and a journalist and provided a well-written, lengthy explanation to each question, which I stored on a cloud server. Unfortunately, I could not control the interview and extract additional information as one would on a live discussion, but the information was well-constructed, rich in content, applicable and relevant.

4.2.2 Focus group

I held a focus group on the 7th of September 2019 at the Islamia College Library in Rondebosch East, Cape Town. Thirteen (13) participants met the criteria as was stipulated in the planned methodology. Before the session, my assistant, a female work colleague who carried out the scanning, prepared the venue to ensure all media and

equipment were set up and in working order. Just before the session, the group and I socialised to create a relaxed atmosphere. At the start of the session, I explained the ethical issues, focus group discussion rules, behaviour rules and voting rules. I used a PowerPoint presentation to relay the main facts about the study to the participants (Fig 4.1).

After the introduction and orientation, I presented the research, which resulted in an overwhelming response of excitement and eagerness to participate. To simplify extracting the information, questions with images clarified basic clothing design options for MAS styling. The questions posed resulted in healthy discussions, which enabled the extraction of a vast amount of data related to experiences whilst wearing MAS. It was interesting to witness the energy level and how, as the researcher, I had to control the discussion and change the questions constantly – to clarify or prevent confusion or cross discussions. I explained many technical terms and industry jargon to ensure that everyone understood each topic discussed. The session was recorded on a laptop and cell phone and later transcribed and analysed.

The design of sustainable athletic clothing for Cape Town Muslim women who are guided by Islamic laws and norms



Rushdeen Rose : Mtech Design
Focus Group: 07/09/2019

SIGNIFICANCE

- Comfort in MAS
- Sporting experience
- Enabling health
- Business sustainability
- Technical product design
- User-centred

Islam Growing Fastest
Muslims are the only major religious group projected to increase faster than the world's population as a whole.

Estimated change in population share, 2010-2050

| | |
|-----------------|-------|
| Muslims | 2.9% |
| Christians | 0.4% |
| Hindus | 0.1% |
| Jews | 0.0% |
| Folk Religions | 0.0% |
| Unaffiliated | -0.2% |
| Other Religions | 0.0% |
| Buddhists | -0.3% |

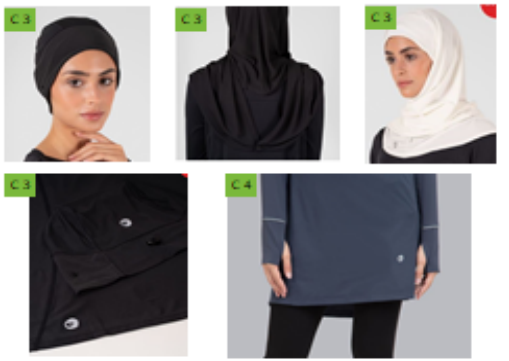
+29% growth in overall global population

Source: The Future of World Religions: Population Growth Projections, 2010-2050
PEW RESEARCH CENTER


Top length



Commercial



BACKGROUND



Headwear



Pant leg



Commercial



BACKGROUND


Modest Athletic Sportswear (MAS)



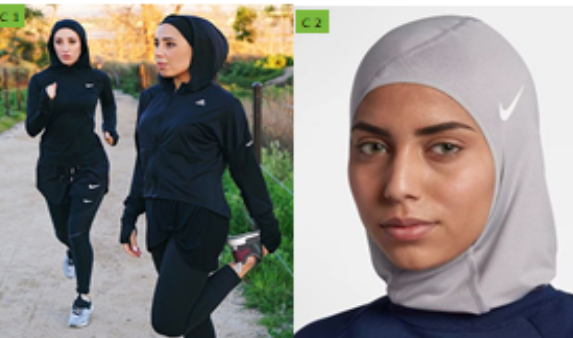
Current Design



Vests



Commercial



Proposed route for field test



Figure 4. 1 Focus group presentation slides

4.3 Fabric selection and testing

Cotton fabrics are associated with comfort due to their sensory properties or the way they feel. It also has good absorption properties, which means maintaining body dryness to a certain point. However, when there is an over-generation moisture/sweat, cotton stores the moisture, which leads to discomfort. Due to its high fabric content and looseness, MAS requires a textile that feels good on the skin and has an excellent drying rate. Products that fulfil the requirements mentioned previously are Transdry® or Wicking Windows®. These products are cotton moisture management fabrics developed by Cotton Inc. Utilising these innovative textiles for MAS is ideal for the loose styling as cotton facilitates wicking and is not prone to static or clinging to the body.

I attempted to import Transdry® or Wicking Windows® cotton moisture management fabric, but the company was unwilling to supply fabric to South Africa due to patent restrictions. In consultation with textile expert and advisor, Mr Dave Mason (pers. con, 9 April 2018). We concluded that local fabric production is possible, but fabric development is not the aim of the research. Instead, I decided to use fabrics and technology that was readily available in South Africa.

I tested ten (10) locally sourced fabric samples used for technical sportswear at the Technology Station Clothing and Textiles (TSCT) testing lab on three parameters: (1) Fabric Mass per square metre; (2) Air Permeability; and (3) Dry-Rate. The standards used for testing the samples were SANS 79:2004, ASTM D737-18, and an in-house TSCT formulated test method, respectively. The conditioned laboratory climate and samples adhered to test standard requirements, and experienced lab technicians conducted the tests. The laboratory tested five fabric swatches, and median values were calculated. (Chapter Five, Table 5.1. depicts the test results.)

4.4 3D Design process

The 3D design process is executed in the order as depicted in Figure 4.2.

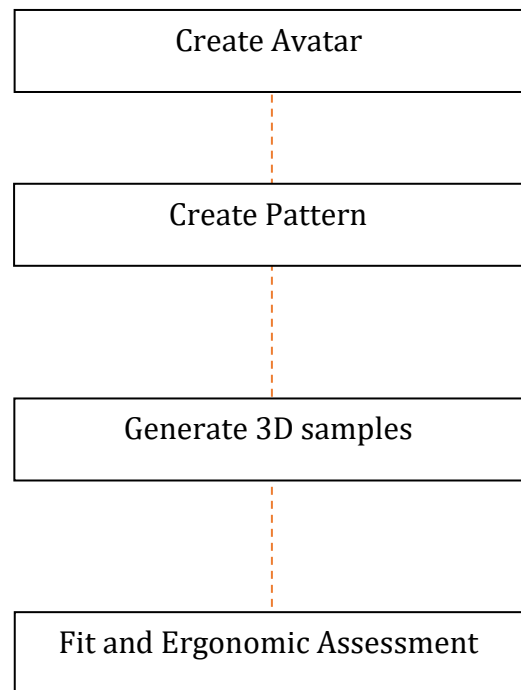


Figure 4. 2 3D design process for MAS (Author, 2020)

4.5 Ergonomic assessment

The ergonomic assessment included evaluating the garment fit in the dynamic running pose, ultimately the most exaggerated action that the athletes would perform during running. By activating the pose, the avatar engages in the motion that simulates running. The strain, stress, fit, and pressure maps, highlight where pattern adjustments are required. These pattern adjustments shape the garment to improve comfort, fit, and wearability during running. The three clothing pieces display an initial base reading. Fit map evaluation allows for pattern adjustment to alleviate any constrictions encountered.

In the next chapter (Chapter 5), all the data gained from the research process will be discussed and visually presented.

4.5.1 Anthropometric data (3D CAD scans) of focus group participants

We scanned the focus group participants to record their anthropometric data. The scanning equipment was transported from the CPUT to Islamia College before the focus group session and was set up and tested to ensure that all was in working order. A register was available to record the details of each participant scanned. According to Islamic guidelines on gender interaction, a female research assistant was assigned to scan and brief each participant on function, operation and data provided by the 3D scanner. In addition, the assistant instructed each participant how to pose and when the scan had concluded. We stored all scans and measurements on the computer's hard drive attached to the scanning equipment, an external hard drive and cloud storage. I transferred the scan data were to an excel spreadsheet for further analysis. Figure 4.1 shows a participant scanned in a make-shift room erected in the Islamia College library/museum.

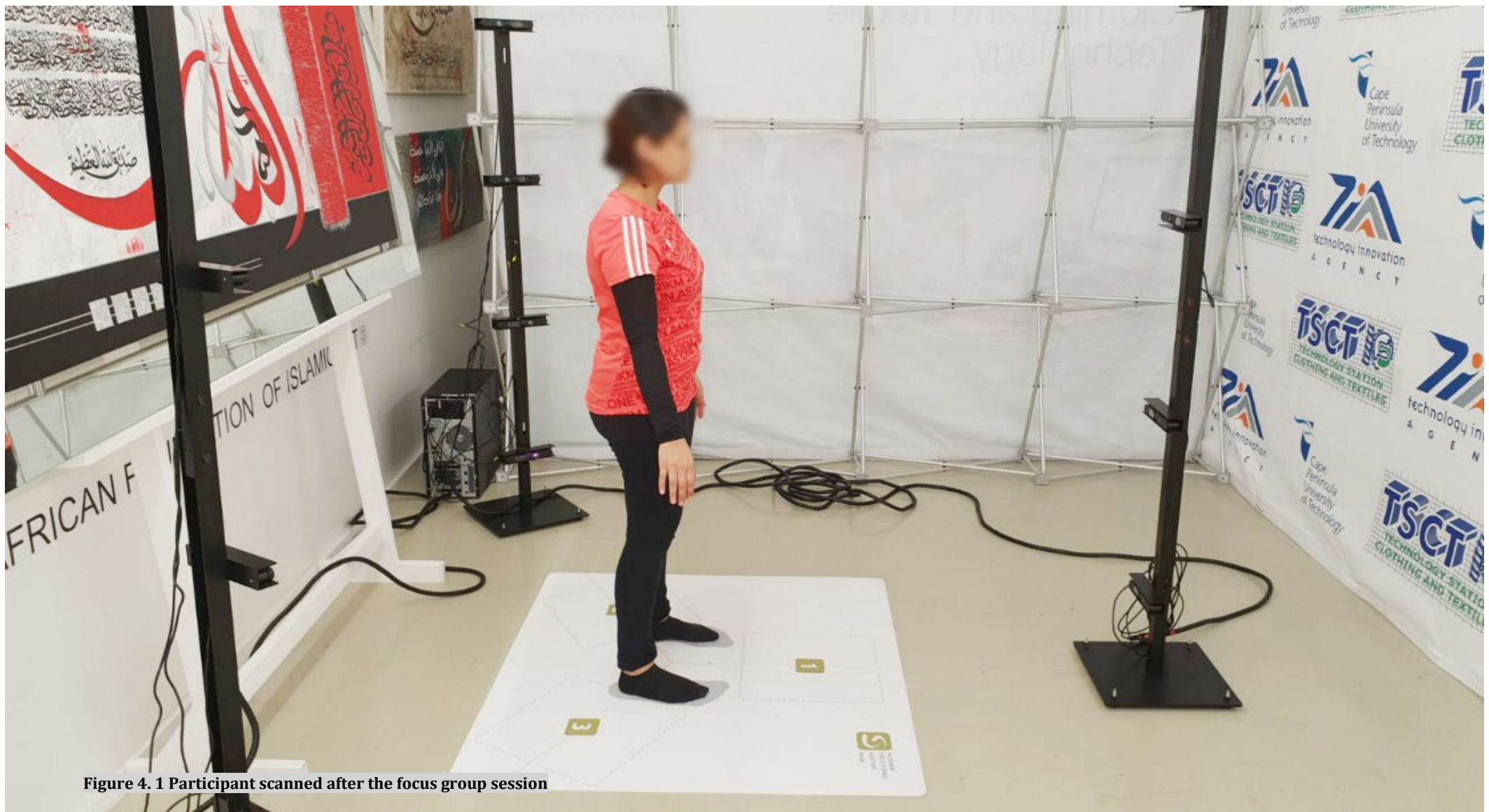


Figure 4. 1 Participant scanned after the focus group session

4.5.2 Textile selection, testing and analysis during design phase and qualitative interviews with industry design experts

Initially, the research proposed a natural fibred moisture management cotton fabric from the international company Cotton Incorporated. After contacting the company, I discovered that Cotton Inc, the product developer, is restricted from retailing in SA. I attempted to procure the fabric from the licensed retailer; however, the fabric intellectual property licences prohibited South Africa retailing.

Textile consultant Mr Dave Mason (pers. con, 9 April 2018) advised that local fabric production is possible through a chemical coating. The chemical supplier, Rudolf Chemicals, is based in Cape Town. I contacted Nicola Laubscher, the Rudolf Chemicals Area Manager in the Western Cape, to establish whether any local supplier produces similar fabrics. Ms Laubscher provided me with chemical details but noted that none of their clients was currently utilising the chemicals for the application in the manner that I required. I then contacted Mr Sefton Fripp (Innovation Process Manager) from Gelvenor Textiles, South Africa's leading technical textiles producer, but that interaction was unsuccessful. Therefore, the only option was to procure synthetic fabric readily available in Cape Town, as the research undertaken is not intended to develop the textiles for the product.

Eleven technical sports textiles sourced from Cape Town companies underwent three international standard tests performed by the TSCT. I printed and filed the results for each tested fabric. I captured the results onto an Excel spreadsheet for analysis. All documentation was scanned and saved onto a cloud server.

4.5.3 3D Ergonomic testing

I recorded eight (8) sets of results that looked at the initial fit and the modified fit for each of the three (3) products in the four (4) fit map areas (see Table 5.2). In addition, I recorded before and after snapshots saved onto a computer and onto a cloud storage area.

4.6 Use of secondary data from Smith and Havenith (2012)

I requested permission to use secondary data discussed in Chapter 2.9.2 by researchers Smith and Havenith (2012), granted by one of the authors, Professor George Havenith from Loughborough University – the data used in Chapter five to select ventilation areas the final product specification.

4.7 Summary

Chapter Four explained the execution of the research process in the interviews and the focus group, and I explained how I recorded and stored the data. My proposed idea for fabric had to be adapted as the original fabric choice was not available. It is essential to mention the contribution and conversations with mentors and industry experts (in 4.5.2), allowing critical direction through their replies and experience. These consultations were not recorded but guided me towards primary sources such as the interviewees and data sources and materials that were more accessible. Finally, I presented a brief overview of the ergonomic testing done with 3D software.

Chapter 5

Presentation and analysis of data

5.1 Introduction

Chapter Five analyses the data extracted from the interviews, the focus group, textiles testing, and anthropometric scans. The interview responses are categorised, presented, and divided into specific topics that answer the research questions and provide new insight into the existing literature. Furthermore, I analyse and summarise the styling directives from the focus group. In addition, as mentioned in previous chapters (2.4.5), I use secondary data in the final product design and specifications. Finally, I incorporate all the elements into the final design, assess the 3D prototype ergonomically, and adapt the patterns to improve fit and functionality.

5.2 Interview thematic analysis (with experts)

The following section highlights the responses from the two interviews. In some instances, I paraphrase the answers.

5.2.1 The function of the hijab

Question: How does the way you dress affect the way you perceive your piety, and has that perception, if at all, been influenced by cultural, religious or societal norms?

Both respondents stated they viewed modest dressing as a means of maintaining a connection to the Divine. Interviewee A said that it was not about how others perceived her modesty and indicated one faces constant negligence, heedlessness or distraction from God in everyday life. She said, "In an Islamic context, it is the sin of forgetting God and one's divine origins or being indifferent of these". Hijab is, therefore, her way of remembering God through everyday distractions. It was about maintaining and improving her relationship and consciousness of God. The sentiment echoed by

Interviewee B, who added, “Muslim women living in cosmopolitan societies, as minorities, struggle to find their identity and spirituality, and although clothing does not influence my perception of piety, it helps me internalise the etiquette of piety. It is more than clothes; it is about one’s state and presence in the awareness of the Almighty. Expressing it and living it then is perhaps the most liberating expression that one can articulate.”

The interviewees' responses add to Abu-Lughod (2012) research in section 2.4.2 (p. 44), showing the diverse reasons why Muslim women wear hijab. The interviewees explained their reasons for wearing hijab as internally motivated the purpose. They do not ascribe their wearing of hijab to societal or religious pressures. Instead, they don the hijab to remind who they are and their relationship with their Creator.

5.2.2 Parameters

Question: What do you consider, for yourself, to be the parameters for modest dressing in Islam? (Head, body, fit, colours, prints, materials, etc.)

Both respondents agreed about the freedom of choice around variation in their choice of hijab styling. Interviewee A stated her choice of dressing was not “static” but driven by everyday activities. However, she said that the hijab had to abide by specific criteria such as “loose-fitting clothing, covering the hair except for hands, face and feet... The materials should not be transparent, not clingy cotton, not showing the shape of the body. The hijab is culturally determined, there is not only one way of existing in the world. There are 1.7 billion Muslims, and to assume that there is going to be one standard group that would explain what hijab looks like or interpreted as - fabrics, colour and moment in time, and the phase in life and you know the older you get, the looser the hijab, the limitations become less, those kind of things. These are all the factors that go into when one should consider design, is to consider those things. Is to consider all of those things, we’re dynamic and there’s a type of monochrome image of a Muslim woman that is piety. That everything else is not. And that’s not true, because there are different moments, different phases, different stages.”

Interviewee B also added that “creative expression, colours, textures and prints are all part of the natural expression of beauty in the human. The only parameters I consider necessary is to avoid transparency and exaggeration of the figure. I am also more conservative in my styling and thus prefer that the garments are loose fitting and give some form of covering. I love colours and do not subscribe to women being confined to dark, obscure colours. Colours reflect emotions, feelings, love and creativity. These should not be stifled but appreciated. Modesty is for me an attitude... This is because for me modesty is comprehensive, it is quietude but confidence, it is intellectual yet spiritual, it is creative expression but also muted. It is up to everyone to decide to what extent and by which norm they want to be influenced. I find peace in that which allows me to be me.... Modest dressing is a personal interpretation and should not be limited to cultural impositions. I disagree with assimilating into Saudi culture, for instance.”

The research data supports the parameters of hijab as described by Bhuiyan (2018:6) definition in Chapter 2.4. – the only difference of opinion from Bhuiyan is that Byuiyan disagrees with the hijab fashionable. This research also confirmed Moors and Tarlo (2007) findings, which states that the hijab has no single description or definition and changes according to the various cultures and situations. An essential acknowledgement in this research is that one person changes her clothing according to her emotion and activities for that day. The Quran does not elaborate on a few style parameters, allowing room for expressiveness and cultural differences. The choice always come back to the intention of the individual. The failed search by Moors and Tarlo for the “Islamic dress code” is supported by this research which confirms that a universal Islamic dress code does not exist. Yes, there are guidelines as to what and how Muslims should cover to be modest, but there is no specific dress code. Searching for an Islamic dress code is akin to searching for the worldwide uniform representing Islam.

5.2.3 The purpose of the hijab

Question: Would you like to comment on anything that was not covered by the previous questions?

Interviewee B explained that “Islam has specific guidelines regarding modesty which incorporate first interaction with each other within the contexts of the ethical prescriptions outlined in the texts and then beyond the expression of character to include some form of dress. Adopting modest dress also implies adopting a modest lifestyle and approach to one’s existence.”

5.2.4 Muslim women participation women in sport

Question: As a prominent Muslim female figure, what is your understanding of sports/fitness and its significance in Islam?

Interviewee A: “A healthy body and a healthy mind and a healthy heart in more ways, and in spiritual ways, and in ways that are quite deep, that is part of being a healthy Muslim. It represents an all-around complete somebody that protects the amaanah (responsibility/trust/obligations) that God has given us. So, recognising that our bodies are actually gifts of God. We need to nurture, feed and exercise and keep healthy and is something that is absolutely one of the key maqasid (objectives). The objectives of the shariah, the preservation of life, the preservation of health, preservation of faith, that are so fundamentally linked to healthy humans and a healthy society.”

Interviewee B:” Absolutely essential – but it needs not be the commodified forms of sports one is exposed to today and it need not be a “branded” approach. However, exercise, training and fitness have specific techniques, require adherence to certain processes and demand the development of skills that will enhance one in that sport. This should not be ignored or ignorantly overlooked. Take instruction from those who have the skill, the expertise, learn from those who have practised, and even if one is not able to engage fully, God has afforded us the opportunity to utilise spaces and places and even the home in order to develop... Gratitude is a core ethical value in Islam, hence investing in one’s health, one’s mind and body, and one’s prayer are all linked to this value. Being Muslim also requires one to be in a state of alertness, preparedness and mobility – it is not about being apathetic, inactive, lethargic or even lazy. Hence the mind and the body must conform to these understandings.

5.2.5 Hijab and oppression

What would you say to those who identify hijab as a form of oppression by Muslim men over Muslim women?

The response by interviewee B on the opinion that the hijab is a sign of oppressed women was, “that this is either ignorance, white supremacist ideology, brainwashing and indoctrination or it reflects what we in South Africa fully understand as an “ignorance contract.” The refusal to learn and know because it would upset their own set of beliefs or status quo. In this case engaging the truth would lead to cognitive dissonance. That’s on the one side.

On the other side there are Muslims immersed in culture and patriarchy that have failed to understand hijab and they do oppress Muslim women with their interpretations. But this is not Islam. It is a failure on the part of these persons to understand Islam. Islam, like any other religion is and can be abused and misused. However, it is necessary for societies to empower themselves, to move beyond the confines of the those who “have always” taught them when they experience oppression and to search for meaning and justice by scholars who are engaged in these wonderful pursuits.

It is necessary to have the courage to break the mould and free oneself from oppression. Allah says in the Quran that He is not an oppressor to those who worship Him so how can hijab be oppressive? I find it exceptionally liberating and empowering and its wonderful the self-expression it allows me.” She also added, “the Quran is a text that is interpreted, and man is fallible, so there can be wrongful interpretations. But belief is beyond interpretation, and it is a comfortable feeling of contentment in the soul and a state of peace in the mind. Entering into faith and recognising Allah’s justice immediately removes all doubts about what modesty is.”

Interviewee A responded that men also have the responsibility of wearing hijab, but many do not uphold their duties. She commented that both women and men are sexual beings and that both need to be modest. She further explained that women are not a-sexual

beings like plants; they react to the opposite sex, just as men do. However, the aspect of men also had the same guiding principles as women are not acknowledged.

As mentioned in Chapter 2.2.5, the topic of hijab can be contentious and filled with various gender, political and cultural/religious debates. However, these prominent South African Muslim women are exceptionally well educated and passionate about defending the hijab. Like so many other studies revealed, Muslim women are offended by the suggestion that Islam is a religion of oppression. These sentiments echo those by Abu-Lughod in section 2.2.5. She states that many Muslim women take offence by the idea that Islam is the cause for any trepidation or adversity that they may be experiencing.

5.3 Focus group thematic analysis

The focus group discussion aimed to establish the expressive, aesthetic, and functional design elements of MAS. In addition, participants provided insight on the importance of the hijab and the social challenges experienced whilst wearing the hijab at athletic events. The focus group methodology and questions are explained in chapter 4.2.2. The following sections convey the sentiments from participants and is depicted in figure 5.1

5.3.1 Expressive

Data extracted confirm that participants continue to wear hijab even though they have experienced social pressure or criticism from other race contestants for wearing hijab whilst participating in sports. These remarks confirm the significance of this study as it indicates that for these women, wearing the hijab is an immutable religious act that supersedes participating in sport or negative social pressure.

The consensus was that mainstream South African retailers do not provide complete sports solutions for Muslim women. Therefore, athletes must buy what is available or must purchase bespoke products. The Nike headscarf, in their opinion, is the only mainstream product branded as hijab. Full-body covering hijab was not an available option. Participants, therefore, express their religiosity at the expense of performance by wearing clothes that are unsuitable for the occasion.

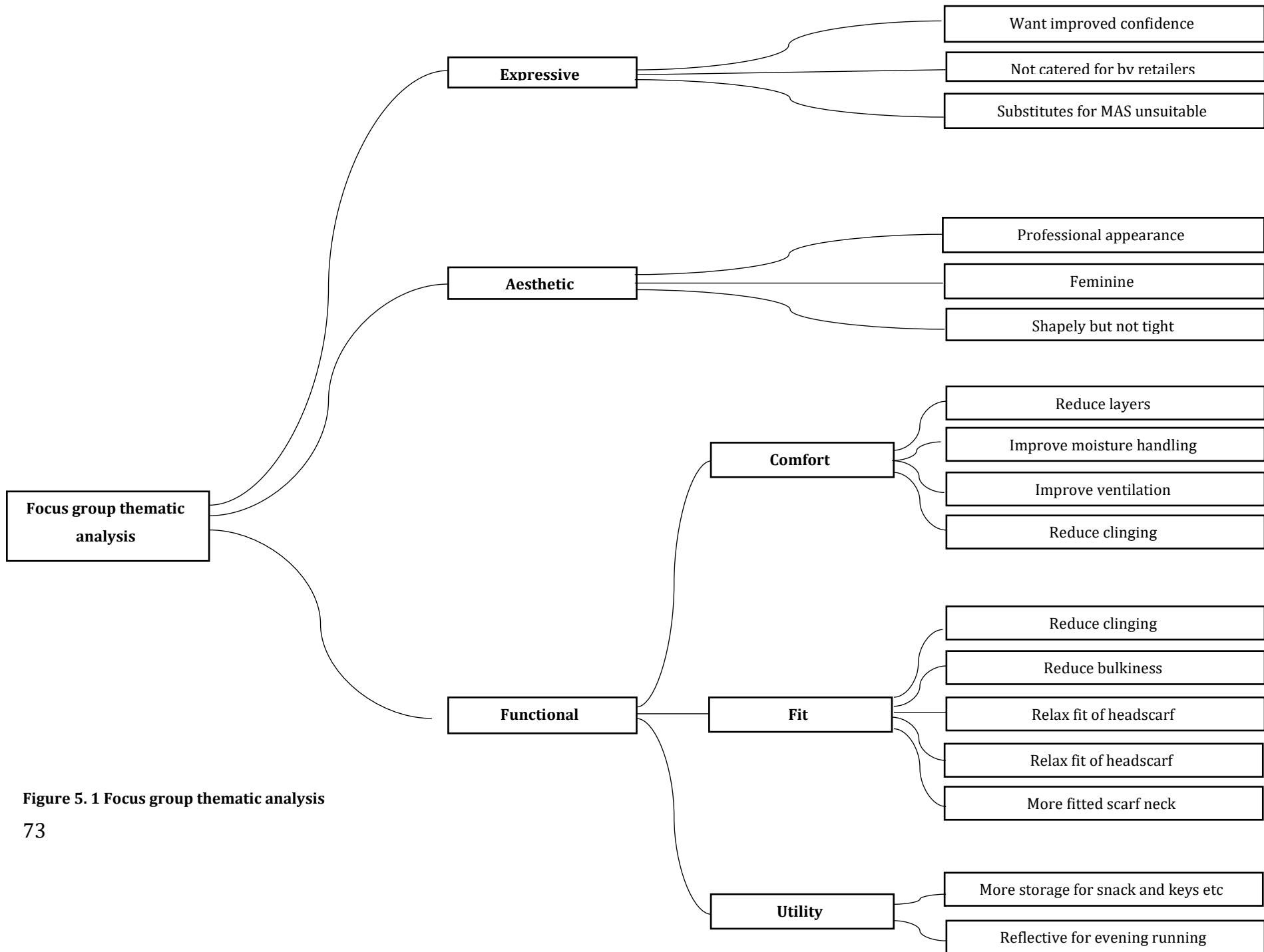


Figure 5. 1 Focus group thematic analysis

5.3.2 Aesthetic

Athletes agreed that they aspired to look professional by wearing technical sports clothing. Clothing should look contemporary and feminine. However, they decided that femininity does not equate to stereotypical notions such as flowery patterns, the colour pink or frills. Feminine, in this case, relates to clothing made to conform to the female shape and fit without being tight. A tailored shape but looser fit and a longer length. The sleeves of the tops that are available in sports stores are too short.

5.3.3 Functionality

5.3.3.1 Comfort

The current solutions for MAS require too many layers of clothing to maintain the line of modesty. The athletes would like to eliminate wearing the skirt over their tights/ pair of pants and wearing long sleeves under short sleeves t-shirts. The athletes prefer a maximum of three items for their running gear. Currently, the layers are cumbersome and restrict movement creating discomfort after a short period of being active. In addition, the layered approach makes it complex to control garment ease and results in restriction.

Another request was for appropriate fabrics that promote moisture handling and improve ventilation to counter the high level of concealment. In addition, athletes noted that the existing clothing does not assist in alleviating clinginess, which results in discomfort.

The headscarf is problematic as uneasiness arises due to moisture, heat and skin sensorial discomfort.

5.3.3.2 Fit

The clothing fit must conform to the feminine shape as ill-fitting men's clothing substitutes add to the discomfort. In addition, wearing men's clothing substitutes in larger sizes to compensate for women's breasts results in looseness in the wrong areas like the belly, shoulders, and arms, resulting in fabric bulking.

In addition, the headscarf needs to be looser around the skull for air circulation and to relieve pressure on the skin, forehead, and hair. In contrast, the neck area of the scarf needs to be more fitted to remove the restriction on the shoulders. At the same time, the neck area must be well ventilated.

5.3.3.3 Utility

The request to reduce clothing pieces would mean replacing accessories like extra bags to carry goods. Therefore, the garment must incorporate minimal pockets that hold keys and small snacks that do not create hindrances during exaggerated motion.

Some participants run at dusk and dawn; therefore, the garment must include reflectors as a protective feature.

5.3.4 Specific styling directives from focus group

The participants unanimously chose image H3, called the loose “ninja” style, for the MAS design. They suggested a more relaxed skull shape but a tighter neck with increased venting.

The top length chosen was image TL2 with an added length of 6 cm longer to end just above the knee.

Participants chose PL3 and suggested that one-piece skirt-tights are preferred.

Extra pockets that were easily reachable for keys, tissues and dates would improve the utility, and the suggestion was a slave with a sewn-on patch pocket.

5.3.5 Focus styling vote

The slides below offer a variety of styling options for which the participants voted. The style option with the highest count was included in the MAS design. In some instances where votes were minimal, the group suggested other styling options.

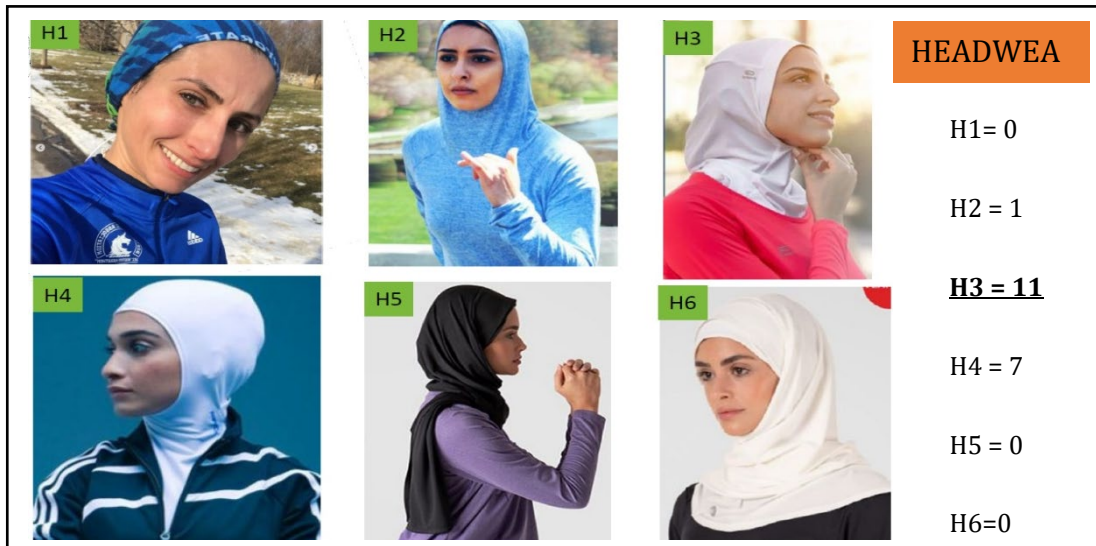


Figure 5.2 Headwear options



Figure 5.3 Top length options



Figure 5.4 Vests options



Figure 5.5 Pants options



Figure 5.6 Commercially available products

*C3 repeated as it is the same product

5.4 Textiles selection

The TSCT textile carried out fabric mass, air permeability and a drying rate test with the results displayed in Table 5.1

Table 5.1 Textile test results

| | STANDARD | | SANS 79:2004 | ASTM D737-18 | TSCT |
|--------|---------------------|-----------------------------------|---------------------|---------------------------------------|-------------|
| | UNIT OF MEASUREMENT | | (g/m ²) | (cm ³ /cm ² /s) | Mins |
| REF NO | TEST CODE | FABRIC CLASSIFICATION | FABRIC MASS PER M2 | AIR PERMEABILITY | DRYING RATE |
| 1 | REF.G: PMA | POLYESTER MESH ACTIVE | 70.63 | 255 | 1h 45mins |
| 2 | EYELET | POLYESTER EYELET MESH | 114.09 | 145 | 1h 45mins |
| 3 | REF.A: TA | TRI ACTIVE | 119.17 | 91 | 1h 45mins |
| 4 | REF.H: BSR | BIRDS EYE RIB | 140.94 | 112 | 1h 45mins |
| 5 | TS | TEDCHNO SHEEN MOISTURE MANAGEMENT | 139.02 | 130 | 1h 45mins |
| 6 | REF.B: BSE | BIRDS EYE POLYESTESTER MESH | 137.37 | 93 | 1h 45mins |
| 7 | REF.A: PXB-MEL | POLYESTER/ SPANDEX BRUSHED | 170.76 | 25.5 | 2 h |
| 8 | REF.D: PKW | KWIK KOOL MOISTURE MANAGEMENT | 164.98 | 97.3 | 2h 50mins |
| 9 | BLACK | POLYESTER SPANDEX | 239.52 | 22.3 | 2h 50mins |
| 10 | REF.E: TFW | TRI FLEX MOISTURE MANAGEMENT | 220.68 | 31.3 | 2h 50mins |
| 11 | REF.I: PXD | POLYSTER SPANDEX PREMIUM | 251.23 | 19 | 2h 50mins |

As can be seen in Table 5.1, I selected eleven samples marketed as sports textiles for testing. The TSCT conducted three tests for mass, air-permeability, and drying rate. The lab tested mass and air permeability using certified standards, SANS 79:2004 and ASTM D737-18, respectively. The dry rate test was developed at the TSCT utilising available resources and a customised test method.

5.4.1 Results-based selection

Sample one (1) had the lowest mass, was most breathable and had the quickest drying rate. The drying rate was equal to six other samples. However, the transparency was inappropriate for the application.

Sample two (2) had the second-lowest mass, was second highest in breathability and had the quickest drying rate, equal to sample one (1). The transparency was acceptable at about thirty-three per cent. Sample two (2) textile was chosen as the venting material, allowing airflow to the specific high-volume sweat regions, and will strategically be placed in such quantity as it does not reveal any undergarments or skin.

Sample five (5) had the third-highest air permeability, fifth-lowest mass, and zero transparency. Therefore, I chose sample five (5) as the main textile. In this instance, I chose air permeability performance over mass.

Sample nine (9) performed the best amongst the stretch textiles even though it ranked eighth best for mass and air permeability. It also had a medium drying rate of two hours, quicker than the other stretch fabrics. Therefore, I chose sample nine (9) for the pant fabric and for the lower side panels in the top to allow for stretch during running.

In summary, sample two (2) was selected for venting, sample five (5) for the main fabric and sample nine (9) for stretch fabric.

5.5 3D design

In section 4.4, the method explains a four-step 3D design process: create an avatar, create the pattern, generate 3D samples, and fit/ergonomic assessment. Next, I made a technical

drawing amalgamating all design elements extracted from the focus group. Finally, I arranged the venting according to the sweat regions as suggested by Smith and Havenith (2012).

5.5.1 Artefact: technical specification

The following design specifications were extracted from the focus group and compiled in fig: 5.6.

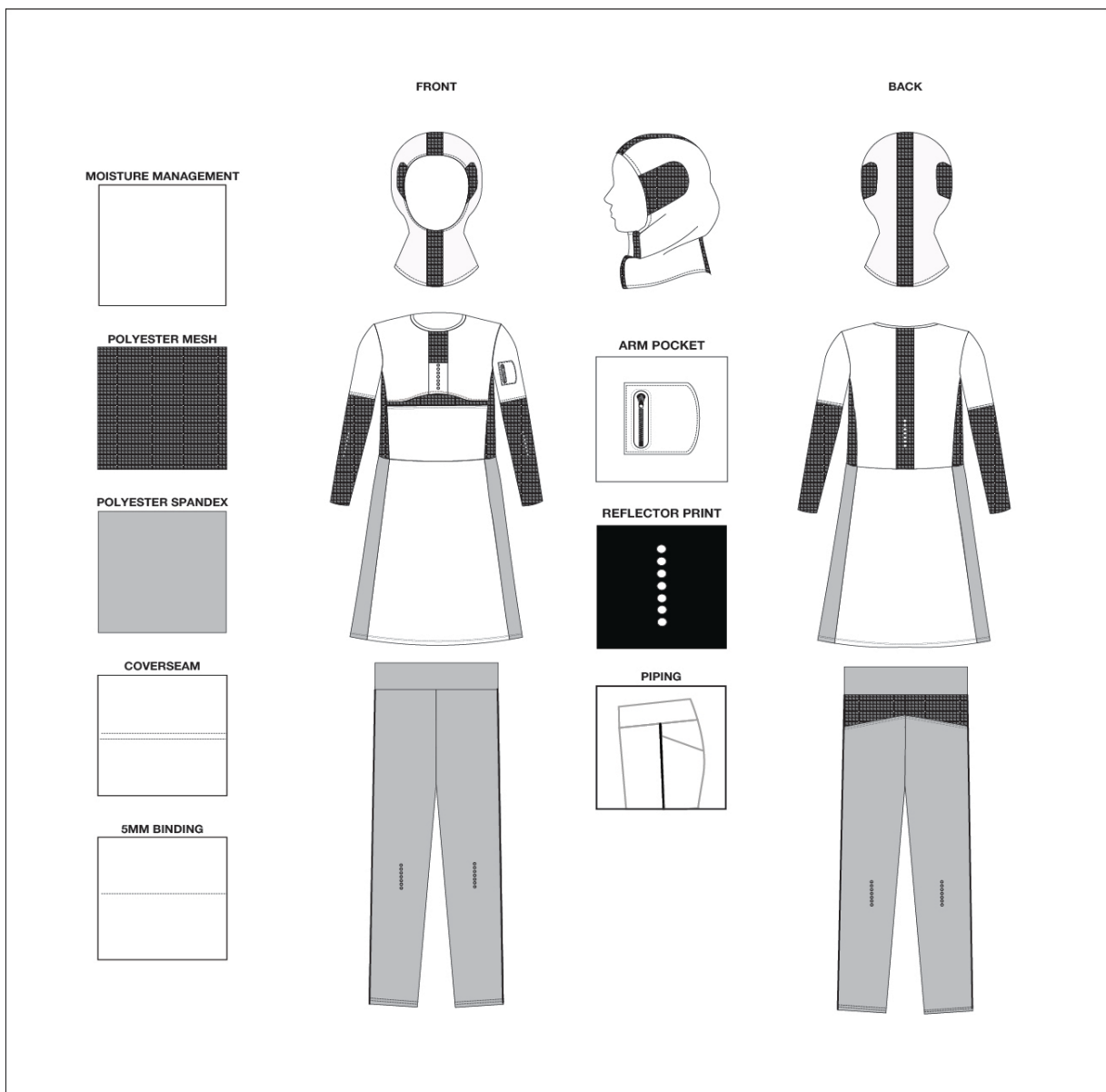
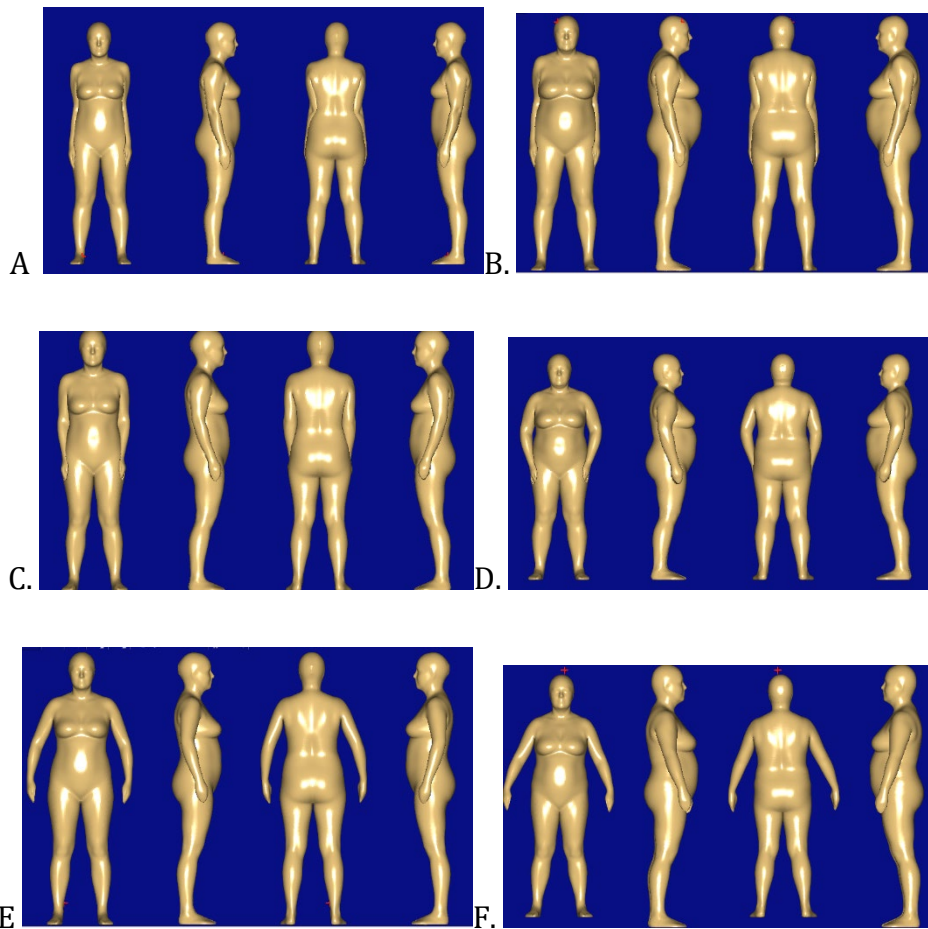


Figure 5. 7 MAS technical drawing (Rose, 2019)

5.5.2 Creating the avatar

I recorded participants' body measurements using a 3D scanner to establish each participant's size and fit dimensions. See below for the scanned measurements as well as individual 3D avatars (Fig. 5.8). The data derived from the scans allow for individually sized samples or an averaged size-scale for mass production. In this instance, I chose an individually sized/ bespoke design using participant H's measurements. The extracted values are body height, crotch height, bust/chest circumference (horizontal), across back width, waist girth, high hip buttock girth, thigh girth and calf girth. The extracted measurement for H is depicted in Figure 5.8. I utilised the measures to create the model 3D avatar upon which I superimposed the virtual patterns, as suggested in section 2.5.1 of the literature review.



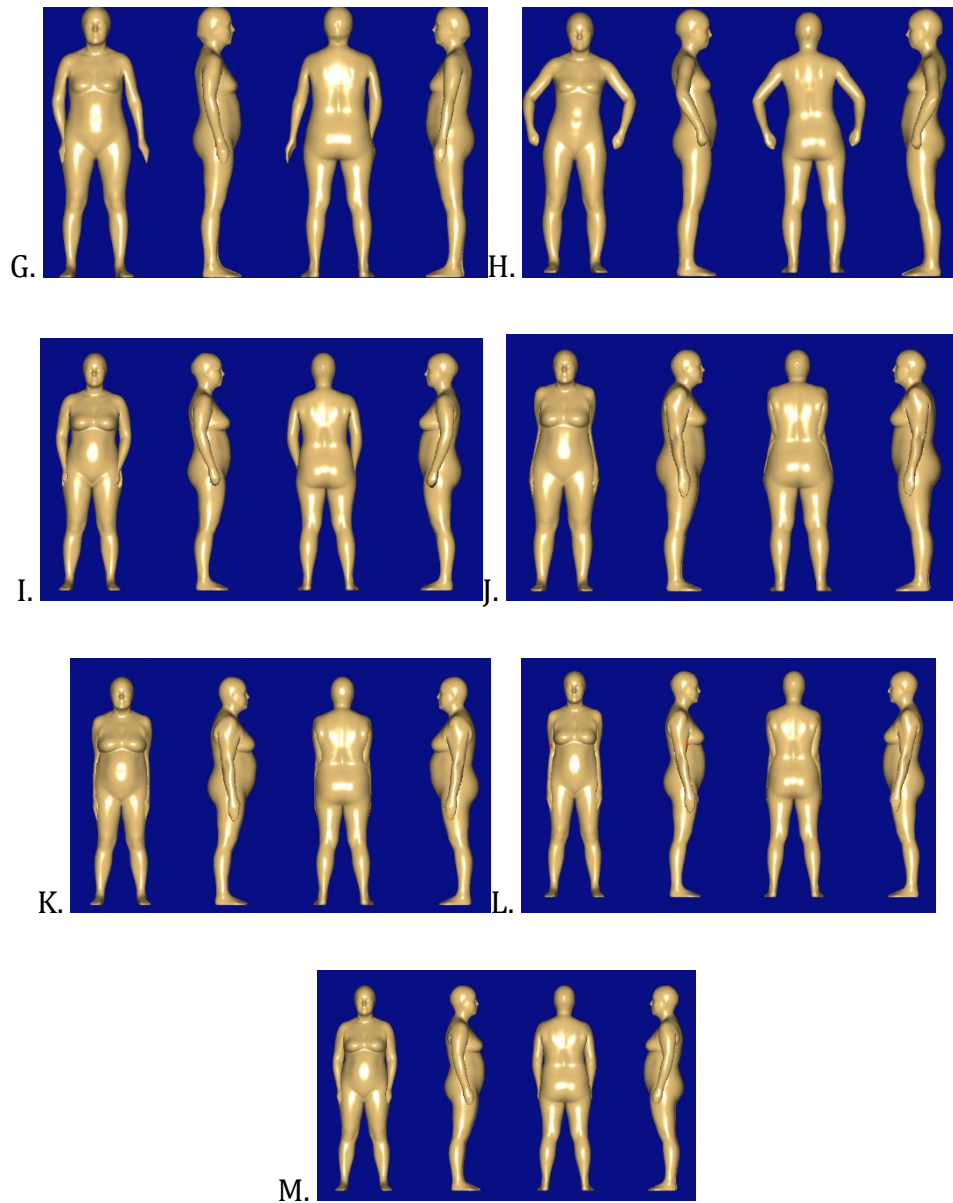


Figure 5. 8 Scans of focus group participants

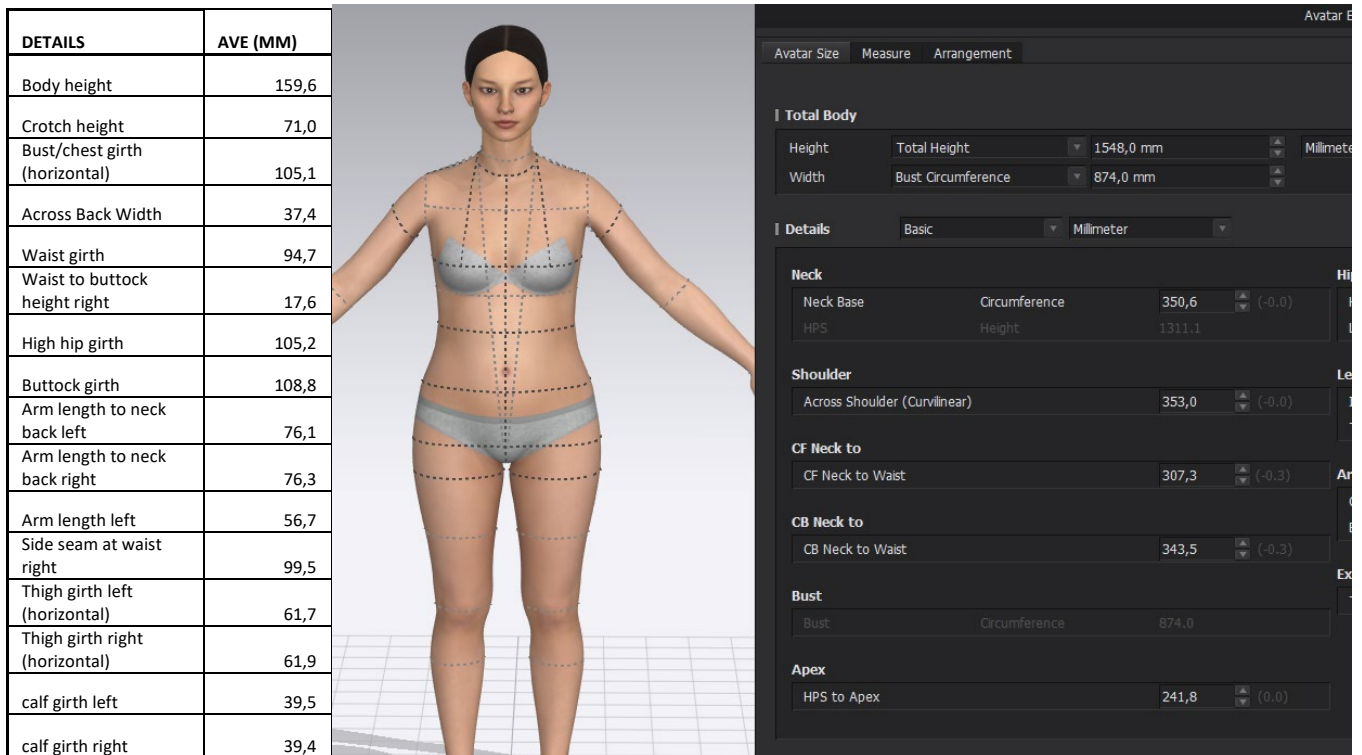


Figure 5.9 Avatar derived from body scans (Author, 2019)

5.5.3 Create pattern

Three garment patterns (Figure 5.9) were drafted directly onto the 3D avatar using the 3D pen and flatten tools (Figure. 5.10). I incorporated most of the specifications requested during the focus group into the final design. I omitted two suggestions. (1) The request for a one-piece skirt-tights was unnecessary as the top incorporated the skirt. (2) The front pocket would be in the way of venting fabrics. Instead, I placed pockets on both sleeves.

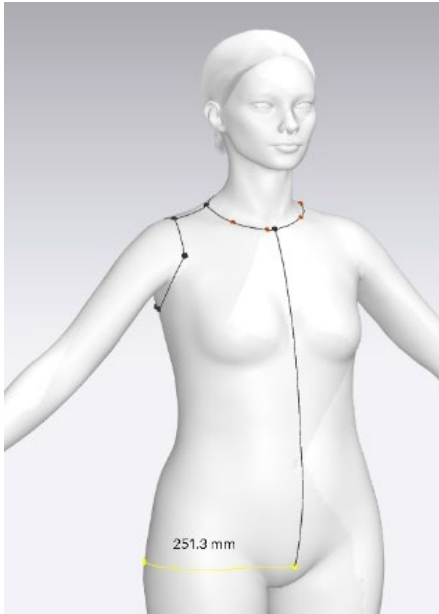


Figure 5. 10 Pattern drafted on avatar



Figure 5. 11 Patterns according to specifications provided

****Grey – Omitted from design**

FOCUS GROUP SPECIFICATIONS

Professional and appropriate appearance.

Modern and feminine.

A tailored shape but looser fit and a longer length.

Longer sleeves

Less layers

More ventilation.

No skirt

H3 – loose “ninja” style chosen for design

Looser head covering with tighter neck but with venting.

6 cm longer than TL2 just above knee.

Most requested PL3

One-piece skirt tights is preferred

Reachable pocket- keys, tissues, dates

Patch pocket

Suggestion for pocket sleeve

Suggestion for pocket on the front

5.5.4 Generate 3D samples

The patterns were arranged onto the avatar using the software tools and virtually stitched to form a 3D sample (figure 5.11). I adjusted the pattern sizing visually to provide ease or looseness into the pattern. Still, I maintained the initial silhouette shape, which resulted in a more relaxed fit.



Figure 5. 12 Pattern arrangement, stitching (left) and ease allowance (right) (Author, 2019)

5.5.5 Ergonomic assessment

Table 5.2 Fit map ergonomic assessment results

| Product | Stress rating (= /> 120%) | | Strain rating (= /> 120%) | | Fit rating (Can't Wear) | | Pressure rating (0-100%) | |
|----------|------------------------------|-------|------------------------------|-------|----------------------------|-------|-----------------------------|-------|
| | start | final | start | final | start | final | start | final |
| Tights | 5% | 0% | 70% | 24% | 0.8% | 0% | 50% | 15% |
| Top | 0% | 0% | 20% | 20% | 0% | 0% | 15% | 15% |
| Headwear | 3% | 0% | 39% | 4% | 0.3% | 0% | 37% | 14% |

Table 5.2 shows the data taken from the 3D ergonomic assessment of the three products. The start and final ratings represent the data of the initial patterns and the corrected patterns, respectively.

5.5.5.1 Stress rating

The stress map indicates the amount of pressure that is applied to the garment by the avatar. The stress rating measures four levels exhibited by green, yellow, orange, and red, which I recorded in the static and running pose positions.

The table shows that five per cent of the tights have a rating equal to or above 120 per cent stress reduced to zero after pattern adjustment. The top shows a stress rating of zero, which is an ultimate score requiring no adjustment. The headwear shows a rating of three per cent, which I reduced to zero per cent after pattern adjustment. Figure 5.5.2 shows the stress exerted on the garment whilst running before and after I adjusted the patterns.

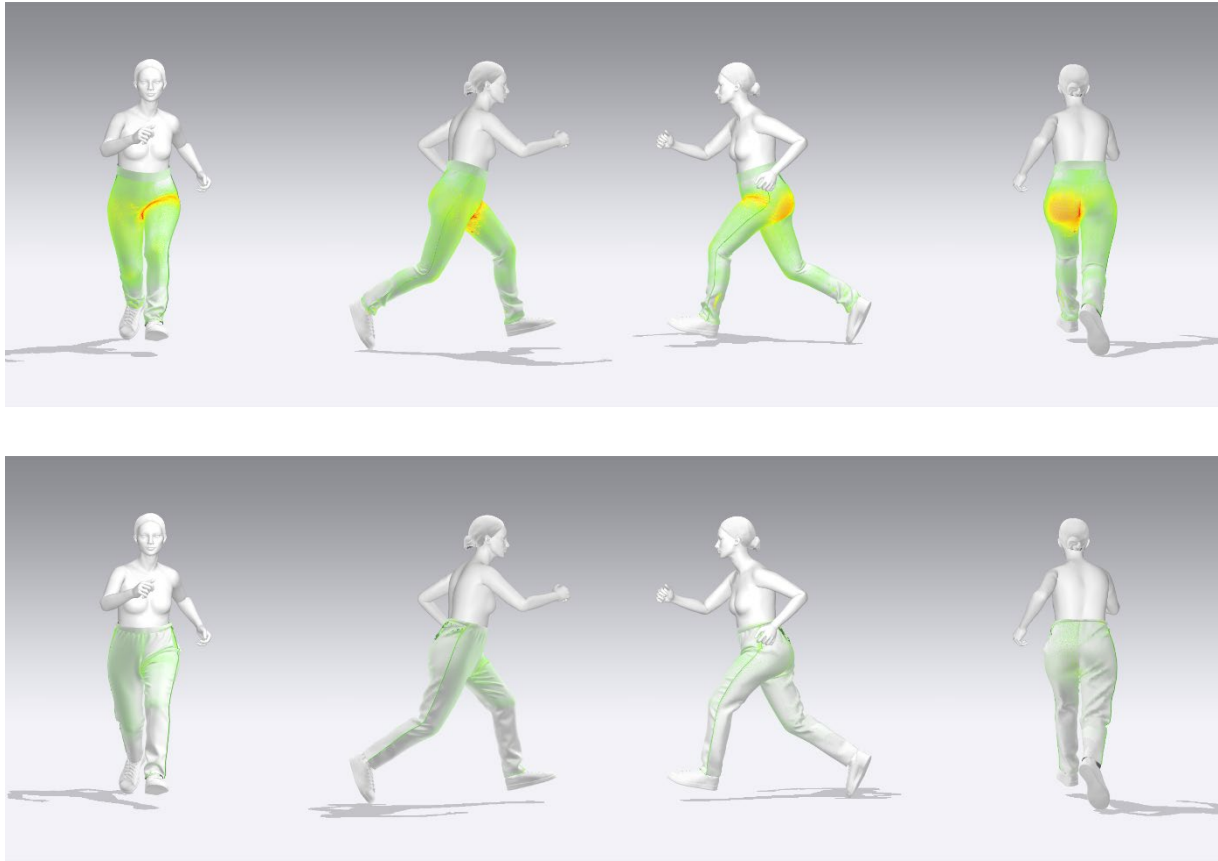


Figure 5. 13 Tights stress visual before (top) and after (bottom) pattern adjustments (Author, 2019)

5.5.5.2 Strain rating

The strain map indicates the amount of stretch that the avatar exerts on the garment. I set the rating to read four stress levels exhibited by green, yellow, orange and red. The colours in the order mentioned indicate the fabric's stretch on percentages from 100 to 105, 106 to 113.32, 113.33 to 119 and 120 %, respectively. A one hundred (100) per cent reading indicates no stretch, and any reading above one hundred (100) per cent indicates stretch. The fabrics are knitted and intended for stretching, especially in the running motion. Therefore, the target was to reduce strain to below twenty-five (25) per cent and not eliminate all stretch. In areas such as the elbows, knees, and hips where movement and bending occurs, stretch is inevitable.

The table shows the percentage of the garment stretched equal to or above one hundred and twenty (120) per cent. One hundred and twenty (120) per cent indicates that a garment has stretched twenty (20) per cent above the garment volume.

The pair of pants show a seventy (70) per cent of the garment equal to or above one hundred and twenty (120) per cent stretch. After pattern adjustment, I reduced the reading to twenty-four (24) per cent, located in the areas of movement such as the crotch. The top had an initial value of twenty (20) per cent, which was acceptable. The headwear had a reading of thirty-nine per cent (39) per cent, which I reduced to four (4) per cent after pattern adjustment. The strain map in the headwear indicated a concentration around the face, as shown in figure 5.7.

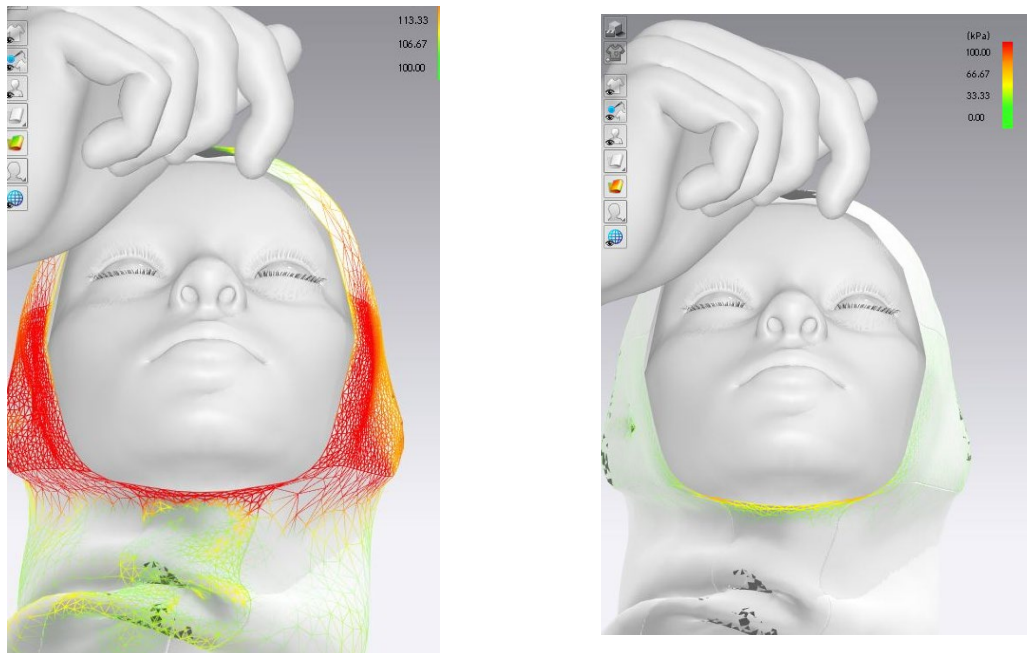


Figure 5. 14 Before and after headwear strain maps (Author, 2019)

5.5.5.3 Fit rating

The fit map indicates which parts of the garment is un-wearable because of pattern construction. The colours indicate constriction, with yellow representing tight at eighty to eighty-nine per cent and a red reading of 90 and above, indicating that that specific sized person cannot wear the garment. Table 5.2 shows the percentage of the garment that had a value of above eighty-nine (89) per cent.

The pair of pants shows an initial reading of 0.8 per cent in the crotch area, which I reduced to zero (0) per cent after adjusting the pattern (figure 5.15). The top had a zero (0) reading, and therefore the pattern did not require any adjustment. The headwear had a reading of 0.3 per cent, which was reduced to zero (0) per cent after pattern adjustment.

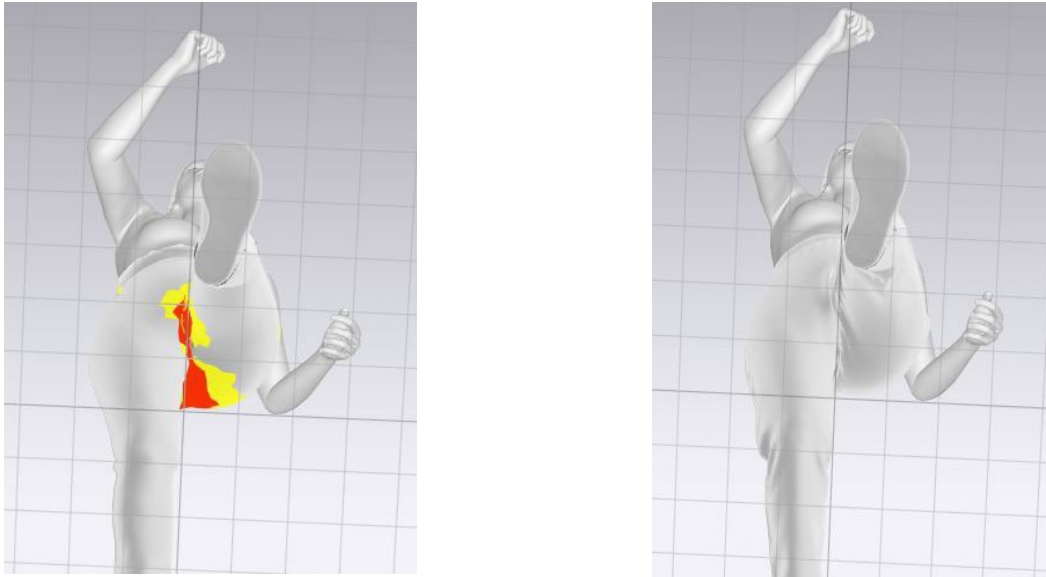


Figure 5. 15 Before and after fit visuals for tights (Author, 2020)

5.5.5.4 Pressure rating

The pressure map indicates the points of contact that garment has with the avatar. This indicator is helpful, especially for MAS, as it allows the control of the looseness or ease of the garment. Considering that the garment must touch the body, I set a fifteen (15) per cent benchmark as the ideal goal. Figure 5.16 shows a fifteen (15) per cent pressure rating visually represented by blue contact points.

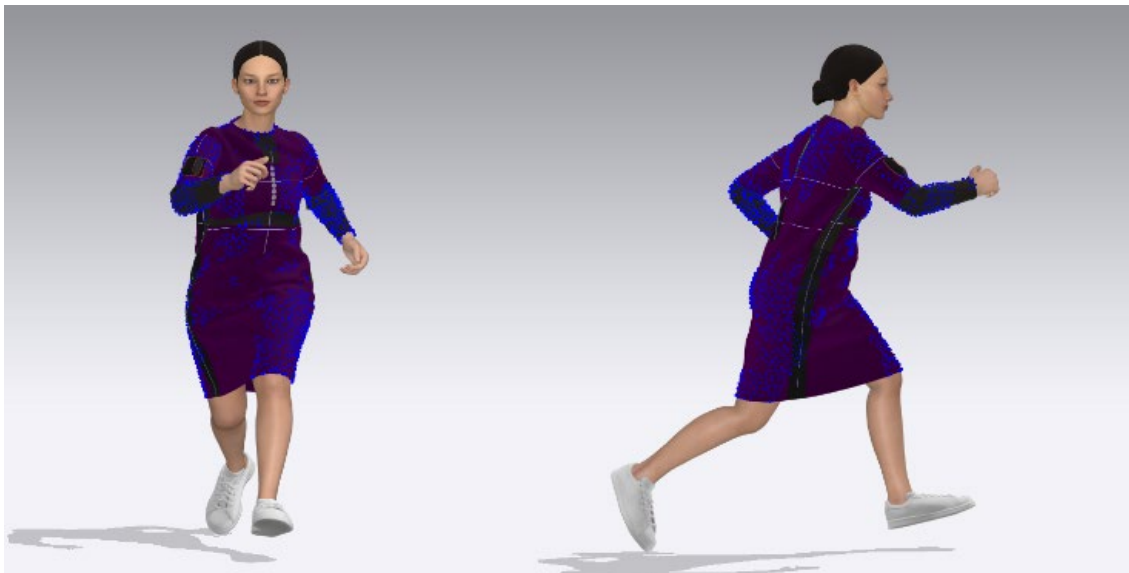


Figure 5. 16 Pressure points on MAS top (Author, 2020)

5.5.5.5 Venting

Figure 5.17 shows the correlation between venting/ mesh placement and high sweat regions for females, as discussed in Chapter 2.4.5. The blue arrows indicate the airflow, which allows for improved drying and cooling.

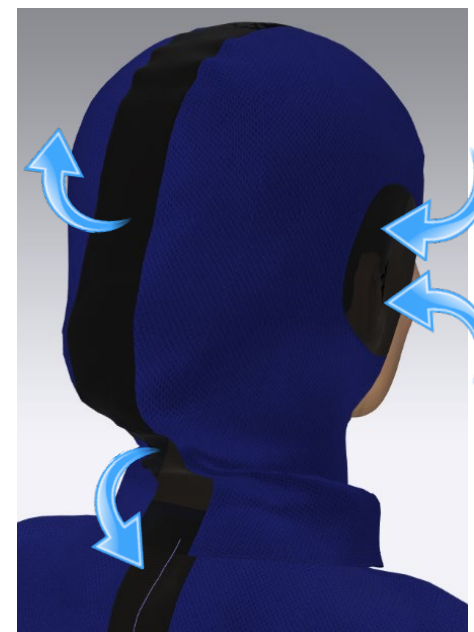
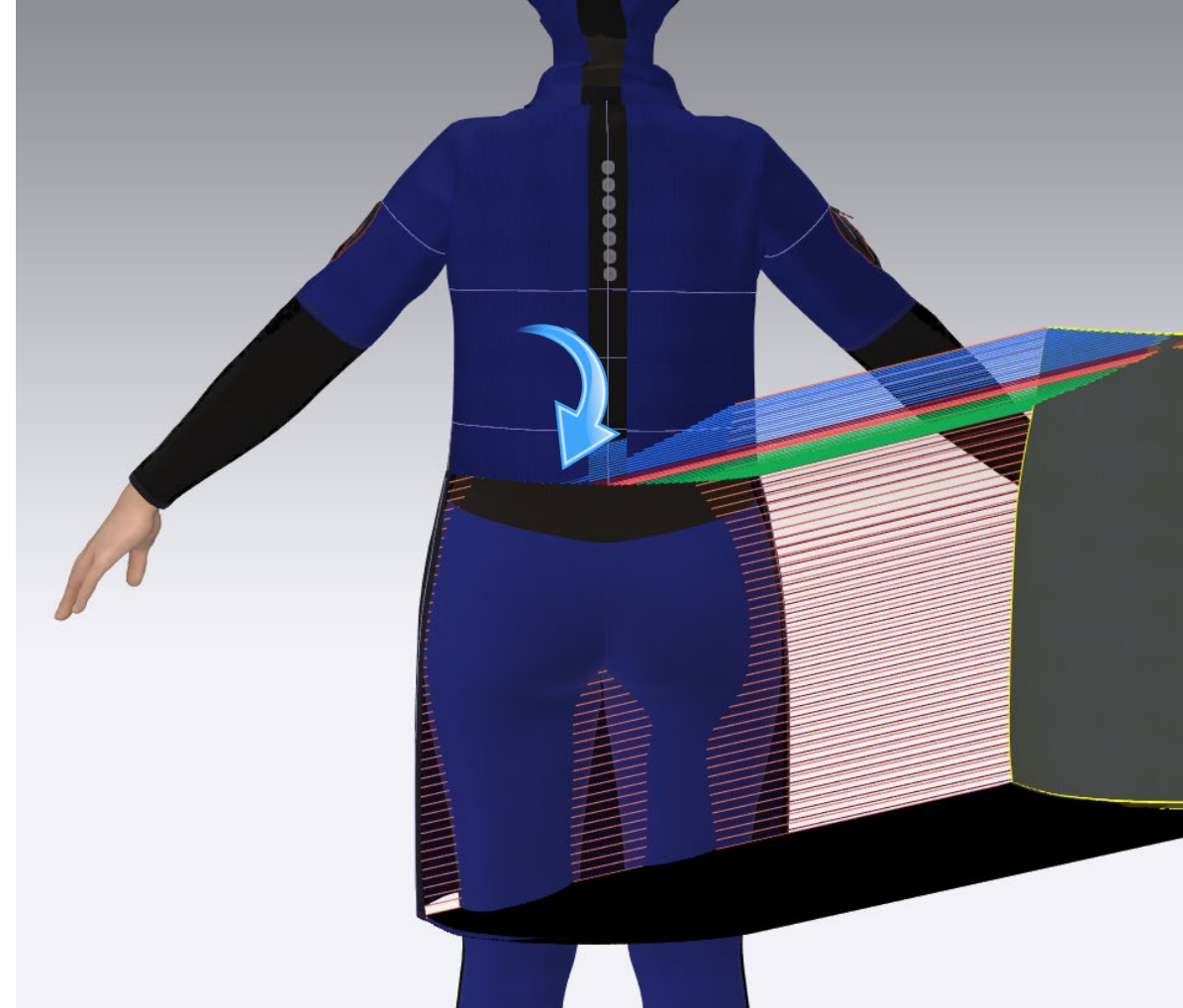
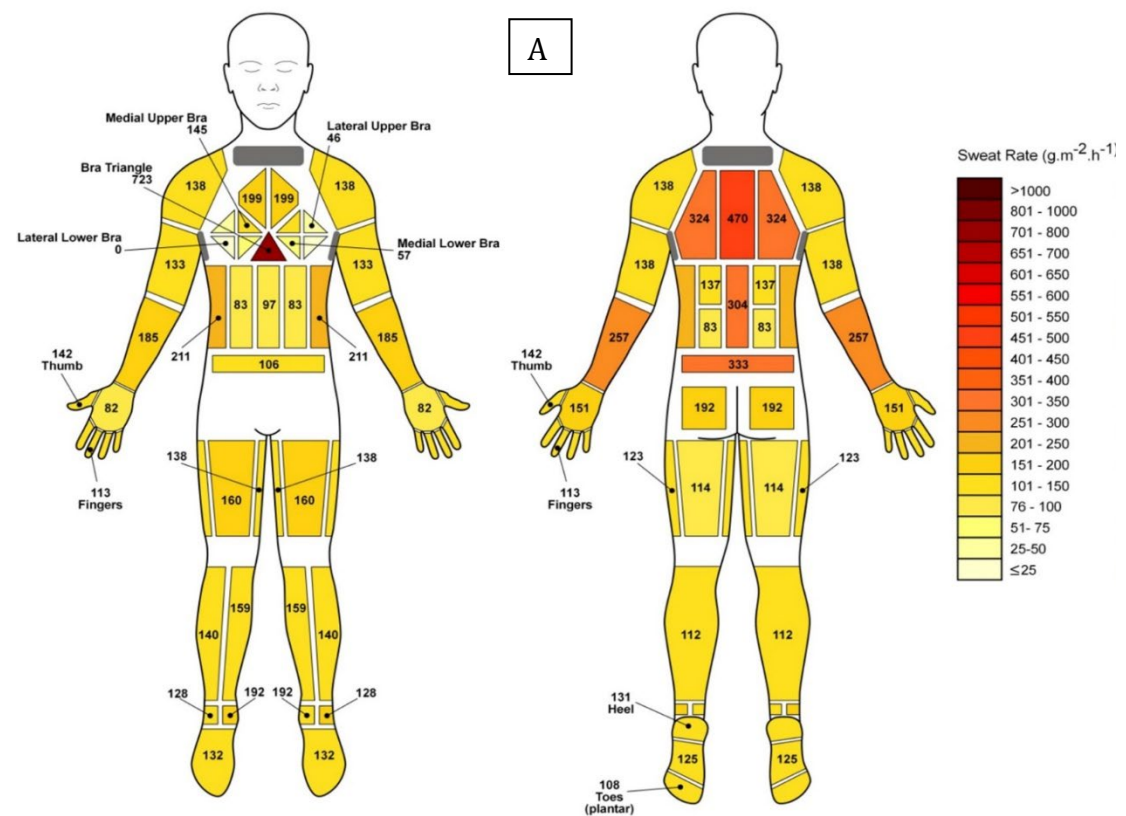


Figure 5. 17 Female Sweat regions (Smith, C.J. and Havenith, 2012) to ventilation positioning (Author, 2020)

The regions with high sweat rates indicate a value of one hundred (100) and higher. Venting was incorporated into the headscarf as requested by the focus group athletes.

5.5.5.6 Ease

Orange arrows in Figure 5.18 show the mesh view of how I altered the pair of tights to improve modest fit criteria and improve ergonomic performance.

The focus group participants requested that the headscarf be “breathable” (more airflow), have a loose fit around the head, and be more tailored around the neck. The arrows in figure 5.11 show the incorporation of the requests.



Figure 5. 18 Ease allowance pair of tights (Author, 2020)

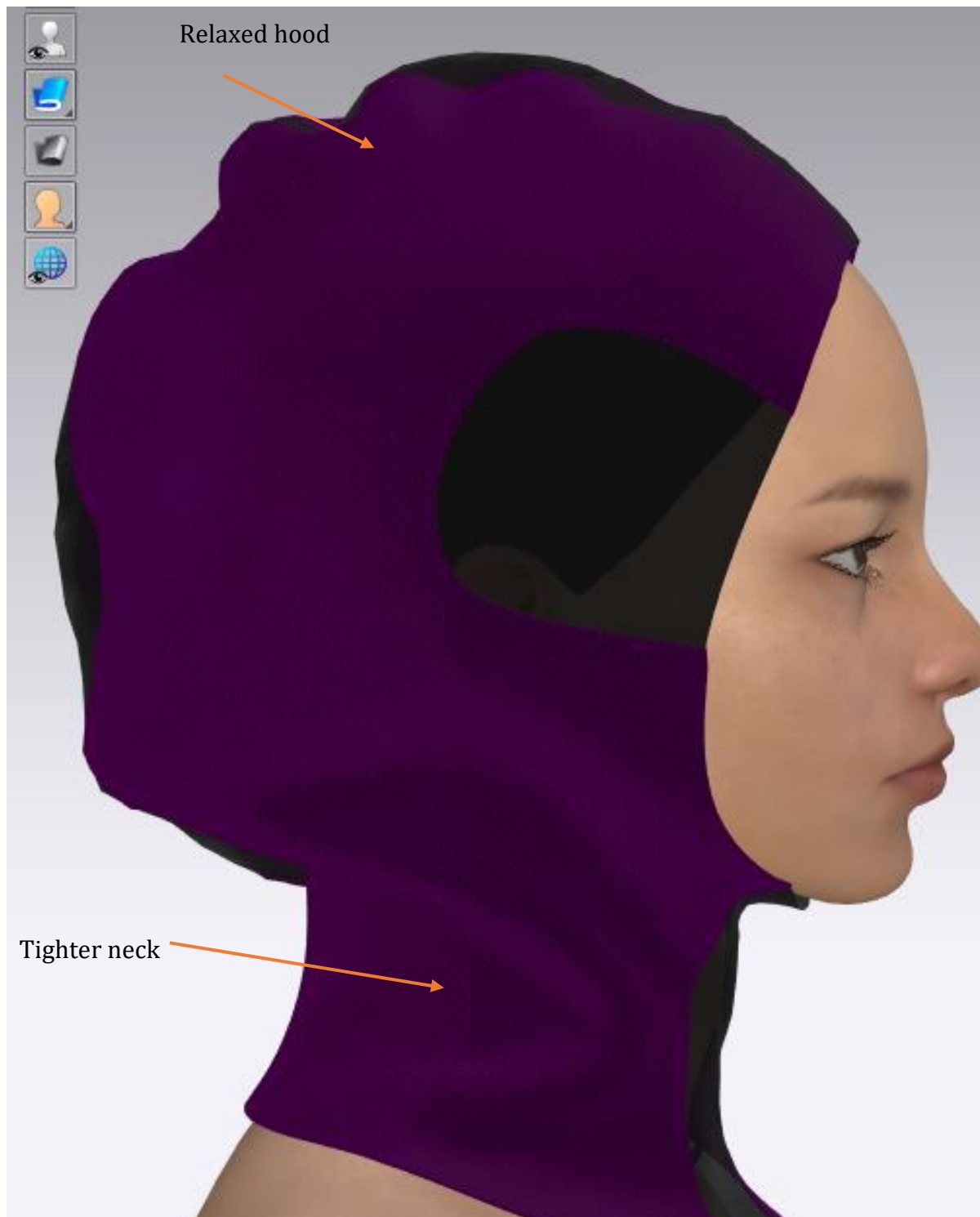


Figure 5. 19 Headscarf styling criteria (Author, 2020)

5.5.5.7 Utility

Figure 5.20 shows the two patched sleeve pockets (with zips) included for easy reach whilst running. In addition, reflector prints have been placed on all sides as protection during early and evening running.



Mesh venting

Mesh venting

Zipped patch pockets

Stretch fabric

Reflector prints

Reflector prints

Figure 5. 20 Final product (Author, 2020)

5.5.6 Final product design

In terms of functionality, the design and construction elements fulfil the sport functions and religious requirements by optimising performance and concealing the body. The product includes easy-reach pockets for keys, energy sweets or sachets and eliminates the waist/ moon bag - as requested by the athletes. In addition, I created the sleeves in a non-transparent perforated mesh which maximises airflow and conceals the arms. I will elaborate on the additional functional elements in the points to follow.

The products design aims to simplify the sporting experience. The athletes reduced the amount of clothing/ gear, which consisted of these seven items: a pair of pants, a skirt, a short-sleeved t-shirt, a long-sleeved t-shirt (to cover arms), a headscarf, a cap, and an accessories bag to hold keys and energy boosters. The design reduces the gear to three items as initially intended.

In terms of comfort, selecting performance fabrics and reducing clothing layers reduces moisture, mass, and movement restriction during running. The placement of mesh fabric to facilitate airflow through venting in the regions identified by Smith and Havenith (2012) in Chapter 2.4.5 improves drying rate and comfort. The position of the arm pockets allows for vertical zipping with slightly bent, raised arms in line with natural running motion, improving ergonomics. The body scans and 3D technology enhance the sizing and fit accuracy by ensuring precise body dimensions, appropriate fullness, and ease-allowance.

Concerning health and safety, the TSCT lab tested the textiles for mass, air permeability and drying rate to determine thermo-regulating properties, as suggested by Das and Alagirusamy (2010) in Chapter 2.4.6. In addition, the design allows for venting in sweat areas by facilitating airflow and accommodating the thermo-regulation processes like heat dissipation and thus preventing hyperthermia. Furthermore, the design maximises the evaporation of sweat from the body and textiles and reduces post-exercise evaporative cooling. In addition, the top and the pair of tights have front rear and side safety reflectors for evening running.

The design conveys a sporty look to improve the sporting performance and experience, focused on functional purpose. The participants requested a focus on enhancing their competitiveness rather than making the clothing “pretty”.

I assessed the virtual garments to improve ergonomics using a 3D design programme. I reduced the negative readings in the various fit ratings relating to stress, strain, fit, and pressure by optimising the patterns during a running motion.

5.6 Summary

Chapter five presented and discussed the data and insights extracted from the interviews, the focus group, textiles testing, and anthropometric scans. I arranged the interview responses into five themes. Furthermore, I analyse and summarise the styling directives from the focus group in a themed analysis. Then, I incorporate all the styling elements from the data gathered to design the 3D prototype. Finally, I assess the 3D prototype using a CAD program for ergonomic performance and adapt the patterns to improve the fit.

Chapter 6

Conclusions and recommendations

6.1 Introduction

This study applied a user-centred clothing design paradigm to develop a practical solution for the fundamental problem of Muslim and other modest dressing females who enjoy running– MAS that achieves the expected aesthetic, modest and sports performance requirements. Furthermore, I accomplished the goal to collaborate with the end-users, religious experts, and industry experts to ensure that those with appropriate knowledge could be part of the design process. I used the theoretical guidance from literature and the data from the investigations as a basis and augmented the design by using contemporary technologies to design the improved MAS.

For an overall perspective of the research, I colour-coded the information to convey how the data contributed to the development of 3D prototypes and how it contributes to existing literature (figure. 6.1). I identified four distinct areas in the process, namely: the review of literature, insight, design concept, and new literature.

The literature review consists of four main sections: modest wear, user-centred design, sportswear, and 3D design to provide a theoretical basis for the study. After establishing the theoretical basis, the insight section utilised the concepts in literature to extract primary data from the interviews, the focus group, textiles testing and knowledge from industry experts. Finally, the design concept depicts how I incorporated the preliminary data into the final design of MAS. The feedback from the primary sources is compared to and builds onto existing literature. I used a mixed-method approach which has aided me throughout the research process, and based on the information extracted, I made various conclusions.

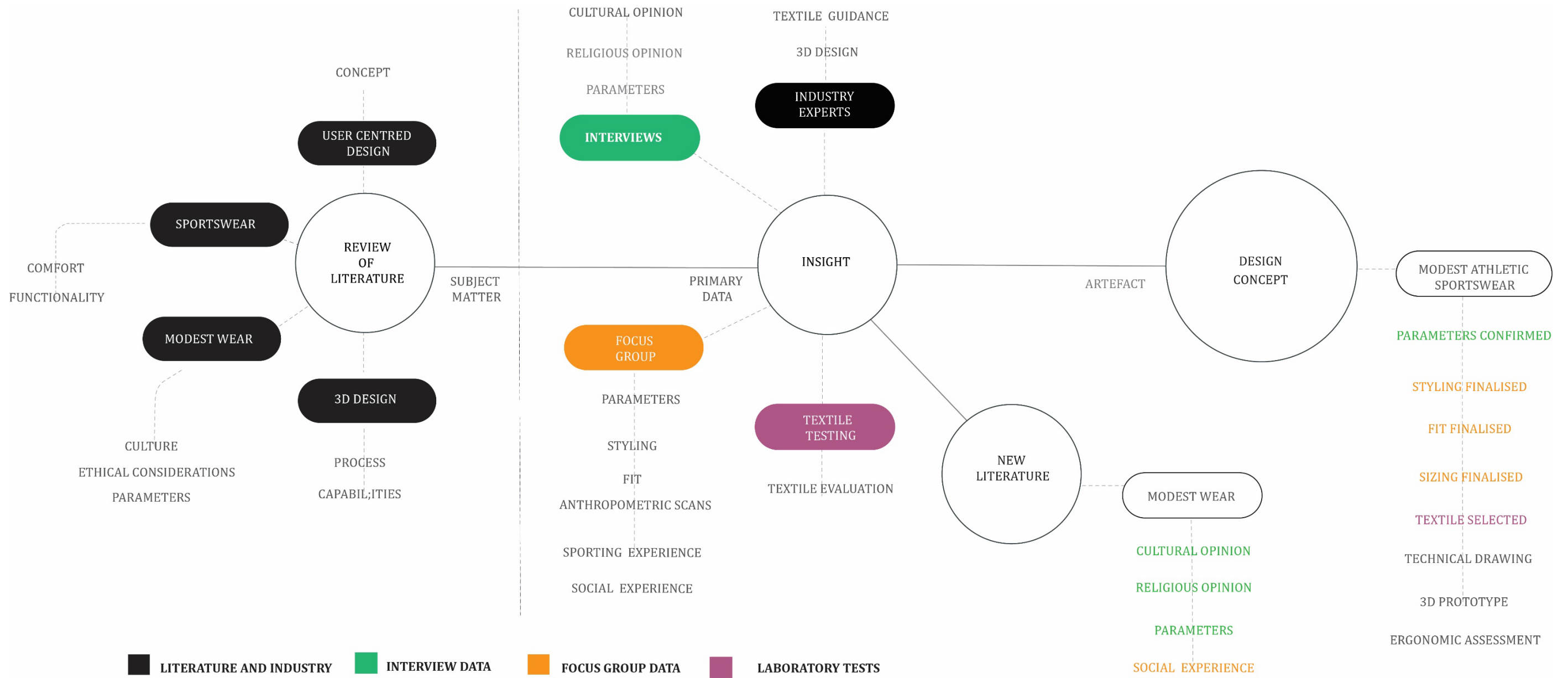


Figure 6. 1 A synopsis of the research process and phases (Authour, 2020)

6.2 Conclusions

In this section, I will start by grouping the conclusions according to the three secondary questions that aim to answer the central question: **How can sports fashion be designed for Muslim women athletes guided by Islamic norms in Cape Town to improve comfort and performance?** After the conclusions on the three secondary questions, I will provide general conclusions.

6.2.1 First secondary question. -What are the current parameters of modest dressing for Muslim Women in Cape Town?

The essential criteria for the hijab are that it should cover the whole body except the face, the hands, the feet and should not be form-fitting or transparent. Moreover, the hijab for women should be feminine and not emulate the dress code for men (Bhuiyan, 2018). Other than these parameters, there is no further stipulated styling for the hijab.

The evidence shows that some successful, educated, professional women, educated in Islamic jurisprudence, do not define their dress as western or eastern, traditional, or modern. Instead, they described their clothing in terms of expression. Moreover, they did not ascribe to dressing in the dark, monotonous attire as “women from Saudi Arabia”. In addition, the looseness of the hijab is flexible as long as garments are not figure-tight, reveal the shape of the body or is transparent. Hijab styling is an individual expression. Therefore, there is a demand for fashionable and conservative styling if designs fulfil the essential criteria. Just like mainstream fashion-conscious women based their dress on colours, textures, aesthetics, and according to their moods, so do women who wear hijab(El-Bassiouny, 2018).

The preoccupation with the religious and political meanings of Islamic dress has concealed the importance of fashion in the lives of modern Muslim women. (El-Bassiouny, 2018; Hassan & Harun, 2016). If one compares discussions in media on religion and politics or the infamous reputation of hijab and juxtapose it to what is evolving on runways and what is present in social media, the perceptions are

contradictory. The research shows that some Muslim women wear the hijab to make a statement about their liberties around dressing modestly and have pushed cultural boundaries to make modest dressing a sign of Islamic cosmopolitanism.

The data showed that athletes agreed to the basic parameters for the hijab but wanted to style the hijab to be more practical, functional, and utility-focussed to accommodate their sporting activities. These are directives that large sports brands should heed if they aim to make any substantial inroads into the MAS market.

In summary, the hijab has a few basic guidelines to cover the whole body, except the face, hands and feet. The hijab should not reveal an exaggerated figure or be transparent. Different women have different degrees of modest dressing. As mentioned by our experts, various factors affect the way women dress or cover themselves.

6.2.2 Second secondary question - How do a growing group of female Cape Town Muslim athletes participating in road running experience the Islamic prescribed sportswear (MAS) when they are competitive?

Through experiences that participants had whilst wearing the hijab during running events, the research shows a definite negative perception of the hijab in South Africa. Women in the focus group experienced resentment for wearing the hijab and shared personal stories about other athletes commenting on the absurdness of wearing MAS during running. As is shown in figure 5.1, Muslim women athletes want to appear to be professional and perform well in their sports. The way to overcome negative perceptions would be to perform well, which is facilitated by fit-for-purpose MAS.

The information extracted in terms of physical and physiological discomfort confirmed that sourcing appropriate MAS was difficult. The study revealed that Muslim women in Cape Town believe that mainstream retailers do not adequately supply modest athletic sportswear that performs the protective function that technical clothing should achieve. In addition, their experiences are that retailers do not provide a full hijab that adheres to the basic parameters stipulated by Islam. Thus, retailers have a growth opportunity if they invest in developing fully compliant hijab that allows Muslim women to perform better,

100

decrease discomfort, and provide appropriate physiological support. Establish brands such as Nike and Adidas cater to Muslim women, but their perception of hijab criteria is incorrect. They currently supply mainly headscarves; however, they need to revise their product lines and develop new size and fit specifications that accommodate all the parameters stipulated.

I found that even though the Islamic goods market has grown significantly, the stigma of hijab has resulted in a global deficit of professionally designed MAS (Chrisafis, 2019). Therefore, Muslim women athletes have improvised by combining men's and women's sports clothing in layered ensembles to achieve sports functionality and hijab requirements. The athletes also wear hats to protect themselves from the sun and have extra gear for carrying keys, snacks and water. In addition, the athletes chose clothing based on price and not on actual performance and functionality, meaning that they are disadvantaged during competitions as their clothing is cumbersome and uncomfortable.

6.2.3 Third secondary question- How can the current products and processes to avail sports clothing to women athletes be designed and manufactured to become more comfortable and performance optimal?

The key messages on sports clothing in the literature mentioned in section 2.4 suggest that garments need to be functional, ergonomic, comfortable, consider health and safety, and improve the experience (Wang, 2015; Yazid, 2016; Kurniawan, 2017). In addition, Gupta (2011) highlighted reducing fatigue, ergonomic design, minimum inhibitory, and maximising comfort and performance.

The research determined that current products worn by Muslim women athletes were of poor design due to the incorrect application of “moisture management” or quick-drying fabrics. Quick-drying fabrics, to perform effectively, need contact with the skin to draw moisture away from the body to the surface of the textile (Troynikov & Wardiningsih, 2011). Warm weather sports textiles contain polyester, a plastic-based synthetic fibre. Polyester fabric tends to trap moisture when incorporated in oversized, layered clothing,

as the participants use. Therefore, the literature suggests a reduction of clothing layers. Unless interwoven, there should only be one layer of fabric to allow skin contact with the fabric. In doing so, moisture will disperse on the fabric surface and enable the material to dry quickly. Currently, the athletes are wearing multiple layers, which prevents the sweat from reaching the outer layer. In addition, appropriately positioned venting located according to the female's sweat regions will improve air access and drying (Smith & Havenith, 2012).

The data highlights that due to a lack of appropriate clothing for Muslim women. As a result, they wear men's clothing to fulfil hijab requirements. The study, therefore, suggests that designers develop patterns that suit the female body shape but without being fitted. This revision of pattern shaping would reduce the fabric bulk and improve comfort. Bulk is a hinderance during the repetitive motion and causes chafing and moisture retention.

The research shows that technologies like 3D body scanners are accurate at taking measurements. In addition, CLO3D has proven to be precise compared to the consequent physical prototypes produced with the software (Wang & Liu, 2020).

6.3 General conclusions

Due to the stigma experienced by athletes about wearing hijab, I extensively investigated the infamous reputation of Islam and the hijab. The research found that Muslim countries have been progressive regarding women's roles in their societies. For example, Muslim majority countries like Indonesia and Bangladesh have elected women presidents before America. In addition, I found that a Muslim woman has established the first university in history (Talbi, 2020) - Islam instructs and rewards each Muslim to search for and share knowledge. However, some attribute oppression or regression to Islam. Oppression and regression originate from other cultural influences and sometimes political agendas (Abu-Lughod, 2013). The world as we know it has a normalised patriarchal ideology that exists in most religious and secular cultures. Still, society or media is more likely to highlight it in an Islamic setting. For example, even though the oppressiveness may originate from Indian or Arabic norms, norms that were present before the advent of

Islam, the inherent patriarchal culture is ignored and attributed to the religion. I specifically looked at Islam's reputation as a religion that fundamentally oppresses women and found that the stereotypical view that Muslim women are helpless and oppressed is unfounded. Abu-Lughod (2013), Esposito (2015) and Goodwin, (2016) are all opposed to this perception of Islam and Muslim women, and their sentiments are confirmed through my primary research in the interviews and focus group. The media has stereotyped the behaviour of approximately 1.7 billion people, which is illogical because human beings are experientially unique and cannot be stereotyped even if they are from the same faith. Human beings are different from each other; they are also different from themselves on various days and periods in their lives. The psychological makeup and their lived experiences are never exactly alike. Therefore, designing the hijab is ethical as its reputation as a tool of oppression is disproven by research.

6.4 Recommendations

Garments produced virtually cannot assess comfort aspects such as skin sensory and thermal comfort and require wearer trials or other instruments. Future studies should include the verification of performance of 3D generated virtual prototypes versus the real-world samples. The research is applied and advocates for a scientific methodological approach in fashion design that is user-centred, technically supported by different expertise, and empirical evidence to support the design choices.

Fashion universities should implement programmes that teach students how to utilise a multi-disciplinary / industrial approach to develop innovative functional products instead of clothing solely for aesthetic purposes. A limited number of large retailers dominate the fast-fashion market. They produce new aesthetically-focused fashion weekly and offer customers a wide variety of choices. Fast fashion floods the market, and the world is overflowing with discarded clothing that pollutes the environment. When one develops user-centred apparel to serve a specific purpose, the clothing becomes more valuable and purposeful. Functional clothing warrants a more expensive price, as it offers protection or improves the user's life in some way or another.

I recommend more studies into developing natural fibre moisture management textiles that can compete with their synthetic counterparts. Such research can lead to more comfortable MAS and reduce “plastic” fibre pollution in water bodies.

Utilising modern technologies such as 3D design programmes have been proven to be accurate (Hou, 2018). Such technologies have the potential to reduce wastage due to the elimination of inputs required to develop virtual prototypes. In addition, virtual prototypes can be assessed by customers before mass production. Retailers can gauge whether products will sell successfully and only produce products that are in demand.

The research by Smith & Havenith (2012) highlighting female sweat regions indicate that user-centred design can be extremely focussed even to the point of being anatomy-specific. Functional clothing can be designed to work in harmony with the body and if one combine’s multidisciplinary knowledge with technology there may be an opportunity to develop textiles that become biologically compatible to the human body.

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Appendices

Appendix A: Consent form

FOCUS GROUP FOR MUSLIM FEMALE ATHLETES

Study Title : A user-centred approach to modest sportswear design for Cape Town Muslim women

Investigator Mr Rushdeen Rose

Name of the Institution Cape Peninsula University of Technology (Cape Town Campus).

Supervisor Dr. Elsabe Pepler (Cape Peninsula University of Technology)

Co Supervisor Dr. Alettia Chisin (Cape Peninsula University of Technology)

Mr Rose is an M Tech candidate studying technical clothing design

Contribution of the study

- The research offers a unique perspective on the impact of culture on sports clothing in Cape Town. It also conveys the importance of cultural consideration in design by investigating the perceived-value associated with the modest dressing in Islam.
- More women may consider healthier lifestyles and participate in sport if comfortable MAS clothing is available to them as the redesigned products improve comfort and experiences of women during sport.
- The redesigned products may improve competitiveness due its improved performance.
- The research will attempt to balance modesty and sportiness. In other words, it will fill a market gap by presenting a solution for women who want to dress modestly whilst at the same time appear to be serious sportswomen. The garments will have a modest and sportswear appearance.

- It will define the criteria for testing comfort in MAS which is a unique situation. Modest clothing characteristics are opposite to the logical design of regular sports clothing.
- It will establish a technical product design method and use an adapted functional design technique the area of Fashion Design.

The study supervisors and other appropriate authorities at the Cape Peninsula University of Technology (CPUT), in the Western Cape Province, have approved the study and its procedures.

The study procedures involve no foreseeable risk or harm to you. The procedures include:

Participation in an interviews conducted by Rushdeen Rose with the aim of collecting information that will be used in the study.

Participation in this study will take approximately 180 minutes of your time.

Please feel free to ask any questions about the study or about being a participant/subject and you may call Rushdeen Rose via the following information:

Contact Details

Office Tel Number : 021 – 959 8441
 Mobile Number : 082 574 7859
 Email Address : roser@cput.ac.za

The study data will be coded so they will not be linked to your name. Your identity will not be revealed while the study is being conducted or when the study is reported or published unless you give explicit consent for the same. To ensure anonymity and confidentiality, all study data will be collected by Mr Rose, stored in a secure place, and not shared with any other person without your permission.

Rushdeen Rose Date

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| Ref | MFA | 0 | 0 | 1 |
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I have read this consent form and voluntarily consent to participate in the study:

Name of Participant/Informant

Signature of Participant/Informant

Date.....

I have explained this study to the above subject and have sought his/her understanding for informed consent:

Signature of Investigator.....

Date.....

Rushdeen Rose_ Date

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Appendix B: Interview questions for Muslim and hijab experts and leaders

1. What do you consider, for yourself, to be the parameters for modest dressing in Islam? (head, body, fit, colours, prints, materials, etc.)
2. How does your clothing affect the way you perceive your righteousness, and has that perception, if at all, been influenced by cultural, religious or societal norms?
3. As a prominent Muslim female figure, what is your understanding of sports/fitness and its significance in Islam?
4. What would you say to those who identify hijab as a form of oppression by Muslim men over Muslim women?
5. Would you like to comment on anything not covered by the previous questions?

Appendix C: Focus group questions and transcription

Who here has been on Hadj or Umrah?

Who in this group runs wearing hijab?

Everyone

With the type of clothing that you are currently running in, have any of you had comments from Muslim or non-Muslim with regards to your appearance?

Yes all enc

Where do you purchase your clothing?

Do you feel that the clothing you wear is comfortable enough?

What do you feel can be improved in your sportswear clothing?

What is hijab and what does hijab symbolise to you?

What makes you cover up on a hot day and why is it important to you?

Participant: besides that when we buy something at the shop, it looks good on the hanger but it might not look good on you so if you there you can see.

Rushdeen: So I want to take it to the next level. That is what I want to do with design. I want to use really highly technical stuff to design products for the end-user. What is happening nowadays is that you have a designer sitting somewhere in the office. And they say you know the Muslim people, we want to target them, lets design something for them. But I don't believe that you can do it that way. I believe that it must be the other way around. Muslim people must decide what they want designed. Because it is a religious thing, it's not a commercial thing. Even though it sell to each other as Muslims. I don't believe that that people who are not Muslims should be deigning things that are Halal and Shariah compliant. Etc. We need to take that stance and say let's start, so that is one of the motivations as well., So yes it is design but I think we can also include Islam and we can also be beneficial. So Insha'Allah, everything will go according to plan and we'll begin the starting process of developing highly technical clothing.

So. Afew ground rules. The phone on silent. It can ring and buzz, you can go outside because I am recording, so if you want to take a call, feel free to walk outside its fine. Take the call it does not matter. There's no wrong answers, everybody's answers

count. And will be counted them and we will consider all of them.. And the also everyone has different perspectives of what hijab is. And it is up to each individual to decide what their form of hijab is and we respect all of that. So it's not a form of judgement. All that I'm going to do here today id to find out how are you experiencing the clothing that your running in.

Presentation starts.

My topic is the Design of sustainable athletic clothing for Cape Town Muslim Women who are guided by Islamic laws and norms. The reason why it says Cape Town Muslim women is because I have access to all of the people that are here today. Secondly, from a weather perspective, we can't, we have to look at Cape Town's weather, you know what I'm saying? It can get really hot here while you are running with clothing like that. So we are going to try to find or move in the direction of finding a solution for running in that type of weather with the clothing that we are supposed to wear.

I just want to know, before we I talk about that. Can we just, everybody just introduces themselves, the club that they run for and the longest distance, if that is ok?

Rihanna, Ommidraai, 42 km

Suraya, Ommidraai, 21 km

Zulfa, Ommidraai, 42km

Shamila, Ommidraai, 42km

Rukshana, Ommidraai, 42km

Waseema, Ommidraai 42.2 km

Zayida Manual, Ommidraai, Comrades, 89km

Gadija, Ommidraai, 21km

Nureen ARD, 21km

Musharafah Majiet, Ommidraai, 89km

Mariam, Ommidraai, 42km

Roshana, Iteko, 42km

Nadeema, Ommidraai, 30km

Ashia, ARD, 42km

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| <p>Rushdeen; So we have dedicated people who are going to give me very valuable input, so shukran to all of you.</p> <p>So I've already, I've come to this slide now. I just want to make sure, there we have a cap, we have a scarf, we have like a pants, we have a skirt and we have a long top, that I got from Aisha.</p> <p>Laughing and chattering.</p> <p>I want to clarify something. The heading that says current design. Am I right in saying, because I assumed that, you are taking moisture management fabric, which is the fabric at the bottom and you are putting it into a modest look.</p> <p>Participants agreed.</p> <p>Let's start with the questions.</p> <p>Rushdeen explains hand voting using thumbs.</p> <p>Has anyone been on hajj or Umrah?</p> <p>12 up</p> <p>2 down</p> <p>Next question</p> <p>Who is dedicated to running in Hijab:</p> <p>14up</p> <p>Other question. I got a comment on the WhatsApp. Someone commented on them about what they wearing and how can they run such a long distance with the type of clothing that they're wearing? How many of you have had that comment before?</p> <p>Participant a: all the time (echoed sentiments) When I was running the comrades and was wearing my Burkah and everybody, you know who asked me, paraphrased the white people asked me....</p> <p>Participant b: I find that the Muslim people actually ask me.</p> <p>Participant a: but for me it was that</p> <p>Musharraf: I've been asked by old white men, they always ask, why are you running.. aren't you getting hot?</p> | <p>Participants wear Hijab even when they feel and are judged by others</p> |
|--|---|

Aisha: even with me, just before the finish line so I was already in my chops, then this two white ladies running next to me saying, take off this thing man, take off this thing. It was just like, I am suffering, it's me, it's not you.

Waseela; I was approached by white people and coloured people.

Recording cuts out.

Participant; I run in a tights and a shorts. I was spraying my legs and then some people asked me how can you run in all that clothes? That's what makes me just feel comfortable, no judgement. I just feel like I can't run in a tights because my shape of my leg is showing. That's me, my personal think, so people always ask like how do I manage to run in all the clothing.

Rushdeen: Next question, let me see. Ok if we can go around the table just to say where do they get their clothing from, their running clothing that they're currently wearing. I know it's going to be a combination, right, but I just, I just want to see maybe, from, from the main retailers and if you do have also the...so you just say one of the main retailers that you get it from and then if you do custom made stuff, then you say where you have it custom made and from this retailer so if we can go around.

{Laughing}

Participant: When there is a sale {Laughing}

Rushdeen: Ja, so whoever has a sale.

Participant Mr. Price Sports...

Rushdeen: Ok.

Participants: Custom made, ya, custom made.

Rushdeen: Ok custom made ok...but there's no science that goes into it, like it hasn't been researched, it hasn't, nobody actually tests on it.

Participants cross talking: No!

Participant: I am making these skirts that I run in and a lot of women, when I made it like pleat, like no, give me a skirt that actually just fits nicely so that...

Participant We also want to look nice.

Participant: Yes, yes

Participant: You want to basically look like a professional sportsman but like longer.

{Participants cross talking}...

No retailers are currently catering for Muslim women and therefore they have to buy what is available, on sale or have someone make it for them.

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| <p>Participant: Standing out or been really different, very different. You don't want to look weird, it's just when you running...</p> <p>Rushdeen: Ok so, so that's interesting comment from Nureen, just want hands around the table, few thumbs up who thinks that their, their clothing should be more feminine? In the way you feel and the way...</p> <p>Participant: I think more modern...</p> <p>Participants cross talking: Modern, Hijab.</p> <p>Rushdeen: More contemporary. Ok but I'm not saying tight, I'm saying maybe...</p> <p>{Participants cross talking}...</p> <p>Participants: it's feminine</p> <p>Rushdeen: In other words, you want to have something that is different to what men cause a man will probably have the same thing but in a shorter version or a tighter version.</p> <p>Participant: We like to match and it must look like girly.</p> <p>{Participants cross talking}...</p> <p>Participant: Like you get the running t-shirts for example, the race t-shirt, then you get the ladies fit – got a cut in it, like it's shapelier, whereas the men's one is just like that!</p> <p>Rushdeen: So who all agrees with that?</p> <p>Participant: I go for the mens t-shirt always.</p> <p>Rushdeen: Bigger and looser ...</p> <p>Participant: Because the ladies one has got a shape.</p> <p>Participant: I don't mind the shape but it must be a little longer.</p> <p>Participant: A very small make & it shows everything.</p> <p>{Participants cross talking} ...</p> <p>Participants discussing that lady's t-shirt is too short even if they take a bigger size, preference for length. So take a man's cut due to length. Sleeve of the ladies is shorter.</p> <p>Rushden: So you basically want a lady's shape but looser fit and longer, over the bums.</p> | <p>Athletes agree that they want to look professional and appropriate.</p> <p>Athletes agree that clothing need to look more modern and feminine.</p> |
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| <p>Participants: Agreement that there is too much clothing , too many layers.</p> <p>Participant: Can you imagine you get a lady’s long top, nice fit, length... everything, and it’s got the holes here, just for extra breathing, no I’m being serious!</p> <p>Participant: So when you say long does it mean you’re not going to wear a skirt?</p> <p>Participant: If I don’t want to wear a skirt then it’s a PLUS!!!</p> <p>Participant: Some women choose to wear a long sleeveless vest under their t-shirt so it sticks out and covers their buttocks – then they don’t wear a skirt.</p> <p>Rushdeen: Commented on participants all talking at the same time and trying to get a recording...</p> <p>Participants: Apologetic...</p> <p>Rushdeen: I do have something planned on there as well that we can maybe look at, which will guide us more in the decisions we are making. I’m going to ask this question: Do you feel like sportswomen when you wear your clothing that you run in?</p> <p>Soraya: We went for a run and we all had our hijab and our caps, we felt like sportswomen. We did a few laps around the track.</p> <p>Rushdeen: Everybody agree with that?</p> <p>Participants: Yes!!</p> <p>Aisha: I feel like your body goes through changes, your muscles getting lekker, so your body feels that way, when you running, it boosts you.</p> <p>Nadeema: I cycle as well so that’s a bit more challenging, skirt may go up and leg opens and you’re on the bike, what can you do???</p> <p>Rushdeen: Ok! We already had the femininity question, we had the fit question, tops must be a bit longer, etc...must have a female shape and I will add the material aspect because I’ve actually done my research on that to test moisture management, air permeability which means breathability, as you guys would call it. I’ve done all of that and I’ve also studied where the sweat zones are of male and female, so there are different sweat zones and I’ve gone through that as well! The materials that I use will be strategically placed on the garment when I design it.</p> <p>Nadeema: Have you taken into consideration menopause?</p> <p>Rushdeen: That will be a bit out of my research topic. That can be something that I can look at in the future but at the moment it’s just runners/running.</p> | <p>A tailored shape but looser fit and a longer length.</p> <p>Sleeves too short</p> <p>Too many layers with current clothing.</p> <p>Asking for clothing with more ventilation.</p> <p>Would like to eliminate the skirt.</p> |
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Participant: Commented on hot flushes (Menopause). You start to get used to it. I manage it with my hijab, a state of mind... you doing this for the creator.

Wasiela: If you do any sports, you don't feel it, it's like your menopause is not at a high state at that moment, it depends what you eat as well. Your diet is very important!

(cross talking)

Rushdeen: I heard a comment that you are doing this for Allah SWT, ok I just want to take note of that statement...before I started on this I did an interview with 2 prominent women in South Africa, in Islam. One is Doctor Quraisha Suliman and the other one was Doctor Fatima Hendriks of Medina Institute. They are very vocal Muslim activists so they are... both of them have PHD'S, both of them have... extremely high educated. I'm bringing in an aspect of from someone who has much education...why they wear Hijab, because there is a narrative that goes out there that says Muslim women are forced by Muslim men to wear what they wear. I think we need to clarify that.

Continues with presentation

Rushdeen: WHY I'M DOING THIS?

I want to improve comfort in modest athletic sportswear, I want to improve your sports experience, I want to enable health (I want people to feel motivated to run i.e. the type of clothing).

ISLAMIC BUSINESS SUSTAINABILITY...That is very important!!! Look at the graph on the right hand side:

ISLAMIC GROWTH FORECAST...By the year 2050 we are going to be the biggest religion in the world, we are going to overtake Christianity!

On the one hand it's been said to us you can't wear hijab, in France they want to close a business there, Decathlon, they want to chase Muslims out of their country, etc...but if you look at the products that they bring out, they cater for Muslims because we are the fastest growing. So on the one hand they say don't do that but we are going to supply you with products! It's very controversial, so we need to take charge of that!

The other reason is that this is a different design process that we're going through, through a technical design process. In other words, take it from the end user, take it to the front & then use all the technologies available to us to try and design something that is better than what Nike and Adidas, or whoever can produce, it won't happen with this research because this is only a Masters, maybe I will do it in my next level...Doctorate, when I try to become a Doctor in what I'm doing! This is just the foundation I'm laying here and its user-centred. It's around you, you are deciding what's going to come out of it, telling me if it works or doesn't work.

Other MAS sports application-cycling

The next one...I want people to vote on this:

HEADWEAR:

- H1= 0
- H2 = 1 (Nureen)
- H3 = 11
- H4 = 7
- H5 = 0
- H6=0

Extra comments/ notes during vote

Products on screen named by participants as:

- H1- Just Kappie
- H2- All in one
- H3- Loose Ninja
- H4- Tight Ninja
- H5- Normal Scarf = 0
- H6- 2 Piece (A kappie with a scarf) - (No thumbs up)

Rushana: I used to run in H1, I changed over to wear the Nike Hijab, the Nike Hijab is much hotter than the kappie, the kappie was cooler, however either/or didn't affect my running or times.

Rushdeen: So your h/w even though it does add a bit of heat and discomfort, it still allows you to achieve the same thing. But if we can do something that allows current h/w to be better, it will be a better option.

Musharafah: I used to run with H1, since 2007 right until 2014. Then I switched over to H4. The Ninja and the cap is too hot.

{Thumbs up in process with some debating.}

Rushdeen: Let's do this with a vote

Voting twice allowed

Participants debating and chatting: H3 is a normal burka

Participants debating and chatting: H4 is like the Nike one

Participants debating and negotiating: One participant says that she had the Nike one but had it converted to H4- loser top and a tighter neck- not too long

H3 – loose ninja style chosen for design

Rushana: Doesn't agree about the tighter neck as she wants more wind to penetrate the neck area.

Rushdeen: What if there is a bit of venting material in the neck area?

Rushana: yes, a lot of people get hot, so they wet their burkas- which is not a good thing because you can get sick but they need to wet it so they can be cool. So we need something cool – very impressed with the Nike fabric

Rushdeen: Vests, this is purely about the vests we are talking about now

VESTS:

- V1= 0
- V2= 0

Extra comments/ notes during vote

Agreed by everyone only length fine but loser fitting

TOP LENGTH: (20;23)

- TL1 =0
- TL2 =4
- TL3 --1

Extra comments/ notes during vote

Ok with a skirt or along vest but not on its own

When you're running it's still going to pull

Long vest – not a skirt that pushes on the bladder whilst running

Length between TL2 and TL3

Just above knee –TL 2 6 cm longer

PANT LEG

- PL1=7
- PL2=7
- PL3=8
- PL4=4

Extra comments/ notes during vote

Suggests looser head covering with tighter neck but with venting.

| | |
|--|---|
| <p>Participant (Rushana)- PL1 is a pair of tights, they say compression is good for running</p> <p>Skirt is attached to pants</p> <p>COMMERCIAL SAMPLES</p> <p>C1= 0 (No for general look)</p> <ul style="list-style-type: none"> • C2= 1 • C3=0 • C4= 0 • C5= 0 • C6= 0 • C7= 0 • C8= 9 <p>Overwhelming like as a look but for a younger age (16-30)</p> <p>Extra comments/ notes during vote</p> <p>Nureen & Rushana will cap, too tight around the head</p> <p>No tights on bottom of foot</p> <p>A one piece will be nice for running but for the option when you get free t shirts the skirt attached to the pants (C9) will be good.</p> <p>Sleeves</p> <p>Who prefers a long top to the attached shirt (7)</p> <p>Must I add a stretch fabric to the long top? Yes</p> <p>Add a pocket</p> <p>Participants discussions:</p> <p>Very important pockets</p> <p>Long top pocket on the side/ not too low with zip, where there is no mobility</p> <p>Musharafah has a pocket in the skirt- Keys , tissues, dates-</p> <p>Zulfa has a pants from Mr Price with narrow long pockets</p> <p>Pocket on the bottom is nice as it doesn't move</p> | <p>None chosen</p> <p>Do not want a skirt.</p> <p>6 cm longer than TL2 just above knee.</p> <p>Most requested PL3</p> |
|--|---|

| | |
|---|--|
| <p>Pockets are comfortable long/ narrow pocket</p> <p>Someone feels a patch pocket is better than a side seam pocket</p> <p>Pocket placement on side of long top sleeve pocket 6</p> <p>Pocket on front 5</p> <p>6:30 time</p> <p>Every 5 km – when they change</p> <p>Unrelated talking</p> <p>Sweating is dependent on the individual</p> <p>Focus group ends</p> | <p>One piece skirt tights is</p> <p>Requests pockets</p> <p>Reachable pocket- keys, tissues, dates</p> <p>Patch pocket</p> <p>Suggestion for pocket sleeve</p> <p>Suggestion for pocket on the front</p> |
|---|--|

Appendix D: Body scanning measurements and images

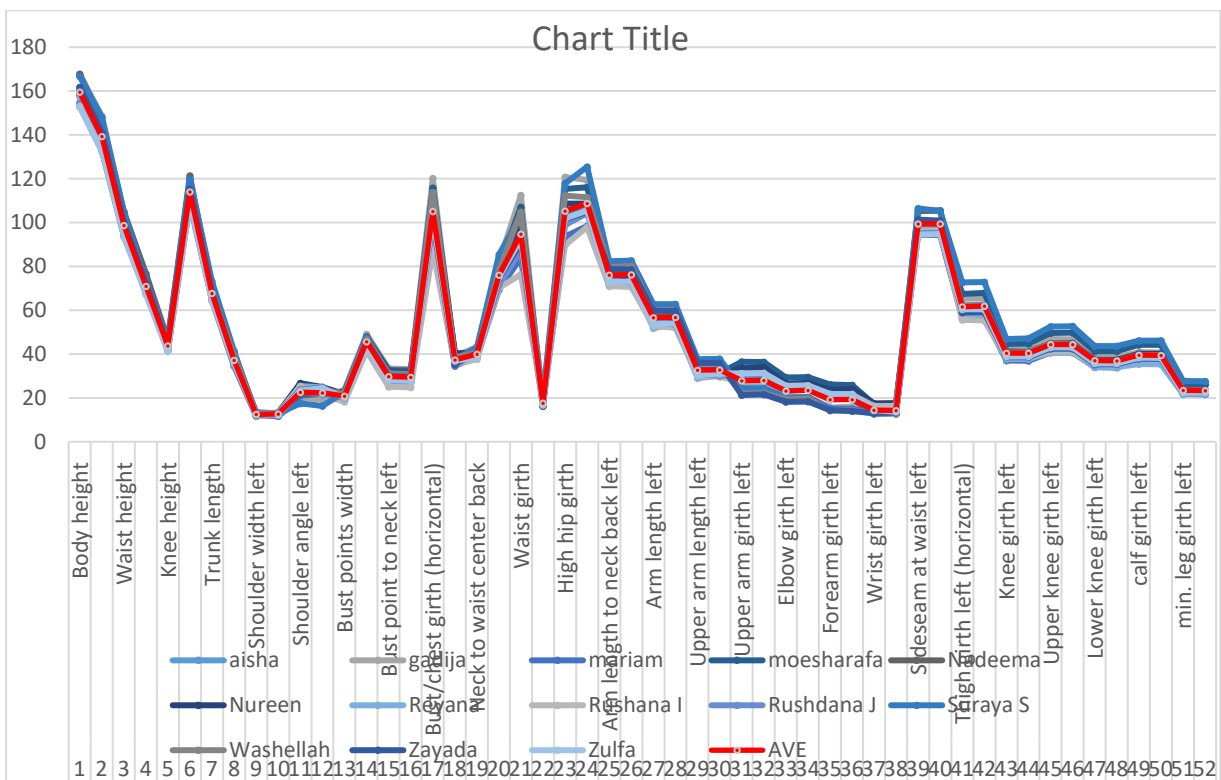
Table:

| | | A | B | C | D | E | F | G | H | I | J | K | L | M | Median |
|----|-------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|--------|
| 1 | Body height | 160,5 | 167,6 | 153,1 | 158,1 | 167,8 | 160,1 | 157,5 | 154,8 | 154,7 | 166,8 | 159,4 | 161,8 | 153 | 159,6 |
| 2 | Cervical height | 140,3 | 148,6 | 132,8 | 138,6 | 146,5 | 139,1 | 136 | 133,5 | 133,9 | 148,1 | 139,8 | 141 | 132,8 | 139,3 |
| 3 | Waist height | 99,7 | 105 | 93,8 | 98,6 | 104,8 | 97,9 | 96,9 | 95,3 | 94,7 | 104,2 | 98,6 | 99,9 | 94,1 | 98,7 |
| 4 | Crotch height | 71,4 | 75,8 | 67,8 | 70,1 | 76,7 | 70,3 | 70,2 | 68,8 | 68,3 | 73,3 | 70,4 | 72,2 | 67,2 | 71,0 |
| 5 | Knee height | 43,8 | 47 | 41,6 | 44,7 | 46,3 | 43,9 | 43,1 | 42,1 | 41,8 | 45,6 | 44 | 44 | 41,5 | 43,8 |
| 6 | Breast height | 115,3 | 119,8 | 108,7 | 112,7 | 121,4 | 113,5 | 112,3 | 111,9 | 110,2 | 119,9 | 113,1 | 115,4 | 109,1 | 114,1 |
| 7 | Trunk length | 68,3 | 71,6 | 64,5 | 67,7 | 69,7 | 68,3 | 66 | 64,4 | 65,3 | 73,1 | 68,5 | 68,3 | 65 | 67,7 |
| 8 | Mid neck girth | 36 | 40,9 | 34,6 | 40,1 | 36,5 | 38,2 | 37,1 | 34,7 | 34,6 | 41,3 | 39,1 | 35,9 | 35,9 | 37,3 |
| 9 | Shoulder width left | 12,4 | 12,4 | 12 | 13,4 | 12,8 | 12,8 | 12,9 | 11,5 | 12,3 | 12,1 | 12,8 | 12,4 | 12,6 | 12,5 |
| 10 | Shoulder width right | 11,7 | 13 | 11,8 | 13 | 13,1 | 13,3 | 13,1 | 12,6 | 13 | 12,8 | 12,8 | 12,3 | 12,3 | 12,7 |
| 11 | Shoulder angle left | 19,4 | 20,1 | 21 | 21,7 | 22,3 | 26,7 | 25,4 | 25,3 | 23,6 | 17,5 | 23,2 | 23,7 | 23,3 | 22,6 |
| 12 | Shoulder angle right | 22,2 | 19,3 | 21,9 | 22,6 | 21,9 | 25 | 24,8 | 21,5 | 21,5 | 16,3 | 23,7 | 24,7 | 24,5 | 22,3 |
| 13 | Bust points width | 20,2 | 23,8 | 19,3 | 22,7 | 21,6 | 21,7 | 19 | 18,3 | 20,2 | 22,6 | 22 | 20,2 | 20,1 | 20,9 |
| 14 | Neck right to waist over bust | 45 | 49,1 | 42,9 | 47,9 | 47,9 | 47,8 | 43,5 | 41,4 | 44,9 | 47,6 | 46,7 | 45,9 | 43,6 | 45,7 |
| 15 | Bust point to neck left | 28,8 | 33,5 | 27,7 | 32,7 | 30,8 | 31,7 | 27,9 | 25,1 | 29 | 31 | 31,3 | 29,9 | 28,3 | 29,8 |
| 16 | Bust point to neck right | 28,5 | 33,2 | 27,3 | 32,5 | 30,4 | 31,4 | 27,8 | 24,8 | 28,7 | 30,6 | 31 | 29,6 | 28 | 29,5 |

| | | | | | | | | | | | | | | | |
|----|-------------------------------|-------|-------|------|-------|-------|-------|-------|------|-------|-------|-------|-------|-------|-------|
| 17 | Bust/chest girth (horizontal) | 101,6 | 120,2 | 95,4 | 115,8 | 106,8 | 111,4 | 95,2 | 87,4 | 100,2 | 113,9 | 113,6 | 102,4 | 102,9 | 105,1 |
| 18 | Across Back Width | 35 | 39,1 | 34,6 | 40,5 | 37,8 | 40,3 | 38,1 | 35,3 | 36,4 | 37,6 | 38,5 | 35,4 | 37 | 37,4 |
| 19 | Neck to waist center back | 39,8 | 43,2 | 38,7 | 39,2 | 41,1 | 40,7 | 38,7 | 37,7 | 38,8 | 43,1 | 40,7 | 40,4 | 38,4 | 40,0 |
| 20 | Crotch length | 76,6 | 82 | 69,5 | 80,3 | 76,3 | 76,4 | 72,2 | 70,3 | 71,9 | 85,4 | 78,3 | 74,8 | 75,2 | 76,1 |
| 21 | Waist girth | 89,6 | 112,5 | 84 | 107,1 | 93,1 | 101,1 | 88,4 | 76,4 | 87,5 | 103,2 | 104,9 | 90,7 | 92,6 | 94,7 |
| 22 | Waist to buttock height right | 18,6 | 17,1 | 16,7 | 16,3 | 19 | 16,4 | 17,2 | 18,8 | 17,6 | 19,7 | 16,6 | 18,1 | 16,9 | 17,6 |
| 23 | High hip girth | 102 | 120,8 | 93,6 | 115,4 | 104,8 | 108,6 | 100,3 | 89,7 | 98,8 | 117,9 | 112,3 | 101,7 | 101,9 | 105,2 |
| 24 | Buttock girth | 107,7 | 119,5 | 98,4 | 116,1 | 108,7 | 108,7 | 106 | 98 | 104,3 | 125,4 | 111,5 | 104,8 | 105,5 | 108,8 |
| 25 | Arm length to neck back left | 76,7 | 81,2 | 71,9 | 77,3 | 77 | 74,6 | 71,5 | 70,9 | 73,8 | 82,3 | 79,8 | 78,8 | 72,9 | 76,1 |
| 26 | Arm length to neck back right | 77 | 81,2 | 72,5 | 77,6 | 77,1 | 74,8 | 73,5 | 70,7 | 72,7 | 82,7 | 80,1 | 78,6 | 73 | 76,3 |
| 27 | Arm length left | 57,8 | 61,3 | 53,6 | 56,5 | 57,6 | 54,7 | 51,9 | 52,9 | 55,1 | 62,8 | 59,8 | 59,8 | 53,6 | 56,7 |
| 28 | Arm length right | 58,6 | 60,7 | 54,3 | 57 | 57,4 | 54,5 | 53,7 | 52 | 53,5 | 62,8 | 59,9 | 59,7 | 54 | 56,8 |
| 29 | Upper arm length left | 34,3 | 36,4 | 30,5 | 30,6 | 32,7 | 31,4 | 29,1 | 30,2 | 30,7 | 37,6 | 35,9 | 36 | 30,4 | 32,8 |
| 30 | Upper arm length right | 35,2 | 35,8 | 31,2 | 31,3 | 32,6 | 31 | 30,1 | 29,6 | 30,2 | 37,8 | 35,8 | 35,9 | 31,1 | 32,9 |
| 31 | Upper arm girth left | 22,1 | 24,9 | 28,8 | 36,5 | 31,6 | 33,6 | 27,4 | 27,5 | 30,4 | 24,4 | 22,1 | 21,3 | 31,2 | 27,8 |
| 32 | Upper arm girth right | 22,7 | 25,1 | 28,8 | 36,3 | 31,8 | 33,9 | 27,2 | 27,9 | 30,6 | 24,4 | 22,3 | 21,6 | 31,4 | 28,0 |

| | | | | | | | | | | | | | | | |
|--------|--------------------------------|-----------|-----------|----------|----------|-----------|----------|----------|----------|----------|-----------|----------|-----------|----------|------|
| 3 3 | Elbow girth left | 18, 4 | 19, 9 | 24, 5 | 29, 4 | 25, 7 | 26, 6 | 23 | 25, 3 | 25 | 20, 3 | 19, 4 | 18, 2 | 25, 5 | 23,2 |
| 3 4 | Elbow girth right | 18, 6 | 20, 4 | 24, 6 | 29, 5 | 26, 26 | 26, 9 | 24 | 25, 6 | 25 | 20, 4 | 19, 7 | 18, 4 | 25, 7 | 23,4 |
| 3 5 | Forearm girth left | 14, 4 | 15, 6 | 19, 6 | 26, 1 | 22, 2 | 23, 7 | 19, 1 | 21, 7 | 21, 6 | 15, 2 | 14, 3 | 14, 5 | 21, 8 | 19,2 |
| 3 6 | Forearm girth right | 14, 1 | 16 | 19, 6 | 25, 9 | 22, 6 | 24, 1 | 20, 3 | 21, 5 | 21, 6 | 15, 1 | 14, 5 | 14 | 21, 7 | 19,3 |
| 3 7 | Wrist girth left | 12, 9 | 12, 9 | 12, 9 | 17, 2 | 16, 4 | 17, 5 | 15 | 16, 3 | 13, 2 | 13, 2 | 13, 2 | 13, 2 | 14, 4 | 14,5 |
| 3 8 | Wrist girth right | 13 | 13 | 13 | 16, 7 | 16, 5 | 17, 6 | 12, 6 | 16, 3 | 13, 3 | 13, 3 | 13, 3 | 13, 3 | 13, 7 | 14,3 |
| 3 9 | Sideseam at waist left | 101 | 105, 2 | 94, 3 | 99, 2 | 105, 3 | 98, 4 | 97, 4 | 95, 8 | 95, 2 | 106, 5 | 99, 4 | 101, 3 | 94, 5 | 99,5 |
| 4 0 | Sideseam at waist right | 100, 5 | 105, 6 | 94, 3 | 99, 3 | 105, 4 | 98, 5 | 97, 4 | 96, 5 | 95, 4 | 105, 3 | 99, 2 | 100, 9 | 94, 7 | 99,5 |
| 4 1 | Thigh girth left (horizontal) | 62, 2 | 65, 3 | 56, 4 | 67, 5 | 61, 1 | 61, 8 | 57, 9 | 55, 6 | 59, 9 | 72, 7 | 62 | 59 | 60, 4 | 61,7 |
| 4 2 | Thigh girth right (horizontal) | 62, 6 | 65, 4 | 56, 8 | 67, 9 | 61, 3 | 62 | 58, 2 | 55, 4 | 60 | 72, 8 | 62, 2 | 59, 2 | 60, 5 | 61,9 |
| 4 3 | Knee girth left | 40, 1 | 42, 8 | 37, 1 | 44, 7 | 39, 8 | 41, 1 | 37, 8 | 38, 3 | 38, 4 | 46, 9 | 40, 8 | 39 | 39 | 40,4 |
| 4 4 | Knee girth right | 40 | 42, 7 | 37 | 44, 8 | 39, 8 | 41 | 37, 8 | 38, 1 | 38, 3 | 47, 1 | 40, 9 | 38, 9 | 39 | 40,4 |
| 4 5 | Upper knee girth left | 44, 5 | 46, 8 | 40, 7 | 49, 6 | 43, 6 | 44, 8 | 40, 7 | 41, 3 | 42, 6 | 52, 5 | 44, 7 | 42, 5 | 43, 1 | 44,4 |
| 4 6 | Upper knee right | 44, 5 | 46, 7 | 40, 7 | 49, 8 | 43, 6 | 44, 9 | 40, 8 | 41, 2 | 42, 6 | 52, 7 | 44, 7 | 42, 5 | 43, 1 | 44,4 |
| 4 7 | Lower knee girth left | 36, 8 | 38, 8 | 34 | 41, 3 | 36, 5 | 37, 4 | 34, 1 | 35, 2 | 35, 1 | 43, 7 | 37, 1 | 35, 5 | 35, 8 | 37,0 |
| 4 8 | Lower knee girth right | 36, 7 | 38, 7 | 33, 9 | 41, 3 | 36, 5 | 37, 4 | 34 | 35, 2 | 35, 2 | 43, 7 | 37 | 35, 5 | 35, 7 | 37,0 |

| | | | | | | | | | | | | | | | |
|----|----------------------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| 49 | calf girth left | 39,2 | 40,9 | 37 | 44,3 | 39,1 | 40,1 | 35,5 | 37,7 | 37,8 | 46,1 | 39,6 | 37,9 | 38,4 | 39,5 |
| 50 | calf girth right | 39,1 | 40,7 | 36,9 | 44,3 | 39,1 | 40,1 | 35,4 | 37,5 | 37,9 | 46,1 | 39,5 | 37,8 | 38,3 | 39,4 |
| 51 | min. leg girth left | 23,2 | 24 | 22 | 26,3 | 22,8 | 23,6 | 21,8 | 23,4 | 22,1 | 27,8 | 23,3 | 22,5 | 22,4 | 23,5 |
| 52 | min. leg girth right | 23,1 | 23,8 | 21,9 | 26,1 | 22,7 | 23,5 | 21,6 | 23,3 | 21,9 | 27,6 | 23,2 | 22,4 | 22,3 | 23,3 |



Appendix E: Test results



WARNING: The sample(s) to which findings recorded herein (the "findings") relate, was drawn and / or provided by the customer. The findings constitute no warranty of the sample's representativeness of any goods and strictly relate to the sample(s). The TSCT – Textile Testing Laboratory, accepts no liability with regard to the origin or source from which the sample(s) is/are said to be extracted.

TEST CERTIFICATE

| | | | |
|-------------------------------------|--|--------------------------------|------------------|
| Customer Details: | RUSHDEEN ROSE 44 Carlton Road, Claremont 7708 | Report No.: | LB159-TC01-18 |
| Contact Person: | Rushdeen Rose | No. of Pages | 1 |
| Sample Description | REF: A – Navy | No. of Attachments: | 1 |
| Laboratory Sample Reference: | LB159-121018/01 | Test Report Issue Date: | 07 November 2018 |
| Testing Location: | TSCT – TEXTILE TESTING LABORATORY | | |
| Atmospheric Conditions: | Temperature: 20° | Humidity: 63% RH | |
| Deviations: | No deviations or additions. | | |

| Test Description | UOM | Test Method | Performance Specification | | Results |
|---------------------------------|------------------------------------|--------------|---------------------------|------|---------|
| | | | Min. | Max. | |
| 1. Fabric Mass per square meter | g/m ² | SANS 78:2004 | | | 119 |
| 2. Air Permeability | cm ³ /m ² /s | ASTM D737-18 | - | - | 237 |

*Refer to Attachment 1 to view results.


TECHNICIAN


AUTHORISED SIGNATORY

07.11.18
Date (dd/mm/yyyy)

07.11.2018
Date (dd/mm/yyyy)

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• <https://www.facebook.com/TSCT.CPUT> • <https://twitter.com/TSCTCPUT> • [33°55'48.295" S 18°38'13.748" E](https://www.google.com/maps/place/33.5548295,-18.3813748)

Compiled by: Claudine Banton
Authorised by: Shami Isaac

Date Established: 19 October 2018
Date Revised: n/a

Document No.: TSCT-LAB-PR01
Page 1 of 1

Basic data

Style: REF.D-PKW (164,98)
Reference: R.ROSE-MTECH
Date: 28.07.2020
Time: 13:26:38
Instrument: FX 3300 LabAir IV
Serial Number: 356

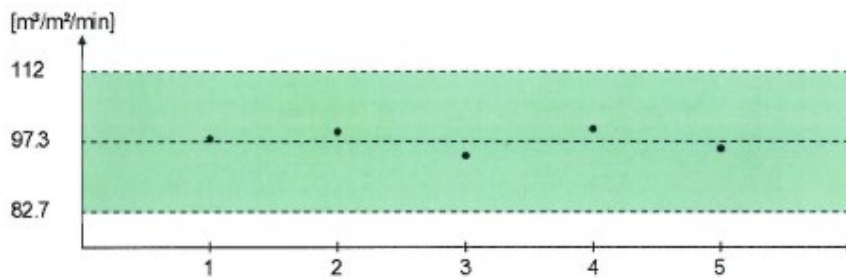
Settings

Test pressure: 125 Pa
Test area: 38 cm²
Nom / Min / Max: -1.00 / -1.00 / -1.00 m³/m²/min

Statistical analysis

Average: 97.3 m³/m²/min
Minimum: 94.2 m³/m²/min
Maximum: 99.8 m³/m²/min
CV: 2.14 %
Cpk: 0.0000

Test results



- 1: ▲ 97.8 m³/m²/min
- 2: ▲ 99.1 m³/m²/min
- 3: ▲ 94.2 m³/m²/min
- 4: ▲ 99.8 m³/m²/min
- 5: ▲ 95.7 m³/m²/min

