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RESEARCH ARTICLE

The impact of knitted linked seams on comfort and friction perception

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ABSTRACT
Friction from knitted clothing can cause discomfort and skin issues, underscoring the importance of tactile comfort for wearers. Seamless knitted garments are assumed to be comfortable to wear, yet there is little understanding of their tactile comfort in comparison to linked seams – the most common form of knitted garment. This novel study examines the influence of a garments knitted structural architecture on clothing comfort and wearability by investigating skin friction and tactile perception across ten body regions in both male and female participants, using two commonly utilised materials and seam designs: cotton and merino wool with plain and linked seams. The impact of seam design and regional factors on skin friction and tactile perception was analysed, revealing varying levels across tested body regions. Removing seams exposed a greater surface area to skin contact, leading to higher perceived friction levels. As such, structural elements in knitted garments enhance wearer comfort.

PRACTITIONER SUMMARY: Seamless knitwear manufacturing offers a more environmentally conscious option compared to traditional cut-and-sew processes. This study investigated the impact of knitted garment material and structure on wearer comfort by analysing skin friction and tactile perception across ten upper body regions. Removing seams increased garment-to-skin contact leading to wearer discomfort.

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KEYWORDS
Clothing comfort; skin friction; tactile perception; knitted clothing; sustainable manufacturing

1. Introduction

Friction between the skin and knitted clothing can cause a range of skin problems, including irritation, redness, itching, and even skin damage (Derler, Schrade, and Gerhardt 2007; Moncrieff 2008; Duncan, Mclellan, and Dickson 2011). When a person wears tight-fitting knitted clothes, the fibres of the fabric can rub against the skin, causing friction. This can result in a condition called friction dermatitis or irritant contact dermatitis (Baby, Mathur, and DenHartog 2020; Baussan et al. 2012; Knapik et al. 1995; Kwiatkowska et al. 2009). Friction dermatitis typically affects areas of the body where the clothing fits tightly, such as the waistband, cuffs, collar, or thighs. The symptoms of friction dermatitis may include redness, itching, burning, and small bumps or blisters. To prevent skin problems caused by friction when wearing knitted clothes, it is important to choose fabrics that are smooth and less sticky. Cotton, silk, and bamboo fabrics are suitable options that are less likely to cause such irritations. Besides the physical skin conditions that can result from wearing knitted garments, the sensation of comfort resulting from the tactile contact of fabrics with the skin is equally significant for users (Derler, Schrade, and Gerhardt 2007; Moncrieff 2008; Duncan, Mclellan, and Dickson 2011). The wearer's perception of smoothness or roughness against the skin can determine whether the experience is comfortable or uncomfortable. Hence, the degree of smoothness or roughness perceived by the wearer plays a crucial role in determining comfort.

The body mapping of skin friction and tactile perception has previously been investigated (Temel, Johnson, and Lloyd 2022), which is an important research area related to skin behaviour and the design of clothing. The study showed that male and female participants had the highest friction areas on their anterior neck, and they reported feeling roughness and stickiness of the tested textiles on their anterior

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torso more than five other body parts (Temel, Johnson, and Lloyd 2022). The study's findings provide valuable insights into the specific areas of the body where people experience higher friction and discomfort with textiles. Clothing designers and manufacturers are able to utilise this information to make informed decisions about material selection, design considerations, and overall product improvement in order to enhance the comfort and satisfaction of their customers.

There are three ways knitted garments can be manufactured, known as cut and sew, fully-fashioned, and seamless (Brackenbury 1996). Cut and sew manufacture mimics the traditional tailoring process, where garment pieces are cut directly from sheets of knitted fabric and sewn together. Fully-fashioned manufacture involves the knitting of panels, which are shaped into the desired form during the knitting process and then 'linked' together (Power and Almond 2019). Linking is the act of attaching two knitted panels together through the insertion of a new knitted course across both panels. This course consists of stitches that are knitted and bound off consecutively to create an enclosed chain. Linking machines are operated to construct fully fashioned garments. The knitted fabric is hooked onto the grooves of a circular dial and a linking needle inserts a yarn through both fabrics in a chain stitch formation, as shown in Figure 1. Linking is a highly skilled, laborious process which requires precision and experience. It is also an expensive part of the development of knitwear products as it can be time consuming and tedious (Mohibullah et al., 2020).

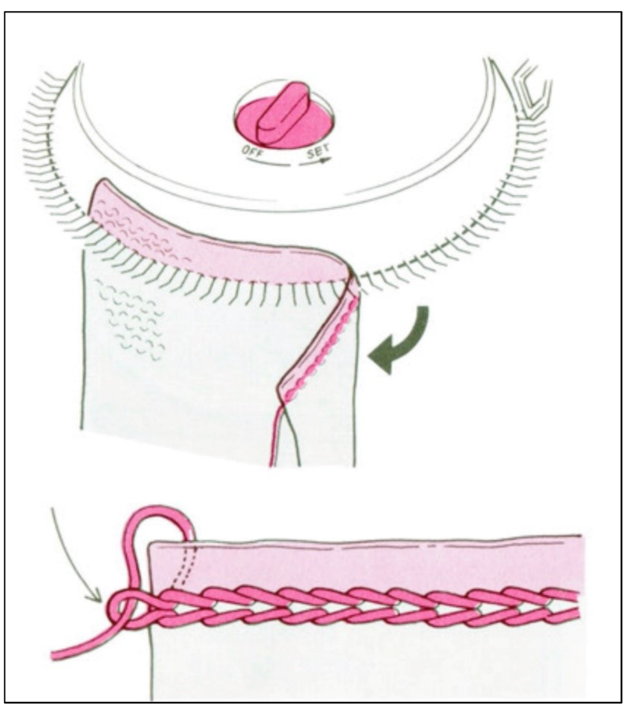


Figure 1. Linking machine and linked seam (Silver Reed 1987).

The most innovative process: seamless knitwear, is knitted three dimensionally (Lu, Jiang, and Wu 2022). Separate, cylindrical tubes are placed together to form a complete garment, often with no post garment construction necessary. Recognised concerns with the cut and sew, and fully fashioned processes include the generation of excessive waste and laborious garment construction (Power 2008). Despite these, both cut and sew, and fully fashioned manufacturing methods are prevalent, often overlooking the benefits seamless knitwear presents of generating low amounts of waste. Existing literature suggests this is due to the complexity of the design process (Sayer, Wilson, and Challis 2006) and the digital skills gap present within the knitwear industry (Taylor and Townsend 2014). It has also been suggested that there is a lack of consumer readiness for buyers who consider trends and not garment construction (Smith 2013). Consumers have come to expect traditional design features on a knitted garment, such as ribs and welts around the neckline; aspects that are difficult to achieve integrally through seamless manufacturing processes.

A recent evaluation of the knitwear industry further confirmed that seamless knitwear is relied on far less when compared to fully fashioned knitwear, which is the industry's preferred manufacturing process (Scott et al. 2023). Interestingly, this study found that 31 global knitwear companies consider their material use to be the most important decision in terms of environmental sustainability, often overlooking the impact of manufacturing choice. Organic wools and cottons, Global Organic Textile Standard (GOTS) certified cottons, and Responsible Wool Standard (RWS) wools were preferred for their sustainability benefits. Scott et al. (2023) identified that wools were prevalent across all manufacturing processes, while cottons were rarely used in seamless knitwear.

Shima Seiki, a leading seamless knitwear machine manufacturer, claim that seamless knitwear is beneficial for the wearer, due to the superior stretch, even stress distribution and minimised skin irritation (Shima Seiki 2019). While this has not been independently verified, if correct it could be assumed that consumer and industry demand would be higher.

Given the opportunity that seamless manufacture presents in terms of waste reduction and efficiency, coupled with the potential wearer benefits, this research explores the relationship between the material and seam design of knitted textiles in terms of generated skin friction coefficients and the tactile perception of wearers. Specifically, the work outlined within this paper seek to i) determine the effect of two commonly used materials in knitted textiles on the skin friction coefficient, ii) assess the impact of seam design on the skin friction coefficient in knitted textiles, iii) to evaluate the influence of material choices on the tactile comfort experienced by wearers of knitted textiles, and iv) to analyse how different seam designs in knitted textiles affect a wearer's perception of comfort and texture.

2. Method

2.1. Overview of the study

To investigate the influence of material and seams design of knitted textiles on skin friction coefficient and tactile perception, a protocol was developed in which the static and dynamic friction coefficient and textile perception (texture, stickiness, pleasantness, and discomfort) were measured. A knitted textile was applied to one of 10 predetermined test sites on the torso using a validated and instrumented friction measurement device in a mixed counterbalanced order (Temel, Lloyd, et al. 2021). The illustration of the tested body regions is shown in Table 1.

2.2. Equipment

The study employed a portable handheld device that was previously introduced by Temel, Lloyd, et al. (2021), shown in Figure 2.

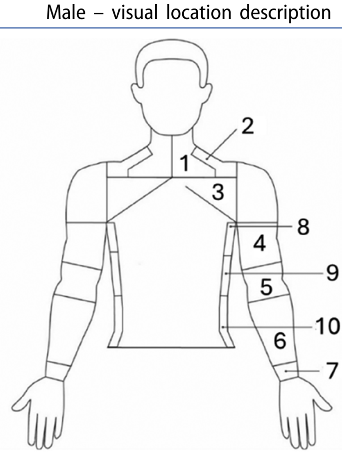
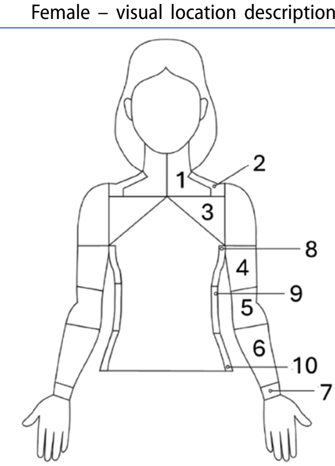
The device shown in Figure 2 was designed to measure the friction coefficient between the skin and different types of textiles, such as cotton, polyester, and silk. Additionally, it facilitated the assessment of regional perception using localised sensory testing methods (Temel, Johnson, et al. 2021). To enable the independent measurement of both normal and frictional forces, the device was equipped with 100 g cantilever straight bar mini-load cell (+/− 0.1%) (Digi-Key Electronics, UK). The device was pressed onto the test body region, causing the probe to reciprocally move vertically at a fixed rate of 0.04 m/s. As the spring stretched, the load cell measured the applied normal force perpendicular to the skin. When the probe and contact surface interacted, a friction force occurred, and the load cell measured this force. The normal load (F_{normal}) and friction force ($F_{friction}$) were registered in real-time by the load cell.

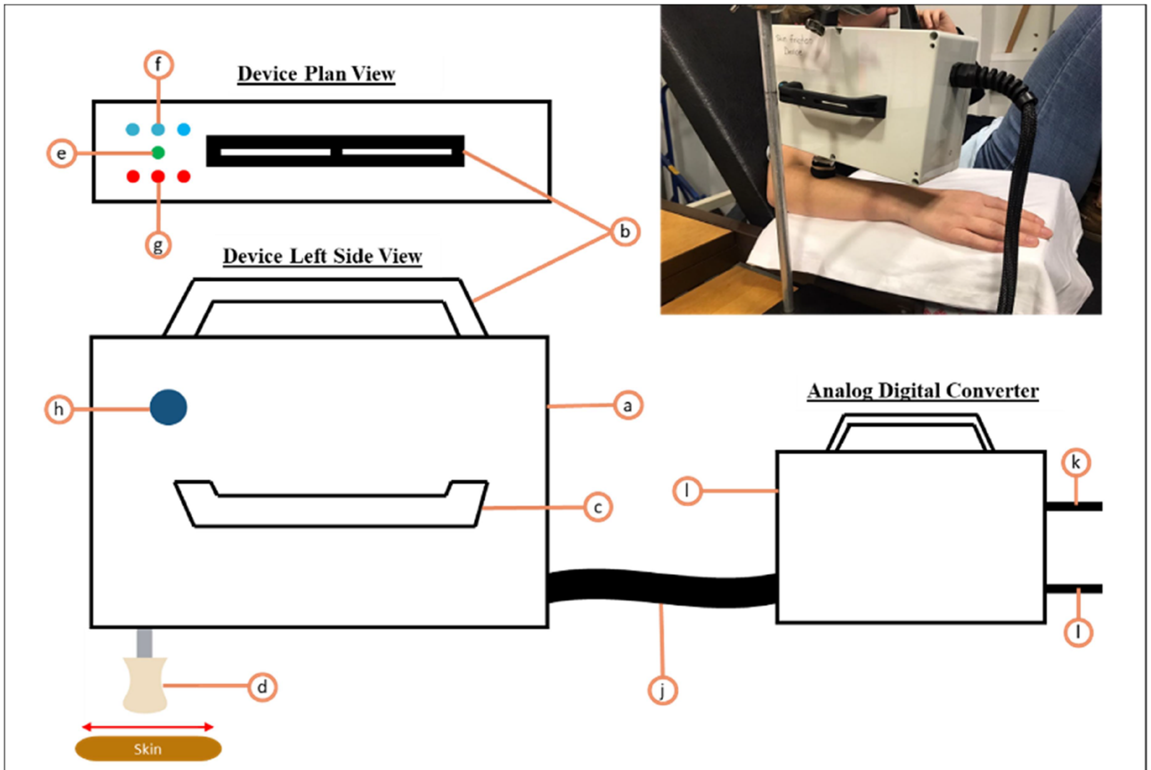
The measured forces were calibrated using a Class M2 calibration weight set. This calibration process ensured that the measurements recorded by the device were reliable and accurate, thereby enhancing the validity of the data obtained through this experimental methodology.

2.3. Contact textile

Two distinct textile materials were employed, specifically merino wool and cotton due to prior investigations identifying their popularity across knitwear SME's. Two types of design were tested, namely plain knit with no seam (to represent seamless garments) and a plain knit with linked seam to represent fully fashioned garments, as shown in Figure 3. The dimension of each textile sample was standardised to 80 × 80 mm in length and width to facilitate consistent testing conditions. Furthermore, to ensure the reliability and consistency of the results, a new and unused sample was employed every three applications across each placement. This approach minimised the potential impact of wear and tear on the textile sample, reducing the risk of measurement bias and ensuring that the results were accurate and robust.

Table 1. Identified test regions.

Label	Location description	Male – visual location description	Female – visual location description
1	Neck		
2	Shoulder		
3	Chest		
4	Upper arm		
5	Cubital fossa		
6	Volar forearm		
7	Wrist		
8	Upper lateral		
9	Middle lateral		
10	Lower lateral		



ID	Description	ID	Description	ID	Description
a	Housing	e	Normal force indication light	i	Analogue Digital Converter
b	Top Handle	f	Low normal force indication light	j	Power Cable
c	Side Handle	g	High normal force indication light	k	Mains supply –low voltage
d	Probe	h	Reset Button	l	USB connection cable

Figure 2. Schematic of the novel skin friction measurement device (Temel, Johnson, et al. 2021).

All specimens were knitted on a 5-gauge Brother k950i domestic knitting machine. Specimens with seams were knitted separately and linked together on a Hague D280E Electric Linking Machine with the seam located at the centre of each specimen. Yarns were chosen as their New Metric (Nm) linear density is identical allowing for less variability in the specimens, as shown in Table 2.

Merino and cotton 4.16 Nm yarns are commonly known as 4 ply yarns and are commonly used in mid-weight comfort knitwear garments such as sweaters. Seam-to-skin contact across such garments where linked seams are positioned include the underarm, side, shoulder, and armscye – as shown in Figure 4.

2.4. Participants

Twenty university students of Western European origin were recruited, comprising of 10 females and 10 males. The mean age, body weight, height, and body fat percentage of the participants were 25.7 ± 2.5 yrs., 65.7 ± 11.5 kg, 168.6 ± 5.8 cm, 24.3 ± 3.6% body fat, respectively. The inclusion criteria stipulated that participants must be non-smokers and free from cardiovascular, musculoskeletal, cutaneous, metabolic, and sensory-related disorders.

To standardise the pre-trial conditions, participants were instructed to abstain from caffeine and alcohol for 24 hours prior, and food 2 hours before the trial, respectively. The study protocol was approved by the Loughborough University Ethics Committee (2022-10339-10401) and adhered to the World Medical Association Declaration of Helsinki for medical research involving human subjects, except for registration in a database. By complying with ethical guidelines, the study aimed to ensure the well-being of the participants and the scientific integrity of the data.

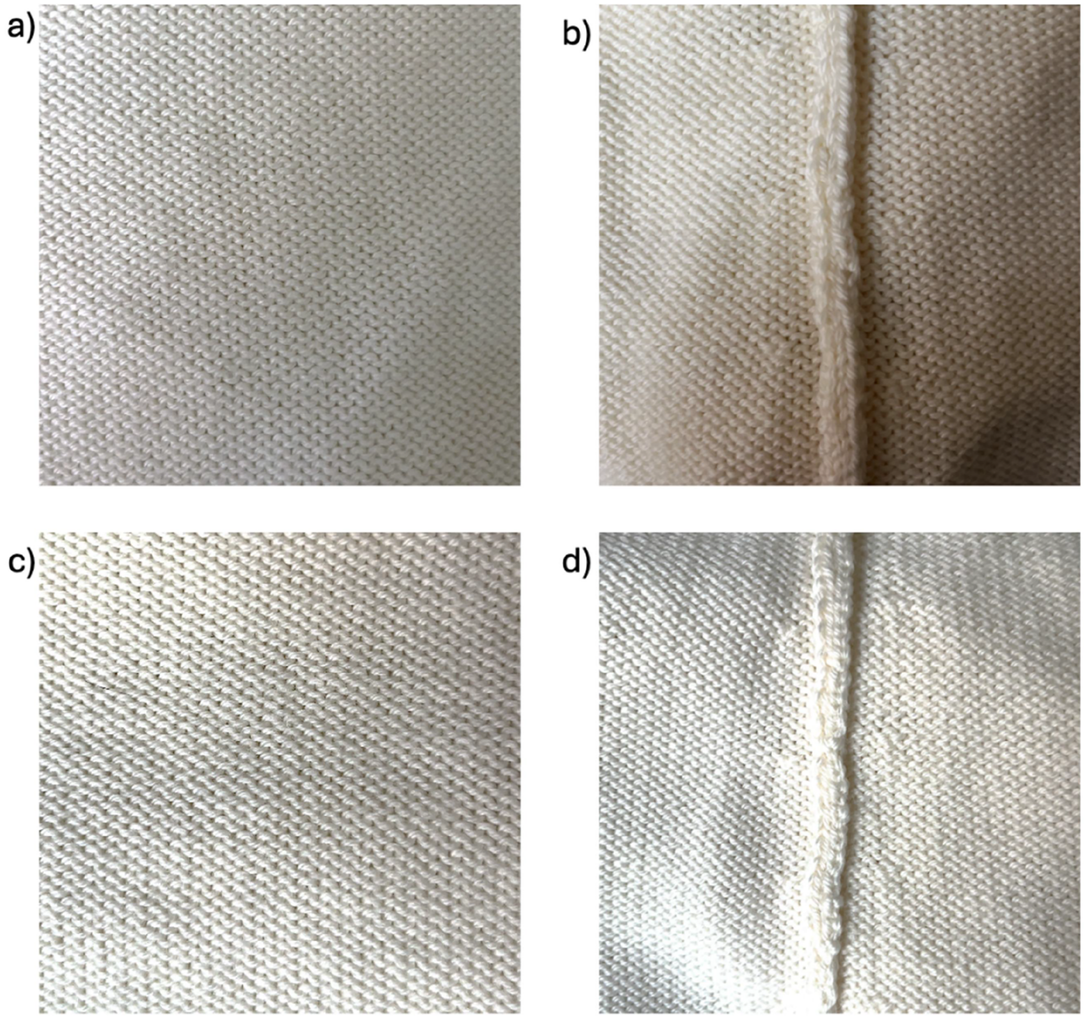


Figure 3. Test specimens, reverse side: (a) merino wool – plain, (b) merino wool – linked, (c) cotton – plain, (d) cotton – linked.

Table 2. Yarn composition.

Specimen composition			
Material	Yarn information	Grams per square metre (g/m^2)	Fabric gauge Courses (C) × Wales (W) per square cm
Merino Wool 4 ply	Composition: 100% Merino (21 micron) Count: 4/16 Nm (4 ends of yarn plied together, each weighing 1gram every 16 m) Yarn Weight: 4 Ply	504 g/m^2	4.4 C × 3.4 W
Organic Cotton 4 ply	Composition: 100% Organic Cotton Count: 4/16 Nm (4 ends of yarn plied together, each weighing 1gram every 16 m) Yarn Weight: 4 Ply	512 g/m^2	4.5 C × 3.5 W

2.5. Test protocol

This study was conducted based on the protocol described in Temel, Johnson, and Lloyd (2022). Prior to conducting the experiments, the participants were provided with a thorough explanation of the procedures, both verbally and in writing through a participant information sheet. Written informed consent was obtained from all participants, and a health screening questionnaire was administered. Anthropometric measurements of height, body mass (using Mettler Toledo Kcc150 equipment), and body fat percentage (using Tanita Corporation equipment from Tokyo, Japan), were obtained before the commencement of the tests. Female participants were instructed to wear a bra and shorts, while male participants wore shorts only during the trials. Following the measurement of body composition, the participants were placed in an environmental control room set at a temperature of 25 °C and a relative humidity of 50%. To eliminate potential sources of bias, the participants' visual observation of the application of the friction device was prevented. A 10-minute baseline period was implemented to facilitate participant familiarisation with the experimental equipment and subjective rating scales.

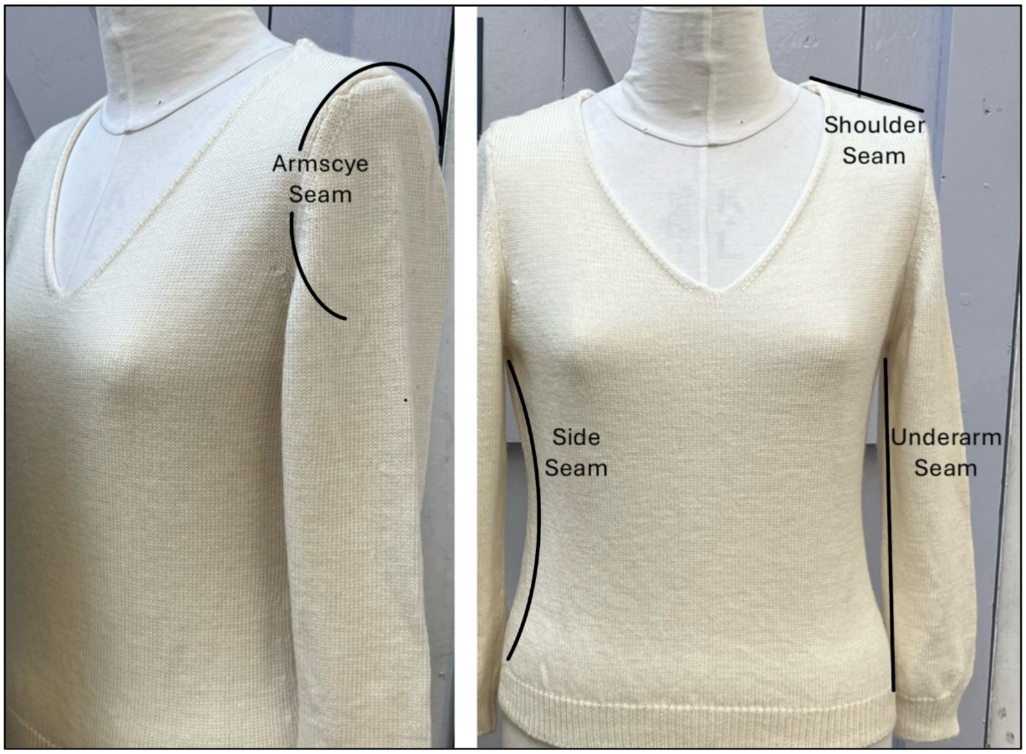


Figure 4. A midweight jumper with seam location.

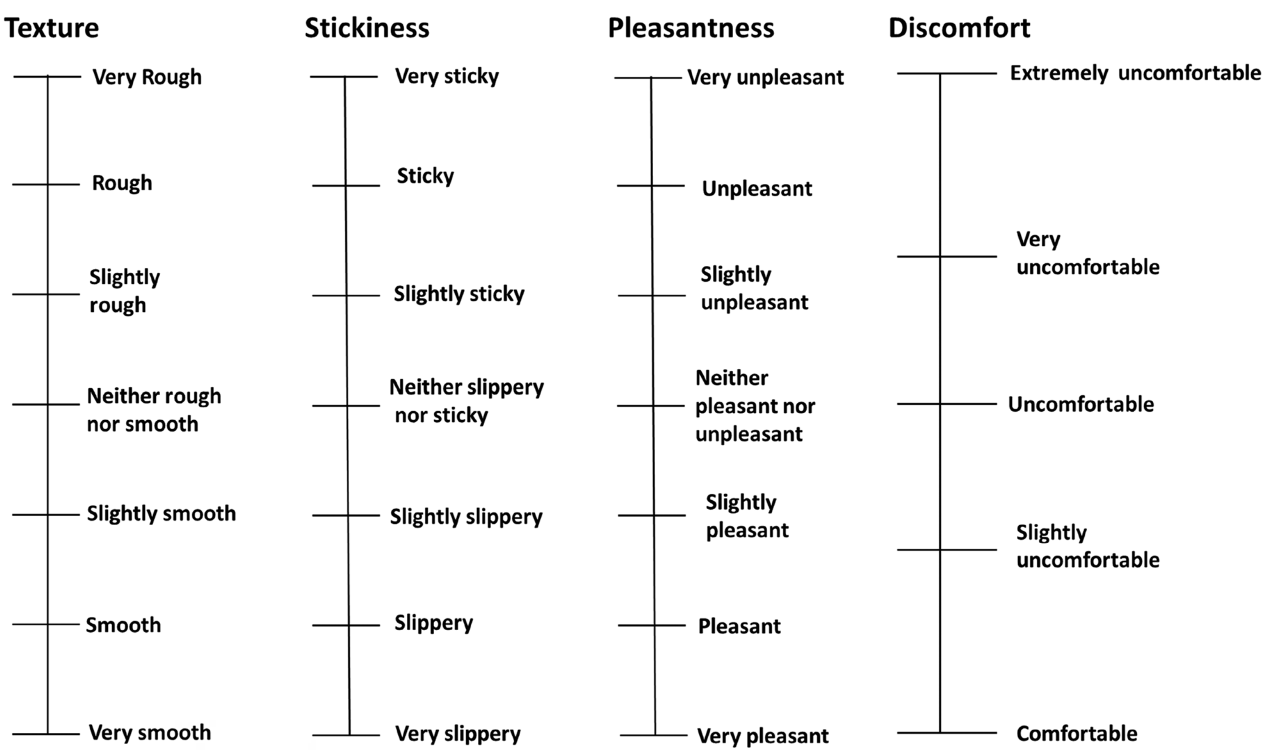


Figure 5. Perception scales for texture, stickiness, pleasantness, and discomfort.

To evaluate the perception of fabric texture, including roughness and smoothness, an ordinal bipolar balanced scale was adapted from (Raccuglia et al., 2017). Additionally, to assess the user's perception of fabric stickiness, i.e., slipperiness and stickiness, a modified seven-point bipolar scale was used, adapted from (Hollins et al., 1993). The pleasantness sensation of the tested fabric samples was evaluated using an adapted bipolar, balanced ordinal scale from Raccuglia et al. (2017). Furthermore, a five-anchor visual scale was used to indicate discomfort, ranging from "Extremely Uncomfortable" to "Comfortable," as adapted from (Griffiths and Boyce, 1971). Each scale was modified by removing numerical values, allowing participants to place a mark on the scale between the descriptor anchors to indicate their exact rating. Participants used a pen to indicate their perceived rating on the scale. The experiment scales are presnted in Figure 5 for reference.

The participants were provided with reference points representing the extremes of roughness and smoothness, including tactile experiences resembling dry wool and dry silk, respectively. Similarly, the extremes of stickiness and slipperiness were defined to the participants as experiences where the probe either did not move at all or moved smoothly on the skin surface without resistance, respectively. To support scale colouration across the mapping of texture, stickiness, and pleasantness perception, the length of each scale measured from 0 mm at the lowest anchor descriptor, to 200 mm at the highest anchor descriptor. Where a participant marked their perception following experimentation, on the scale allowed the investigators to colour grade perception across each test region.

This study employed a friction probe to apply a normal force of 2 ± 0.5 N, and a fixed velocity of 0.04 m/s across ten predetermined test sites on the human body, as outlined in Table 1, with a mixed counterbalanced order. The probe was applied to the skin, with the knitted seam facing the skin and the seam parallel to the direction of the friction motion, for a duration of 10 seconds during each application, after which the coefficient of skin friction to the knitted textile was recorded. Subsequently, participants were asked to rate their tactile perception with respect to texture, stickiness, pleasantness, and discomfort. This procedure was repeated for both cotton and wool knitted textiles, using both plain and linked seam designed specimens.

2.6. Data analysis

Microsoft Excel software was used to measure and export the normal and friction force data. MATLAB (version R2011b; The MathWorks Inc. Massachusetts, USA) was employed to process the data after all tests were completed. A custom-made MATLAB program was used to determine the peak and stable points for each cycle. The mean value of the ten given peak points was used to represent the superior and inferior static skin friction coefficient, while the ten stable points were used to represent the superior and inferior dynamic skin friction coefficient.

Statistical analysis was conducted using Prism, version 9.0 (GraphPad Software Inc., La Jolla, CA, USA). Data were presented as either means ± SD or median (25% – 75% quartile). The normality of all data distributions was confirmed by employing the Kolmogorov - Smirnov test. Following, parametric statistics were applied. Independent sample t-tests were used to compare individual characteristics (age, mass, height, and BF) between two independent groups.

3. Results

3.1. Friction coefficient

As shown in Figures 6 and 7, this study demonstrated that the design of a knitted textile has a significant impact on skin friction coefficient ($p < 0.05$). Specifically, linked design specimens exhibited lower skin friction coefficient values when compared to the plain design for both organic cotton and wool yarn materials. This effect can be attributed to the real contact area of the plain design, which was found to be larger than that of the linked design.

Moreover, the results showed a clear difference in skin friction on different parts of the body. The neck region had a much higher levels of friction in comparison to other test areas ($p < 0.001$). However, the study highlights the absence of any material effect on skin friction coefficient for both genders ($p = 0.83$ for females and $p = 0.79$ for males), thus underscoring the significance of design as the primary determinant of skin friction coefficient. Furthermore, there was no significant difference in skin friction coefficient between males and females, indicating that there is no sex effect on this variable.

Within Figure 6, panels 'A' and 'B' show female skin friction with cotton plain and link knitted specimens respectively, while panels 'C' and 'D' show mean male skin friction with the same specimens, respectively. A scale of skin friction coefficient represents high and low levels of skin coefficient of friction with different colours, relative to the measured values.

Within Figure 7, panels 'A' and 'B' show female skin friction with wool plain and link knitted specimens respectively, while panels 'C' and 'D' show male skin friction with the same specimens. Again, the scale of skin friction coefficient represents high and low levels of skin coefficient of friction with different colours, relative to the measured values

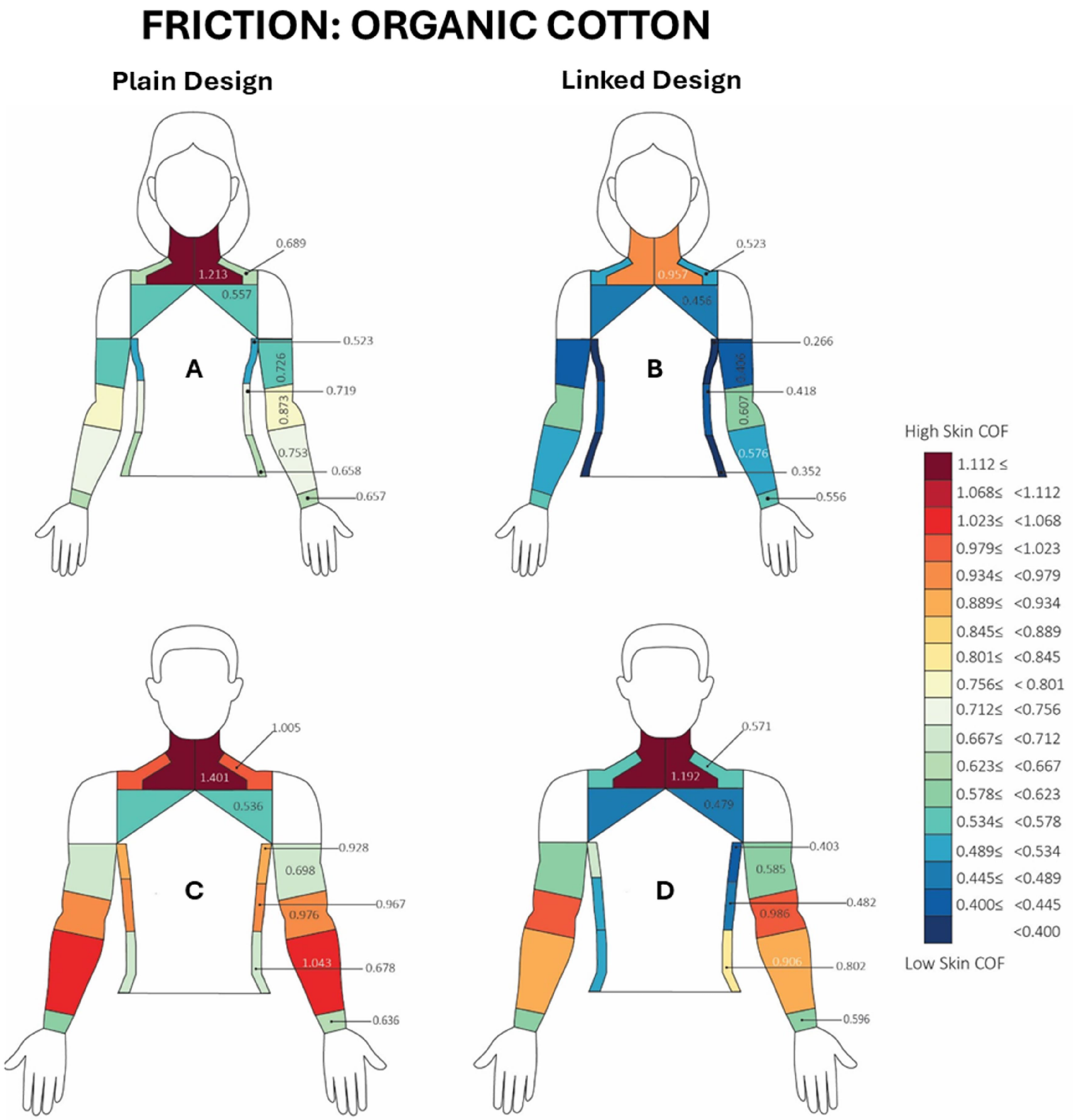


Figure 6. Median skin friction coefficients across ten body regions for organic cotton knitted specimens across participants ($n = 10$ male, $n = 10$ female).

3.2. Texture perception

This study also examined the impact of body region, seam design, and material on texture perception. As shown in Figures 8 and 9, the results revealed that texture perception varied significantly across the tested body regions ($p < 0.001$), with the neck being the area with the highest sensitivity across both sexes.

In addition to body regions, the impact of seam design on texture perception was also examined. The results indicated that the design of seams had a significant effect on texture perception ($p < 0.05$), with knitted textiles featuring linked seams being perceived as rougher than those with a plain design. However, the type of material tested did not show to have a significant effect on texture perception. Furthermore, the results indicated that females perceived textiles to be rougher compared to males ($p < 0.05$).

Within Figure 8, panels 'A' and 'B' show female skin friction with cotton plain and link knitted specimens, respectively, while panels 'C' and 'D' show male skin friction with the same specimens, respectively.

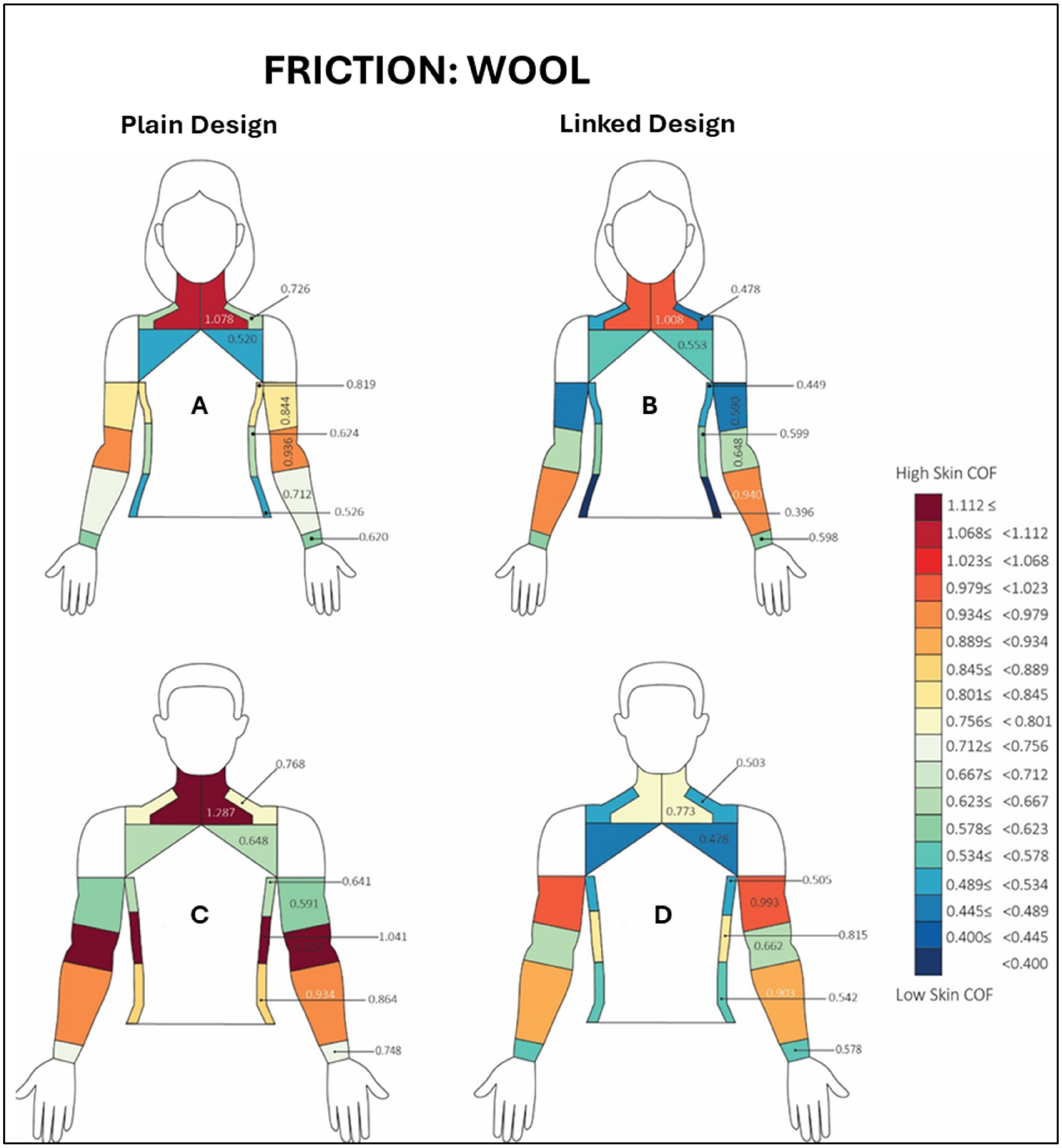


Figure 7. Median skin friction coefficients across ten body regions for merino wool knitted specimens ($n = 10$ male, $n = 10$ female).

Within Figure 9, panels 'A' and 'B' show female skin friction with wool plain and link knitted specimens, respectively, while panels 'C' and 'D' show male skin friction with the same specimens, respectively.

3.3. Stickiness perception

The results of this study showed that there was a significant difference in stickiness perception across the ten tested body regions ($p < 0.05$), shown in Figures 10 and 11. Specifically, the upper lateral region was perceived as less sticky compared to other regions. Furthermore, this study found that seam design had a significant effect on stickiness perception. Participants perceived linked design textiles as more sticky compared to plain knit designs. This indicates that the design of a surface can significantly influence its perceived stickiness.

In contrast, no material effect on stickiness perception was observed. Participants perceived no difference between cotton and wool material samples and this study found no sex effect on stickiness perception for the studied age-group.

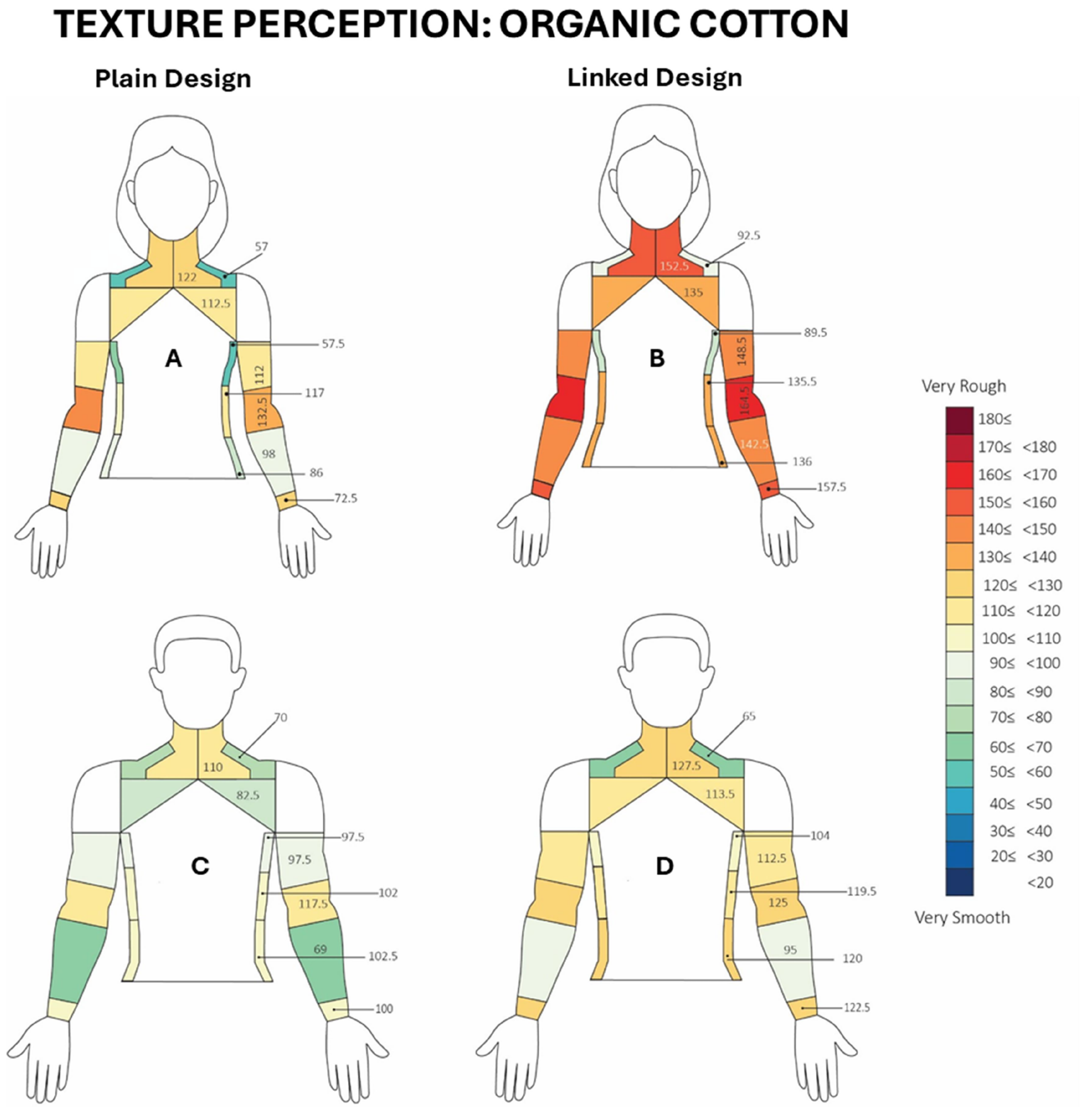


Figure 8. Median texture perception across ten body regions for organic cotton knitted specimens ($n = 10$ male, $n = 10$ female).

Within Figure 10, panels 'A' and 'B' show female skin friction with cotton plain and link knitted specimens, respectively, while panels 'C' and 'D' show male skin friction with the same specimens, respectively.

Within Figure 11, panels 'A' and 'B' show female skin friction with wool plain and link knitted specimens, respectively, while panels 'C' and 'D' show male skin friction with the same specimens, respectively.

3.4. Pleasantness perception

There was a notable difference in the perception of pleasantness across different body regions, as shown in Figures 12 and 13. The study found no obvious effect of sex on pleasantness perception, suggesting that sex in the studied age-group did not play a significant role in influencing individuals' perceptions of pleasantness in this context. Also, there was no observed material effect on pleasantness perception. The constrained variability between these two materials is considered an important factor contributing to the observed lack of significant differences in this study.

Within Figure 12, panels 'A' and 'B' show female skin friction with cotton plain and link knitted specimens, respectively, while panels 'C' and 'D' show male skin friction with the same specimens, respectively.

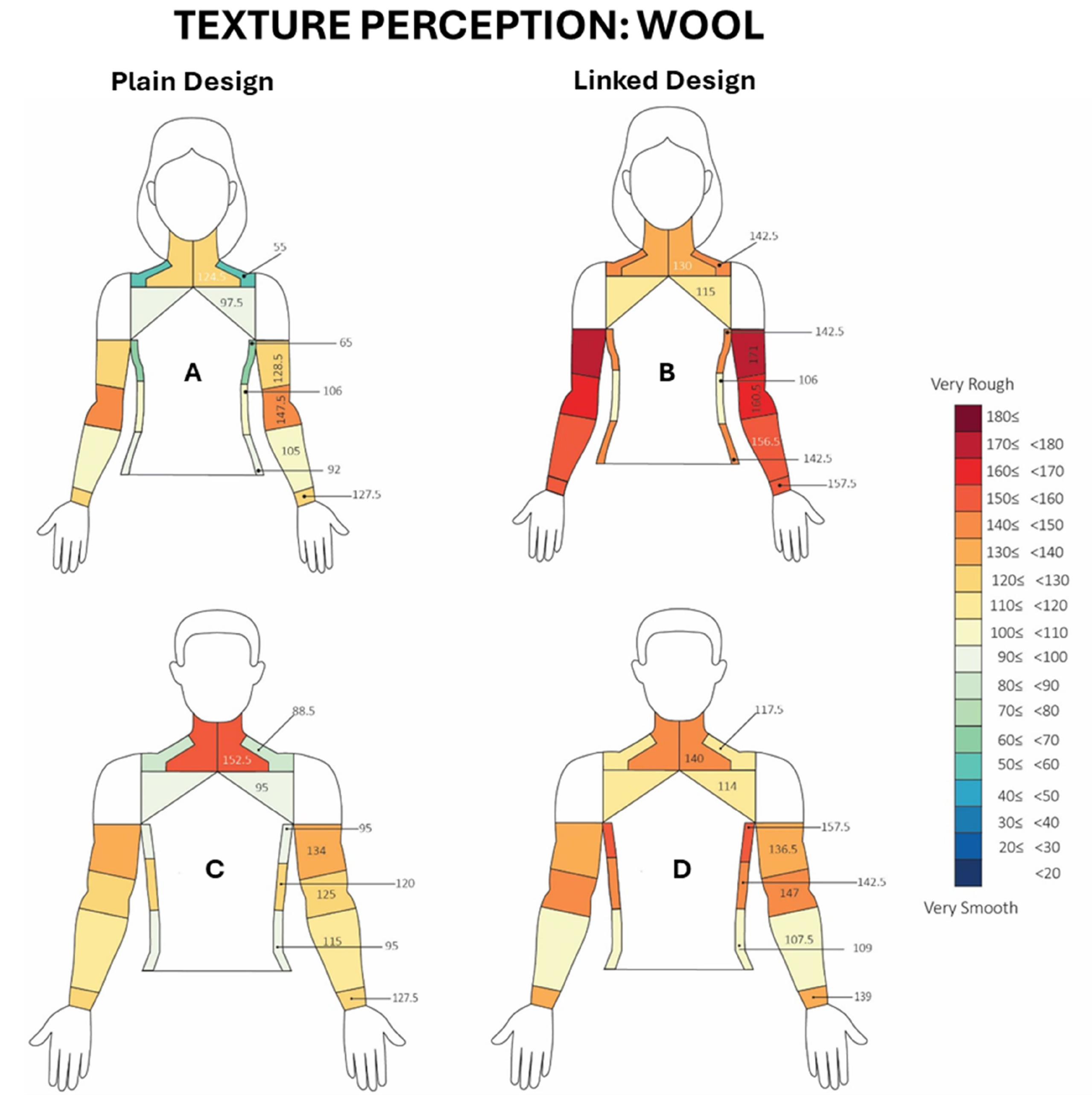


Figure 9. Median texture perception across ten body regions for wool knitted specimens ($n = 10$ male, $n = 10$ female).

Within Figure 13, panels 'A' and 'B' show female skin friction with wool plain and link knitted specimens, respectively, while panels 'C' and 'D' show male skin friction with the same specimens, respectively.

3.5. Discomfort perception

The discomfort perception scores for various body regions did not exhibit any noteworthy variations ($p = 0.224$), indicating a similar level of discomfort across different areas. Additionally, when comparing the discomfort perception scores between female and male participants, no significant difference was observed ($p = 0.137$). These findings suggest that both sexes in the studied age-group experienced discomfort to a similar extent.

4. Discussion

The impact on skin friction coefficient and the tactile perception of a linked seam within a knitted textile revealed a novel understanding of the beneficial characteristics of which linked seams provide. This study is the first of its kind to evaluate the effect of seems in knitted textiles and how they are perceived by the wearer. Despite the commonly held view that seams

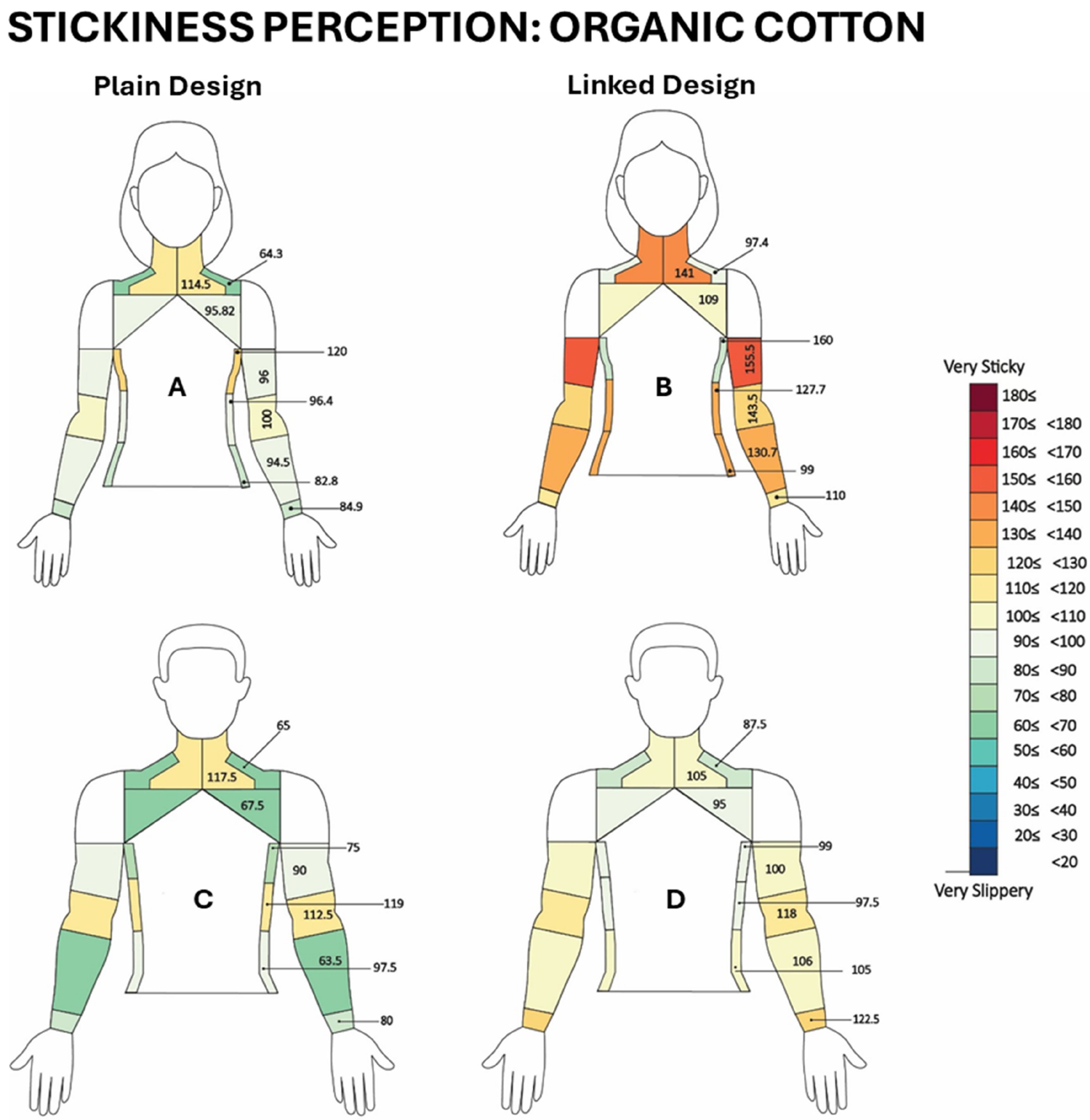


Figure 10. Median stickiness perception across ten body regions for organic cotton knitted specimens ($n = 10$ male, $n = 10$ female).

agitate the wearer, and therefore accelerate the development of contact dermatitis which occurs in the aforementioned areas, some beneficial characteristics of seams were uncovered. For example, friction was perceived to be lower in the seamed specimens due to the reduced contact area between the fabric and the skin. The removal of seams causes a greater surface area to be exposed to contact and therefore a higher perceived level of friction was noted. Friction was most significantly perceived on the anterior neck, an area which often contains seams due to the addition of garment trims, in the form of welts or ribs. To add such trims to knitted panels, a skilled garment constructor will attach the required trim to the panel stitch-by-stitch to form a linked seam. The act of linking necklines during garment construction is not only laborious and therefore expensive, but there is a large margin for human error, as often knitted neckbands are stretched out of shape during the process causing a loose or uneven neckband, or attached too tightly, causing a neckband that is too tight to wear. The results of this study indicate that insufficient variation in tactile properties was observed across the two test materials, leading to a lack of significant differences in texture perception. It should be noted that the limited divergence between these two materials is considered

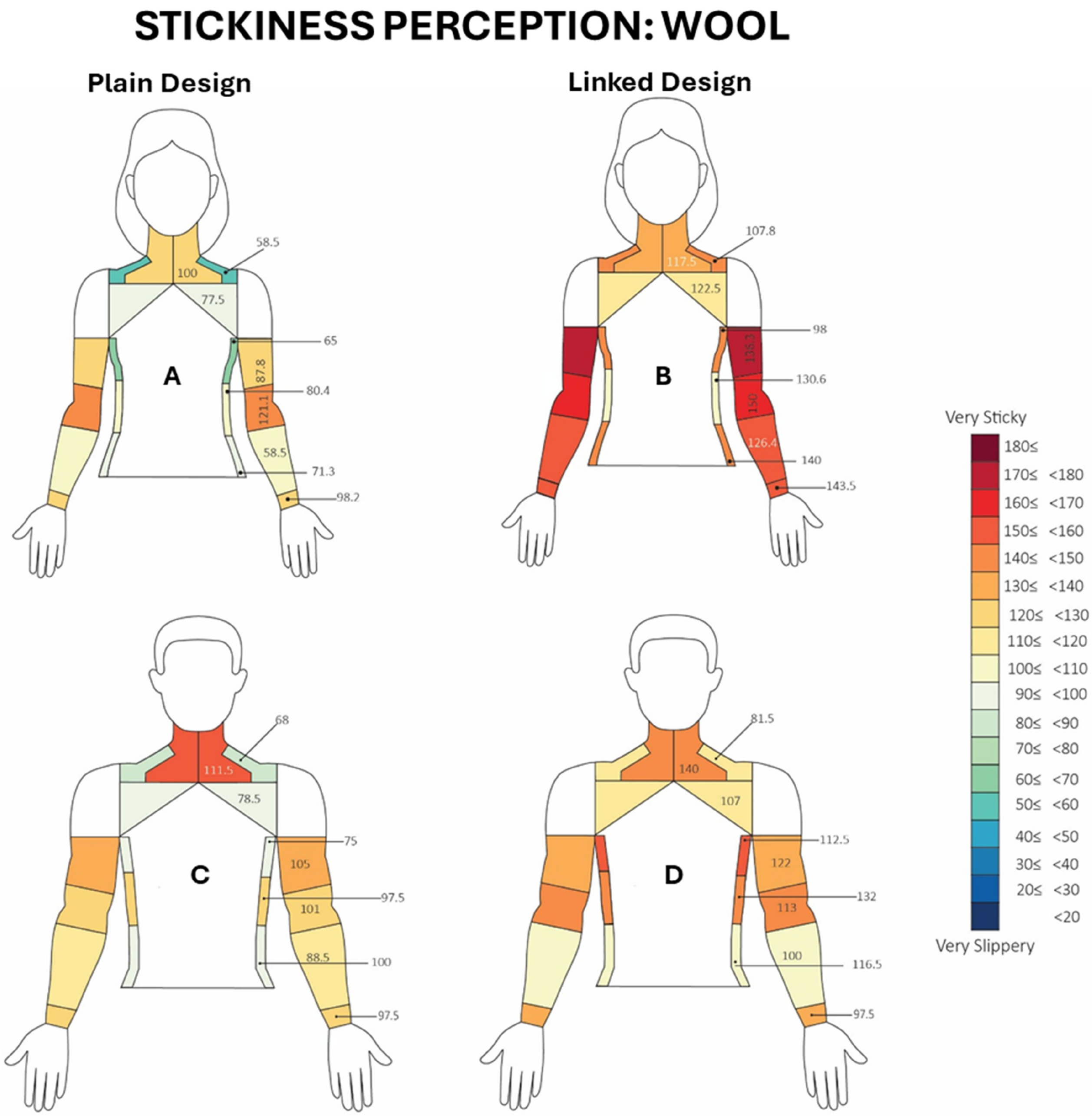


Figure 11. Median stickiness perception across ten body regions for wool knitted specimens ($n = 10$ male, $n = 10$ female).

a key factor in the absence of substantial differences observed in this study.

Machine manufacturers have attempted to solve such issues through the development of garment shapes which can be manufactured on seamless knitwear machinery. The uptake of such garment shapes has been low, due to the aesthetic benefits of such trims on the technical face of the garment, and perceived improved quality. It could now be suggested that the neckband addition is not only an aesthetic addition, but also a functional one which reduces anterior neck friction and wearer discomfort. The increased exposure to a knitted textile over a flat surface area can now be assumed to directly influence the perception of friction within clothing. It should also be recognised that despite the reduced friction, the texture perception of seams across the anterior neck were perceived as rougher. Trade-offs also occur as it was discovered that participants found the aesthetics of linked seams unpleasant, due to the preference of simpler patterns or designs. Considering these trade-offs, the design of seams in this area could be optimised to reduce roughness and decrease friction and contact within the skin through the development of seamless knitwear technology, however the simplicity of the fabric should also be a consideration.

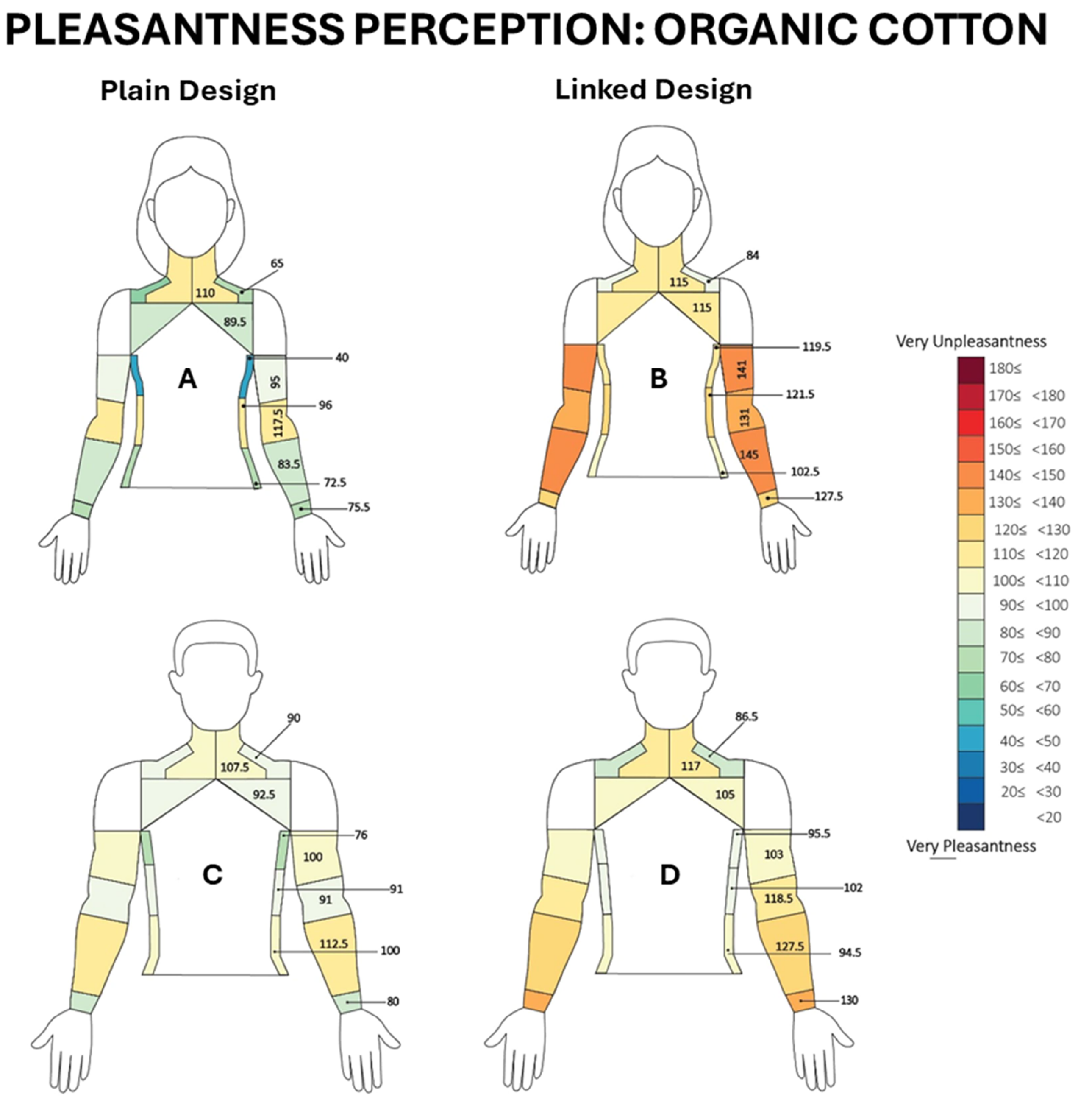


Figure 12. Median pleasantness perception across ten body regions for organic cotton knitted specimens ($n = 10$ male, $n = 10$ female).

The type of material used does not significantly affect how sticky a surface is perceived to be. It is noteworthy that the restricted variance between these two materials is regarded as an important factor contributing to the absence of substantial differences observed in this study. It was further discovered that seams improve the stability of the garment for the wearer due to its decreased slippage against the skin during motion. It may be presumed that stickiness has a negative association when fabric interacts with the skin, however slippery fabric can cause excess and unwanted movement in close fitting garments, causing a reduction in dimensional integrity and stability. It was found that in the upper lateral region slippage was perceived most strongly which is an area of great importance, as when movement takes place in the arms (to reach up or down) slippage will be greatly perceived, causing a garment to rise up unintentionally, a fit issue often reviled by consumers. Seamless garments often have a 'weak spot' at the underarm, where the tube which forms the arm hole intersects with the tube which forms the torso, subsequently failing quality checks due to the integrity of this area. Seamless knitwear manufacturers have responded to

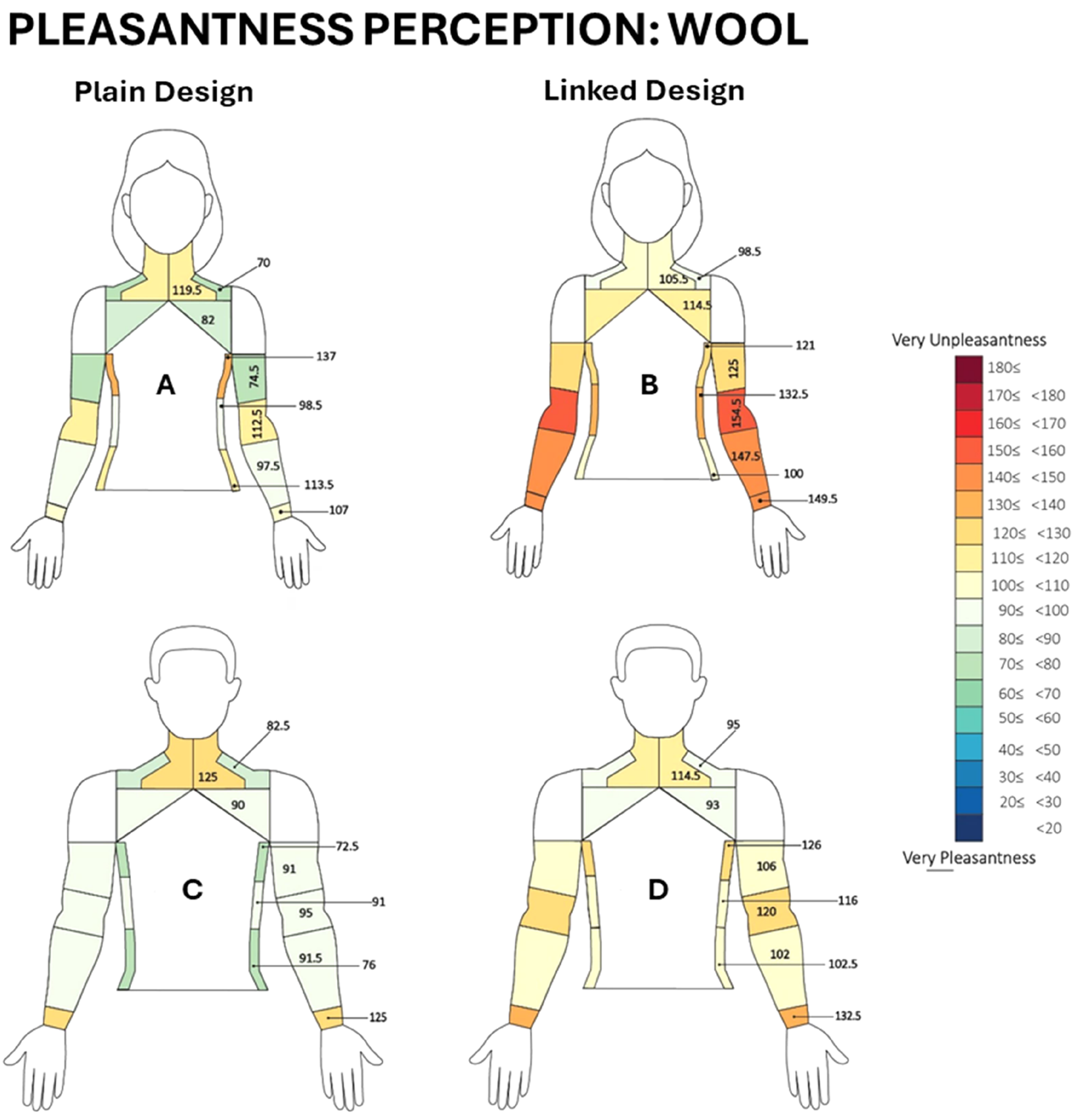


Figure 13. Median pleasantness perception across ten body regions for wool knitted specimens ($n = 10$ male, $n = 10$ female).

this by including structural stitch patterns at this weak point, however, it could now be suggested that this additional structure could be extended down to the upper lateral region, along where a 'side seam' would be placed, to provide less slippage. The linked seam knitted textiles were found to be more unpleasant compared to the plain seam knitted textiles. Also, individuals may have varying levels of sensitivity for certain sensations in specific areas of their body. It must also be considered that the seams perceived to be most unpleasant were placed on the arm region, therefore it would not be advisable to prolong this along the underarm.

Interestingly, the wool and cotton knitted fabrics used within this body of work offered no significant differences, confirming that the structural architecture/design of the seamed and seamless textiles were significant factors in wearer comfort. However, this outcome was likely anticipated given the substantial similarity of the samples.

5. Conclusion

This research has illustrated the positive and negative impacts of linked seams within knitted textiles for a specific age group, notably, seams reduce friction in specific regions such as the anterior neck, thereby enhancing overall comfort and stability by mitigating slippage. However, these beneficial effects must be weighed up against the tactile perception of roughness and a potential decrease in visual aesthetics. To optimise clothing design, it is imperative to strike a delicate balance between these factors through the incorporation of seamless technology and the extension of structural stitch patterns, particularly in areas prone to slippage. This study provides a profound contribution to further elevate understanding relating to the influence of a knitted structural architecture on clothing comfort and functionality, regardless of the type of material used. It is important to be cautious in interpreting the findings of this study since this study concentrated on two materials made using knitting technology. However, this focus can serve as a starting point for more extensive research into different materials and manufacturing methods, which could have significant implications for the clothing industry. For example, exploring sportswear or specialised technical clothing like military or fire-resistant attire has great potential within this context. Ultimately, the findings offer knitwear designers and manufacturers the opportunity to maximise consumer comfort and stability of knitwear garments.

Authors' contributions

Andrew Johnson led study conceptualisation. Andrew Johnson, Eleanor Scott, and Mevra Temel contributed to the study design. Specimen manufacture and preparation was undertaken by Eleanor Scott. Data collection and analysis was performed by Mevra Temel. Manuscript preparation was led by Mevra Temel with input, review, and feedback by all authors.

Disclosure statement

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