Improving the Natural Ventilation in Classic Women's Shirts by Using Textile Manipulation Techniques

Klasik Kadın Gömleklerinde Tekstil Manipülasyon Teknikleri Kullanılarak Doğal Havalandırmanın İyileştirilmesi

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Received/Geliş Tarihi: 27.05.2024 Revision/Düzeltme Tarihi: 10.10.2024 doi: 10.5505/pajes.2024.14303
Accepted/Kabul Tarihi: 16.10.2024 Research Article/Araştırma Makalesi

Abstract

Today's consumers prefer clothing which combines comfort and aesthetic together. Discomforts feeling (sweating, odor, etc.) usually observe in around armpit because of the changes in the micro-climate between the body and clothing. The simplest way to decrease the discomfort feelings is making dimensional changes along the arm of clothing. In the first stage of this study, several easy modifications were made in the shirt sleeves to improve the natural ventilation in the clothes. In the second stage, shirt sleeves were manipulated using textile manipulation techniques such as smocking and hand stitching to provide an aesthetic appearance in terms of design and to make improvements in clothing comfort by natural ventilation. After applying the manipulation techniques, through wear trials and then thermal camera measurements were carried out. Manipulated and non-manipulated shirts were compared and analyzed to see how the designs should be to improve thermal comfort in women's shirts.

Keywords: Aesthetic appearance, textile manipulation techniques, thermal distribution, natural ventilation, sleeve design.

Öz

Günümüz tüketicileri konfor ve estetiği bir arada barındıran kıyafetleri tercih etmektedir. Vücut ve kıyafet arasındaki mikro klimanın değişmesi nedeniyle genellikle koltuk altında rahatsızlık hissi (terleme, koku vb.) görülür. Rahatsızlık hissini azaltmanın en basit yolu giysinin kol kısmında boyutsal değişiklikler yapmaktır. Bu çalışmanın ilk aşamasında, giysilerdeki doğal havalandırmayı iyileştirmek için gömlek kollarında çeşitli kolay modifikasyonlar yapılmıştır. İkinci aşamada, tasarım açısından estetik bir görünüm sağlamak ve doğal havalandırma ile giysi konforunda iyileştirmeler sağlamak amacıyla büzme, el dikişi gibi tekstil manipülasyon teknikleri kullanılarak gömlek kolları manipüle edilmiştir. Manipülasyon teknikleri uygulandıktan sonra giyim denemeleri yapılmış ve ardından termal kamera ölçümleri yapılmıştır. Kadın gömleklerinde termal konforun artırılmasına yönelik tasarımların nasıl olması gerektiğini görmek için manipüle edilmiş ve manipüle edilmemiş gömlekler karşılaştırılmış ve incelenmiştir.

Anahtar kelimeler: Estetik görünüş, tekstil manipülasyon teknikleri, termal dağılım, doğal havalandırma, kol tasarımı.

1 Introduction

Research on clothing thermal comfort is largely carried out for sportswear and protective clothing [1-4] and there is much less research for the clothes we use in our daily life, especially in office life. However, in order to improve the quality of life, different design approaches (such as shirts that are used more frequently in our daily lives, other than the existing classical designs of clothes) need to be presented in order to improve the comfort components of clothes, In addition, such designs can provide functionality to the garment in order to support sustainability, allowing the product to be used more efficiently and for a longer period of time. In creating new designs, in addition to the ergonomics of the clothing, the thermal comfort of the clothing should also be taken into consideration. Clothing dimensions, properly garment fit to body, and clothing thermal comfort have been identified as important features. It has been observed through studies included surveys regarding clothing comfort that a big majority of today's consumers have the similar decision [5-8]. A well-designed garment that provides free movement and comfort in daily usage must also enable a thermoregulatory function to maintain thermal comfort. Human movements result in variations of airflow (pumping effect) in airgaps between garment layers and around the human body. It reduces the thermal insulation along with ventilation through the fabric and openings [9]. The reduction in thermal insulation during human movement has been experimentally investigated by several researchers [10-11]. Their results showed that there was a reduction of clothing thermal insulation by 33% for males and 51% for females due to pumping effect [12].

It is possible to change or make improvements with different types of surface applications with fabric manipulation techniques. These applications can be colours, textures, and patterns, as well as embellishments with stitches, beadwork, embroidery, or ready-made materials [13]. Hand sewing is a traditional method and has always been a technique used mostly in decorations because it gives a natural appearance to the fabric surface. Regardless of the fabric structure, hand stitching is preferred because it looks closer to nature and can be applied easily. In addition, hand stitching helps the designer in giving an aesthetic appearance to the form and surface in textile design and provides functional features [14].

Hamamcı and Oyman (2023) applied four different manipulation techniques, including ruffles, flounces, flat pleats, and ribs, to the poplin, calico and flannel fabric surface prepared from cotton fabrics in 15 x15 cm dimensions. As a result of the applications, they concluded that the applicability of manipulation techniques differs in fabric structures and every technique cannot be applied to every fabric. They emphasized that the harmony of the materials and techniques used in their article is a major topic that should be taken into consideration for the designer to express his imagination [15].

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Akpınar and Bulat (2016) applied ribbing, pleating, and gathering techniques, which are among the sewing manipulation techniques, to woven textile surfaces. They experimented with digital transfer printing on nine different manipulated woven surfaces. They presented the study to a three-person evaluation jury. In the designs, dimensionality, mobility, perspective, and aesthetic appearance were identified as innovation and difference. They concluded that they created innovative and artistic textile designs. It was also stated that this experimental study was the first of its kind [16].

Joshi et al. (2021) investigated the effect of the air layer on heat transfer in different combinations of t-shirt-trousers and shirt-trousers as loose and tight fit on the thermal mannequin. However, there is no form changes made on the shirts [17].
Chan, A.P., et al. (2005), Kim, K. et al. (2017) and Musilove, B. et al. (2014) examined the relationship between body size and shirt patterns for men's shirts; No form changes were made on the shirts [18-20].
Atasagun et al. (2018) determined the combinations with the highest cooling performance in terms of thermal comfort of office workers; investigated the weaving types and fiber types on the thermophysiological properties of underwear-shirt fabric combinations with objective measurements. Measurements were made only in fabric form and measurements in shirt form were not included [21].
Köroğlu's (2019) examined the emotional comfort of summer shirting fabrics. The parameters affecting users' shirt fabric preferences were evaluated with subjective and objective measurements. As a result of the examination, it has been revealed that factors such as fiber type, fabric design, fabric weight, volume, colour, etc. are effective in summer shirting fabric selection [22].
Atasagun, et al. (2019) in another study studied the effect of fabric properties (fibre types and weaving types) and clothing fit on heat loss through clothing combinations (undershirt and shirt) for different parts of the upper body via a thermal mannequin. A shirt model of normal size and classic pattern was used, and no form changes were made in their study [23].
When the literature research was conducted, it was observed that in studies which manipulation techniques were used, products were examined only in terms of aesthetics and clothing comfort was not taken into consideration and the studies on comfort of shirts were carried out only on men's shirts models and did not include any form changes made with manipulation techniques. Its giving suggestions of form changes made with manipulation techniques on the women's shirt model will add a new perspective to the literature and will provide both an aesthetic appearance in terms of design and improvements in terms of user comfort.
In our previous study [24]: Two simple ways of rolling-up shirt sleeves were investigated through wear trials to discuss how easy-way modifications around arm part can improve the thermal comfort of the shirts. In first wear trial, the woman participant was asked to roll the cuff of shirt sleeve up in two times. In next wear trial, the woman participant was asked to roll the cuff of shirt up in three times. To compare the effects of non-rolled up and simple ways of rolling up shirt sleeves, the average clothing surface temperatures in wear trials (before and after a moderate activity) were obtained via thermal analyses (Flir Ignite Software). A decrease in forehead temperatures was observed at the end of the activity in all wear trials. The temperature drop rates in shirts with rolled-up sleeves are much higher than the one in the shirt with non-rolled up sleeves. What caused this may be that the shirts with rolled-up sleeve tighten the sleeve and through trapping the air layer into the armpit causes sweating. Accordingly, sweating also caused the forehead temperature to decrease.

This study consists of two stages: In first stage, to improve the results obtained from our previous study, two different methods such as folding the sleeve part inwards were added in addition to the simple rolling-up methods. The effects of the form changes on forehead temperature and shirt surface temperatures were examined again. In addition, unlike the previous study, measurements were made regionally (elliptical and rectangular area) on the right arm, left arm and frontal body, rather than measurement points used only right arm in our previous study. In the final stage, the effects of form changes that can be made using manipulation techniques on forehead temperature and shirt surface temperatures were examined.
In this study we investigated several modifications using manipulation techniques instead of simple rolling-up sleeves to make a better comfort feeling. Discomforts feeling (sweating, odor, etc.) usually observe around armpit. The simplest way to decrease the discomfort feelings is making modifications on sleeve part. These kinds of dimensional modifications enable natural ventilation and can improve thermal distribution on clothing surface. This effect that may occur was researched through activity protocol imitates the movements regularly done in office conditions.

2 Materials and Methods

2.1 Materials

The women's shirts having long sleeves were produced by garment producer. In order not to affect the measurements, care was taken to ensure that the shirt model did not feature a functional fabric, had a basic pattern, same size (38-size) and was plain white in colour. Fabric specifications of the shirts are shown in Table 1.

Table.1. Fabric specifications

Material	Weave Type	Fabric Weight (gr/m²)	Warp density (pick/cm)	Weft density (pick/cm)
%50 CO-%50 PES	Plain	120	28	20

The model's pattern information (sleeve length (a), front length (b), chest circumference (c), and waist circumference (d)) were measured. Measurement locations and measurements are shown in Figure 1.

	Measurement locations	Measurements (cm)
	Sleeve length (a)	60
	Front length (b)	62
	Chest circumference (c)	45

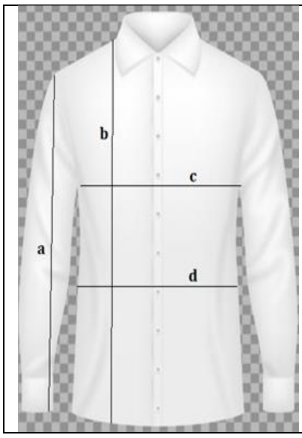	Waist circumference (d)	39

Figure 1. Measurement locations and measurements

2.2 Methods

The women participant was informed about the procedures of the wear trial. A trial room at a temperature of 20± 2°C, relative humidity of 50± 5% was prepared. Before the wear trials, the shirts were hanged on for a whole day and subject was asked to rest for 10 min to accommodate to the room conditions.

Subject was asked to hold both arms straight and stand still. The constant measuring distance while thermal capture and constant body posture were maintained during thermal capturing (Fig.2).

Figure 2 Body posture while thermal camera capture.

Only one wear trial was made each day. In the beginning of procedure, the woman participant wearing the shirt rested 10 min before thermal image capturing. The stand-still body postures were imaged with thermal camera in a constant distance. She was asked to make an activity imitated the movements regularly done in office conditions. In a cycle of activity, she sat on a chair and then stood up, walked to the shelf, put up books through to shelf and repeated this activity in opposite way. She carried out the activity for ten times in a row. After every cycle of activity, the stand-still body postures were imaged. Figure 3 shows four types of rolling up shirt sleeves used in the first stage of study.

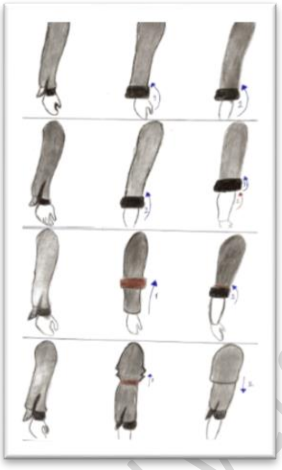

Figure 3 Types of rolling up shirt sleeves.

The cuffs of shirt sleeves were rolled up in wear trials as seen in Figure 3. In the first type, the cuff of the shirt sleeve is rolled up twice. In the second type, the shirt sleeve cuff is rolled up three times. In the third type, the shirt sleeve is folded inwards from the elbow part. In the last type, the shirt sleeve is folded inwards in near the shoulder area. Figure 4 shows the non-applied sleeve and four types of rolling up and folding inwards types in wear trials of first stage.

Figure 4 The types of rolling up and folding inwards in shirt sleeves in wear trials.

Figure 5 shows the form changes made by using manipulation techniques on women's shirts in wear trials of second stage. Hand sewing was preferred as a sewing technique due to the structure of the shirt fabric. There is no shortening on the sleeves of five shirts.

Figure 5 The form changes made by using manipulation techniques in wear trials.

Manipulation techniques applied to shirts' sleeves are mentioned below, respectively:

a- The shirt sleeve was cut lengthwise from shoulder level to below the elbow, and the edges were folded inwards with thin white sewing thread and sewn by hand. The longitudinal slit-cut is attached horizontally with thread in the middle, giving it a two-piece appearance. The technical drawing and opening dimensions of the shirt sleeve with the manipulation technique is shown in Figure 6.

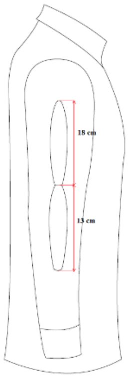

Figure 6. Technical drawing and opening dimensions of the shirt sleeve with manipulation technique (a)

b- The shirt sleeve was cut and shaped in three different sizes (from large to small) in a heart shape from top to bottom, starting from the shoulder. The edges of the shapes are folded thinly inwards and hand-sewn with black sewing thread to create contrast. The technical drawing and opening dimensions of the shirt sleeve with the manipulation technique is shown in Figure 7.

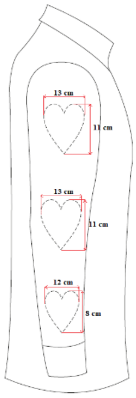

Figure 7. Technical drawing and opening dimensions of the shirt sleeve with manipulation technique (b)

c- Four rows of windows were designed by cutting the shirt horizontally from shoulder level downwards in a rectangular shape. The edges are folded thinly inwards and completed with hand sewing technique using white sewing thread. The technical drawing and opening dimensions of the shirt sleeve with the manipulation technique is shown in Figure 8.

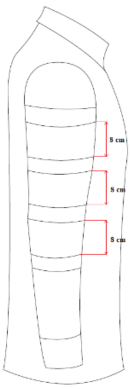

Figure 8. Technical drawing and opening dimensions of the shirt sleeve with manipulation technique (c)

d- The shirt sleeve was cut in three circular rows from larger to smaller, spaced from top to bottom of the shirt sleeve, and sewn around with white sewing thread. The technical drawing and opening dimensions of the shirt sleeve with the manipulation technique is shown in Figure 9.

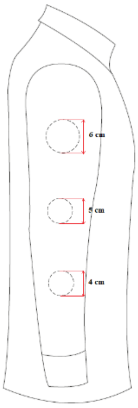

Figure 9 Technical drawing and opening dimensions of the shirt sleeve with manipulation technique (d)

e- Guipure from the lace group, which is one of the ready-made materials such as cord, mortar, buttons, and beads, was used by cutting horizontally above and below the elbow of the shirt sleeve. Guipure preferred in white colour to be compatible with the shirt, was added to the cut parts of the shirt and sewn by hand. The manipulation technique was completed in three rows by attaching the same guipure to the end of the cuff of the arm. The technical drawing and opening dimensions of the shirt sleeve with the manipulation technique is shown in Figure 10.

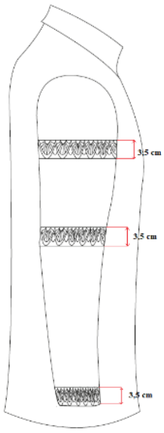

Figure 10 Technical drawing and opening dimensions of the shirt sleeve with manipulation technique (e)

3 Results

3.1. Evaluation the Results of First Stage

Flir Ignite Software (Figure 11) was used for thermal imaging. Five body regions (Bx1, El 1-2-3-4-5) were defined on the right arm, left arm and frontal body. El-1-2-3-4 elliptical measurement regions show the surface temperature distribution of the participant's right and left shirt sleeve, Bx1 rectangular measurement region shows the surface temperature distribution of the frontal body and El-5 elliptical measurement region shows the forehead temperatures.

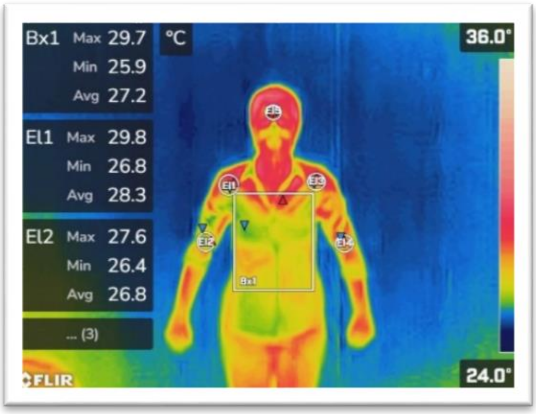

Figure 11. The thermal capture of measuring areas on frontal body.

The appearances of the shirts on the participant are shown in Figure 12.

Figure 12 The appearance of the shirts on the participant

Measurements were made regionally (elliptical and rectangular area) on the right arm, left arm and body of the shirt, rather than pointwise to improve the measurement results.

The participant participated in five wear trials by wearing shirts with sleeves unfolded, shirts with sleeves rolled-up in two and three times respectively, and shirts with sleeves folded inwards. Figure 13 shows the thermal imaging of the participant before the activity (left column) and after the activity (right column) in the wear-trials (wear-trials 1-2-3-4-5, from top to bottom) respectively.

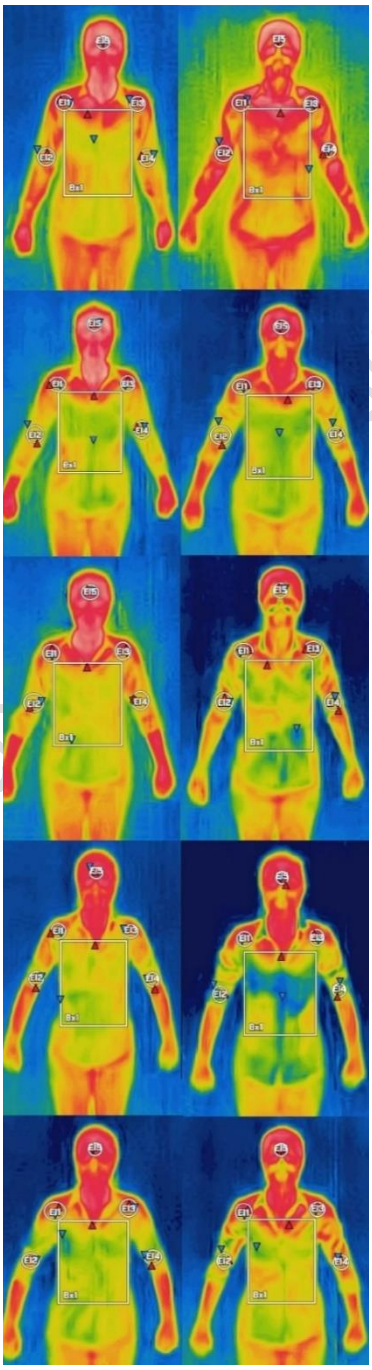

Figure 13 The thermal imaging of subject before and after activity in wear-trials respectively (1-2-3-4-5).

The average surface temperatures and forehead temperatures in the measurement regions on body are shown in Figure 14. The average temperature values in the measurement regions were divided into two groups: before the activity (El 1-2-3-4-5 and Bx1) and after the activity (El 1A-2A-3A-4A-5A and Bx1A).

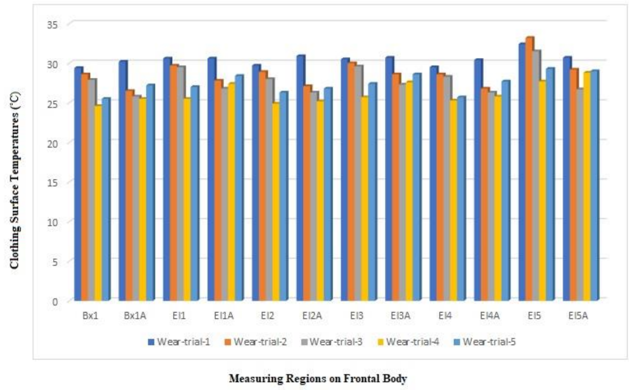

Fig 14. The average surface temperatures on body regions

3.1. Evaluation the Results of Second Stage

The effects of form changes that can be made using manipulation techniques on the entire surface of the shirt sleeve on forehead temperature and average shirt surface temperatures were examined. The appearances of the shirts on the participant are shown in Figure 15

Figure 15 The appearance of the shirts on the participant

As in the first stage, measurements were made regionally (elliptical and rectangular area) on the shirt's right arm, left arm and torso. The participant participated in six wear trials, wearing shirts whose sleeves were not manipulated and shirts whose sleeves were manipulated by different manipulation techniques. Figure 16 shows the thermal imaging of the participant before the activity (left column) and after the activity (right column) in the clothing trials (wear trials 1-2-3-4-5-6 from top to bottom) respectively. In wear-trial 1, shirts without manipulation techniques were used, and in wear-trials 2-3-4-5-6, the shirts shaped by manipulation techniques (a-b-c-d-e) were used respectively.

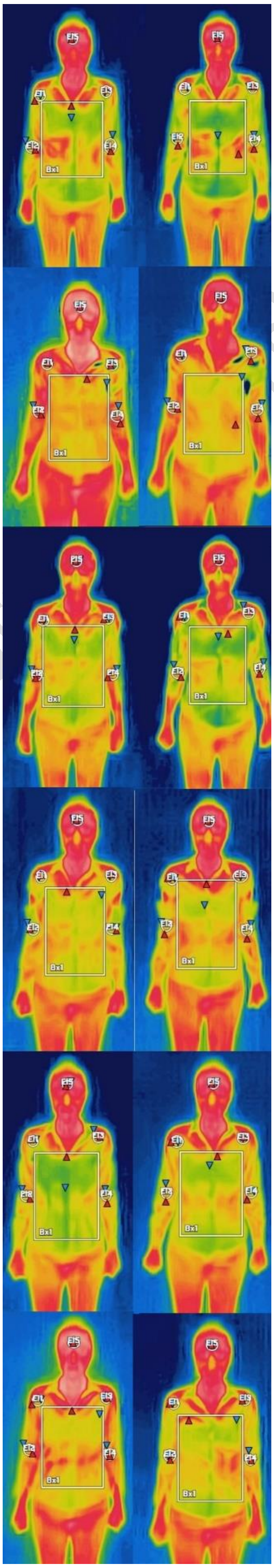

Figure 16 The thermal imaging of subject before and after activity in wear-trials respectively (1-2-3-4-5-6).

The average surface temperatures and forehead temperatures in the measurement regions on body are shown in Figure 17. The average temperature values in the measurement regions were divided into two groups: before the activity (El 1-2-3-4-5 and Bx1) and after the activity (El 1A-2A-3A-4A-5A and Bx1A).

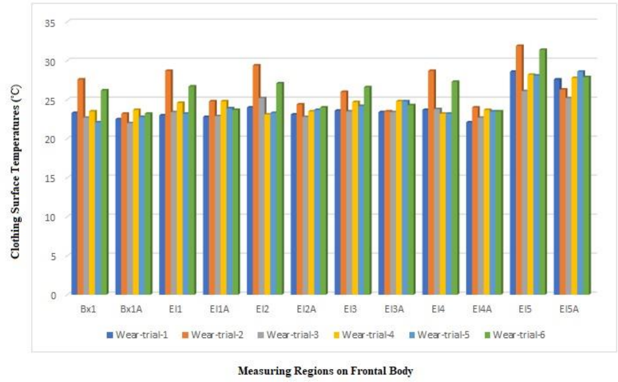

Figure 17. The average surface temperatures on body regions

Figure 18 shows the percentage change of average surface temperatures in measurement regions on the body after activity in wear trials.

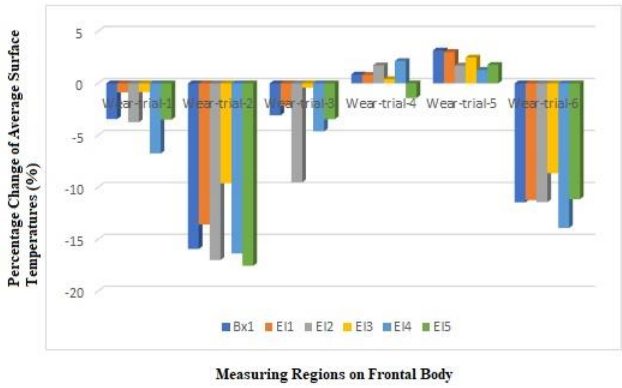

Fig 18. The percentage change of average surface temperatures in measuring regions on the body after activity in clothing trials

4 Discussion

In wear-trial results of first stage, similar results were obtained for simple rolling up types as in the wear-trials in our previous study. Sleeve rolling-up methods changed the microclimate along the sleeves of shirts and caused sweating that also caused surface temperatures to decrease. This is not a desired situation in terms of comfort. However, in addition to the methods in the previous study, an increase in surface temperatures was observed after the activity in the folded-inwards methods used in wear-trials 4 and 5. In these wear-trials, forehead temperature measurement (El5) showed lower values compared to wear-trials using simple rolled-up sleeve. Whereas they increased after the activity. In wear trials 4 and 5, there was no sweating occurred to the extent observed in wear trials 1-2-3. This shows that the method of folding sleeve inwards in wear-trials 4 and 5 provides more efficient results.

In wear trial results of second stage, the largest average temperature decrease percentages were observed in wear trial 2 (manipulation technique a) and wear-trial 6 (manipulation technique e), respectively. An increase in average surface temperatures was observed in wear trial 4 (manipulation technique c) and wear trial 5 (manipulation technique d). In wear-trials 3-4-5, the use of manipulation techniques (b-c-d) that created large openings on the surface enabled the forehead temperature to increase without sweating after the activity. In addition, the openings on fabric surface minimized clothing insulation in thermal camera measurements. Thus, the body surface could be measured directly through the openings and the average surface temperatures were observed to be high. The manipulation technique used in wear trial 2 (a) caused shrinkage in the sleeve section and caused sweating by trapping the air layer in the sleeve section. Sweating also caused surface temperatures to decrease. This is not a desired situation in terms of comfort. The manipulation technique (e) used in wear trial 6 caused sweating and a decrease in average surface temperatures because of not providing sufficient airgaps in the clothing that would improve the thermal comfort of the clothing.

5 Conclusion

This study was carried out with the aim of improving the thermal comfort of classic women's shirts with textile manipulation techniques and providing an aesthetic appearance with techniques such as cutting, gathering, folding and hand sewing on the shirt sleeves and contributing a new perspective to the literature. Wear trials and thermal camera measurements were carried out in two stages to examine the effects of the form changes that can be made in the sleeve part on forehead temperature and shirt surface temperatures.

In the first stage, in addition to the simple rolling-up sleeve methods, two different methods folding sleeve inwards were added and the effects of the form changes that could be made on the sleeve section on forehead temperature and shirt surface temperatures were examined. It has been observed that the folding sleeve inwards method provides a more positive effect after activity than the rolling-up methods. In the second stage, the effect of form changes that can be made using manipulation techniques on the entire shirt sleeve surface was examined. It has been observed in thermal camera measurements that form changes such as shrinking and narrowing, as in the sleeve folding method, change the microclimate along the arm and cause sweating after activity, and the forehead temperature decreases with sweating. Form changes that provided wide openings on the surface provided more positive results.

The experimental results show that form changes on sleeves influence the heat distributions and clothing surface temperatures. Thermal distribution is a key factor on overall clothing comfort. So, form changes enabling natural ventilation in clothing can help to stabilize the heat transfer and make a better comfort feeling in office conditions.

In addition to the form changes that can be made on the sleeves, it is thought that similar form changes around the armpit can also improve clothing thermal comfort, and it is planned to examine the effects of these changes in future studies.

6 Author contribution statements

Author 1 contributed to the article by carrying out thermal camera measurements to compare the results in experiments and tests, evaluating the results and writing the manuscript. Author 2 contributed to the article by manipulating the women’s shirts to improve the natural ventilation.

7 Ethics committee approval and conflict of interest statement

"There is no need to obtain permission from the ethics committee for the article prepared".

"There is no conflict of interest with any person / institution in the article prepared".

8 References

[1] Lei Z. "Review of the study of relation between the thermal protection performance and the thermal comfort performance of firefighters' clothing". Journal of Engineered Fibers and Fabrics, 17,1-9,2022. https://doi.org/10.1177/15589250211068032

[2] Nawaz N. "Development of firefighters' protective jacket for female firefighters offering improved thermal comfort through modification of materials, garment design, construction and fit". PhD Thesis, School of Fashion and Textiles College of Design and Social Context, 2013.

[3] Öner E, Okur A. "Thermophysiological comfort properties of selected knitted fabrics and design of T-shirts". The Journal of The Textile Institute, 106:12, 1403-1414, 2015. DOI: 10.1080/00405000.2014.995931

[4] Öner E. "Çeşitli Liflerden Üretilen Kumaşlardan Yapılan Spor Giysilerinin Termal Konforunun Değerlendirilmesi ve Geliştirilmesi [Evaluation and modification of thermal comfort properties of the sportive garments made from fabrics composed of different fibres]". PhD Thesis, Dokuz Eylül Üniversitesi. 2015.

[5] Çivitci Ş, Dengin S. "Koşu Giysileri Konforunun Kullanıcıları Tarafından Değerlendirilmesi Üzerine Bir Araştırma [A Research on Assessment of Comfort of Jogging Suits by Users]". International Journal of Science Culture and Sport, Special Issue 1, pp.553-569. 2014. DOI: 10.14486/IJSCS126

[6] Kaplan S, Okur A. "The Meaning and Importance of Clothing Comfort: A Case Study for Turkey". Journal of Sensory Studies, 23, 688-706. 2008. https://doi.org/10.1111/j.1745-459X.2008.00180.x

[7] Voyce J, Dafnıotıs P, Towlson S. "Elastic textiles. In: SHISHOO, R. Textile in sport". Woodhead Publishing in Textiles, Cambridge. 2005.

[8] Arık B, İkiz Y, Çalışkan M, Karaibrahimoğlu K. "Determination of tactile properties of shirt fabrics by sensory analysis and physical tests and evaluation of the relation between these two methods". Pamukkale University Journal of Engineering Sciences, 24(7): 1262-1271. 2018.

[9] Berger X. "The pumping effect of clothing", Int. J. Ambient Energy, 9(1), 37–46, 1988. https://doi.org/10.1080/01430750.1988.9675909

[10] Nielsen R, Olesen B.W, Fanger P.O. "Effect of physical activity and air velocity on the thermal insulation of clothing", Ergonomics 28 (12), 1617–1631, 1985. https://doi.org/10.1080/00140138508963299.

[11] Vogt J.J, Meyer J.P, Candas V, Libert J.P, Sagot J.C. "Pumping effects on thermal insulation of clothing worn by human subjects", Ergonomics 26 (10), 963–974, 1983. https://doi.org/10.1080/00140138308963425.

[12] Joshi A, Psikuta A, Bueno M, Annaheim S, Rossi, R. "Effect of movement on convection and ventilation in a skin-clothing-environment system", International Journal of Thermal Sciences, 166 (1), 2021 https://doi.org/10.1016/j.ijthermalsci.2021.106965

[13] Udale J. (Güngör, Translator). "Moda Tasarımında Tekstil ve Moda [Textile and Fashion in Fashion Design]". İstanbul: Literatür Yayınları. 2014.

[14] Akbaş Gürcan, K, İmre H. "The Movements of The Fıber Art in Hıstorıcal Process And Fıber Art Practıces Performed By Usıng Sewıng Technıques". International Journal of Interdiciplinary and Intercultural Art, Vol.4 Issue.7 June-July.pp.101-119. 2019. 10.29228/ijiia.7.76

[15] Hamamcı A, Oyman N.R. "Pamuklu Kumaşlarda Kumaş Manipülasyon Teknikleri [Fabric Manipulation Techniques in Cotton Fabrics]". International Journal of Social and Humanities Sciences Research (JSHSR), Vol.10 Issue.91. pp.221-233. 2023. https://doi.org/10.26450/jshsr.3440

[16] Akpınarlı F, Bulat F. "Tekstil Yüzeylerinin Manipülasyonu Ve Dijital Transfer Baskı Denemeleri [Manipulation of Textile Surfaces and Trialling Of Digital Transfer Printing]". Motif Akademi Halkbilimi Dergisi, Vol.9. Issue.:17. pp.167-186, 2016.

[17] Joshi A, Psikuta A, Bueno M, Annaheim S, Rossi R.M. "Effect of movement on convection and ventilation in a skin-clothing-environment system". International Journal of Thermal Sciences, 166, 1-14, 2021. https://doi.org/10.1016/j.ijthermalsci.2021.106965

[18] Chan A.P, Fan J, Yu W.M. "Prediction of men's shirt pattern based on 3D body measurements". International Journal of Clothing Science and Technology, Vol. 17 No. 2, pp. 100-108, 2005. https://doi.org/10.1108/09556220510581245

[19] Ki, K, Innami N, Takatera M, Narita T, Kanazawa M, Kitazawa Y. "Individualized male dress shirt adjustments using a novel method for measuring shoulder shape". International Journal of Clothing Science and Technology, 29 (2), 215-225, 2017. DOI: 10.1108/IJCST-02-2016-0011

[20] Musilova B, Nemcokova R. "Study of Czech male body proportions and evaluation of men's shirt pattern making methods". Tekstil ve Konfeksiyon, 24 (4), 399-404, 2014.

[21] Atasağun H.G, Okur A, Psikuta A, Rossi R.M, Annaheim S. "Determination of the effect of fabric properties on the coupled heat and moisture transport of underwear–shirt fabric combinations". Textile Research Journal, 88 (11), 1319-1331, 2018. https://doi.org/10.1177/0040517517700192

[22] Köroğlu A.N. "Yazlık gömleklik kumaşların objektif ve subjektif değerlendirilmesi [Subjective and objective evaluation on summer shirt fabrics]". Master Thesis, Pamukkale Üniversitesi, 2019. https://acikbilim.yok.gov.tr/handle/20.500.12812/239107

[23] Atasağun H.G, Okur A, Psikuta A, Rossi R.M, Annaheim S. "The effect of garment combinations on thermal comfort of office clothing". Textile Research Journal, 89 (21-22), 4425-4437, 2019. DOI: 10.1177/0040517519834609

[24] Güney S, Gümüşer T. "An Investigation on the Effect of Rolling Up Women's Shirt Sleeves on Clothing Thermal Distribution". International Conference on Modern and Advanced Research, 81–84, 2023. https://doi.org/10.59287/icmar.