



THE EFFECT OF DART GEOMETRY ON DYNAMIC FIT PERFORMANCE IN CIRCULAR KNITTED FABRICS

Scientific paper
DOI: 10.5937/CT_ITI26228A

Arzu Arslan¹, Banu Hatice Gürcüm²

¹Giresun University, Şebinkarahisar Vocational High School, Department of Design, Fashion Design Prog., Turkey,

E-mail: arzu.arslan@giresun.edu.tr, ORCID ID: 0000-0001-9231-934X

²Ankara Hacı Bayram Veli University, Faculty of Art & Design, Department of Textile Design, Turkey, E-mail: banu.gurcum@hbv.edu.tr, ORCID ID: 0000-0001-9687-9598

ABSTRACT: This study is a research paper aiming to investigate the fit performance of different dart manipulation techniques in garments made from circular knitted fabrics under dynamic body movements. In this research designed in an experimental pattern with a control group, three different dart manipulation techniques (shifting to the shoulder, to front centre, and to side seam) were applied to four different circular knitted fabrics (jacquard interlock, ottoman, three-thread fleece, and rib knit) and a woven fabric as a control group. The samples were evaluated using visual analysis during four basic arm movements (abduction, elevation, flexion, extension). The findings demonstrated that, owing to the inherent elasticity of knitted fabrics, the displacement at the dart apex was lower than that observed in woven fabrics (+1 cm versus +3 cm), and no sensation of tightness was reported for any of the knitted fabric samples. These findings suggest that the influence of dart geometry cannot be considered independently of fabric type, as the two factors jointly affected garment performance. In particular, the centre-front shifted dart technique (P2) provided an excellent fit in rib-knit fabric without causing any surface distortion. In contrast, the side-seam shifted dart technique (P3) resulted in pronounced armhole wrinkles in some fabric types. Findings emphasize the importance of selecting the appropriate fabric–dart combination to optimize dynamic comfort and garment aesthetics, while providing practical guidance for dart design in ready-to-wear knitted garments.

Keywords: Circular knitted fabric, dart manipulation, dynamic fit, garment comfort.

UTICAJ GEOMETRIJE UŠIVAKA NA DINAMIČKE KARAKTERISTIKE PRISTAJANJA KOD KRUŽNO PLETENIH MATERIJALA

APSTRAKT: Ova studija predstavlja istraživački rad čiji je cilj ispitivanje performansi pristajanja različitih tehnika premeštanja ušitaka (dart manipulation) u odevnim predmetima izrađenim od kružno pletenih tkanina tokom dinamičkih pokreta tela.

Istraživanje je sprovedeno prema eksperimentalnom dizajnu sa kontrolnom grupom. Tri različite tehnike premeštanja ušitaka (premeštanje ka ramenu, prednjem središtu i bočnom šavu) primenjene su na četiri različite kružno pletene tkanine (žakard interlok, otomanski plet, troslojni flis i rebrasti plet), dok je tkana tkanina korišćena kao kontrolna grupa. Uzorci su procenjivani metodom vizuelne analize tokom četiri osnovna pokreta ruke (abdukcija, elevacija, fleksija i ekstenzija). Rezultati su pokazali da je, zahvaljujući prirodnoj elastičnosti pletenih tkanina, pomeranje u vrhu ušitka bilo manje nego kod tkanih materijala (+1 cm naspram +3 cm), pri čemu ni kod jednog uzorka od pletenih tkanina nije zabeležen osećaj zatezanja. Dobijeni rezultati ukazuju da se uticaj geometrije ušitka ne može posmatrati nezavisno od vrste materijala, jer ova dva faktora zajednički utiču na performanse odevnog predmeta. Posebno se pokazalo da je tehnika premeštanja ušitka ka prednjem središtu (P2) obezbedila odlično pristajanje kod rebrastog pleta bez pojave deformacija na površini materijala. Nasuprot tome, tehnika premeštanja ušitka ka bočnom šavu (P3) dovela je do izraženih nabora oko rukavnog otvora kod pojedinih vrsta materijala. Rezultati naglašavaju značaj pravilnog izbora kombinacije materijala i tehnike ušitka radi optimizacije dinamičke udobnosti i estetskog kvaliteta odeće, uz pružanje praktičnih smernica za projektovanje ušitaka u konfekcijskoj proizvodnji odevnih predmeta od pletenih materijala.

Ključne reči: Kružno pleteno platno, premeštanje ušitaka, dinamičko pristajanje, udobnost odeće.

1. INTRODUCTION

Textiles primarily include woven and knitted fabrics. Knitted fabrics are formed by interlocking yarn loops, providing high flexibility and extensibility [1]. Among weft-knitted structures, circular knitted fabrics are widely used in apparel because their elasticity enables garments to conform more closely to body dimensions and movement than woven fabrics. Garment performance should be evaluated not only through fabric mechanics but also through anthropometric and ergonomic principles, which support garment fit, comfort, and functionality during movement [2–4]. Garment comfort results from the interaction of fabric properties, pattern design, garment fit, and body movement. Clothing must not only protect the wearer from environmental conditions [5] but also accommodate different body morphologies and postures [6]. Although body type, shape, and posture influence garment fit, the present study employed a standard women's size 40 body to eliminate body-shape variability and evaluate the effects of fabric type and dart manipulation. Because body dimensions change continuously during movement, garments must adapt to these changes to maintain comfort and freedom of movement [7]. Previous research has mainly examined the physical, comfort, and functional properties of knitted fabrics, including the effects of fibre composition, spinning technology, sewing, and manufacturing parameters [8]–[10]. However, limited attention has been given to the interaction between knitted fabric structure and dart manipulation under dynamic conditions. This study addresses this gap by investigating the combined effects of three dart manipulation techniques (KP1, KP2,



and KP3) and four circular knitted fabric types—jacquard interlock, ottoman, three-thread fleece, and rib knit—on garment fit during body movement. A post-test experimental design was adopted, using woven-fabric garments as the control group and circular knitted garments as the experimental groups. Accordingly, this study seeks to answer the following questions:

1. How do different dart manipulation techniques applied to various circular knitted fabrics influence neckline shape and bust dart behaviour during dynamic arm movements compared with woven control samples?
2. How do dart manipulation techniques affect the armhole, side seam, and overall garment silhouette during dynamic movements?
3. How do different dart geometries influence surface deformation characteristics, including folds, ripples, and wrinkles, in circular knitted garments under dynamic body postures?

2. DART MANIPULATION IN GARMENT SHAPING

Dart manipulation is a fundamental patternmaking technique that influences garment fit, three-dimensional shaping, and freedom of movement. By transferring, rotating, relocating, or eliminating darts, different silhouettes can be achieved while preserving garment fit. Although widely applied to woven fabrics, its behaviour in circular knitted fabrics remains insufficiently understood because the elasticity and recovery of knitted structures modify the performance of conventional dart constructions during movement. Garment performance depends on the continuous interaction between the human body, clothing, and the environment [11]. Accordingly, accurate patternmaking is required to transform three-dimensional body geometry into two-dimensional garment patterns while accommodating body shape and movement [12, 13]. Standardized anthropometric measurement systems support accurate sizing and pattern development [14, 15]. Among these, the Müller and Sohn system is widely recognized for its anatomical accuracy and was therefore used to develop all garment patterns in this study [16, 17]. In women's bodice patternmaking, the bust dart is a principal shaping element that controls garment fit [18]. Dart manipulation involves relocating or rotating darts while maintaining garment volume and fit, thereby enabling alternative design solutions without altering the basic garment structure [19]. A dart is a triangular wedge that removes excess fabric to transform a flat textile surface into a three-dimensional form conforming to the human body, particularly around curved regions such as the bust, waist, and hips [20–22]. Structurally, it consists of a dart point, dart legs, and a dart intake, which together determine the degree of shaping achieved [23, 24]. Depending on design requirements, darts may be transferred using slash-and-spread or pivot techniques [19]. Among the various dart types reported in the literature, including French and double-pointed darts [22–24], the straight dart is the most widely used for shaping bodices, skirts, and trousers. Proper construction and sewing are essential for achieving the intended fit and appearance [22, 23]. Because it is the most common bust-shaping method in apparel patternmaking, the present study focuses exclusively on the straight bust dart, to which three different dart manipulation techniques were applied.

3. ANATOMICAL BASIS OF DYNAMIC ARM MOVEMENTS IN GARMENTS

Darts, which provide garments with three-dimensional shaping, are subjected to varying mechanical stresses during body movement. Understanding the interaction between dart geometry, fabric structure, and these stresses requires consideration of the fundamental arm movements used in dynamic garment evaluation.

Body movement continuously deforms garments during daily activities, making ergonomic garment design dependent on three-dimensional conformity with the human body while allowing unrestricted movement [25, 27]. Accordingly, garments should accommodate body shape and provide sufficient ease for everyday activities [28, 29]. Owing to their elasticity, flexibility, and wrinkle resistance, knitted fabrics are particularly suitable for achieving dynamic comfort [30]. Incorporating dynamic anthropometric data into garment design further improves wear performance by accommodating coordinated body movements [31]. Human movements occur around joints within the sagittal, frontal (coronal), and transverse (horizontal) anatomical planes [25, 26]. Because the shoulder is the primary reference joint for upper-limb motion, this study evaluates movements performed in the sagittal and frontal planes. Flexion and extension occur in the sagittal plane, whereas abduction and elevation occur in the frontal plane (Figure 1). Flexion decreases the angle between body segments, whereas extension increases it by returning the joint toward its anatomical position [33–35]. Abduction is the lateral movement of the arm away from the body's midline in the frontal plane [25, 26, 33, 34], while elevation refers to raising the arm above shoulder level [25, 33, 34] (Figures 2 and 3).

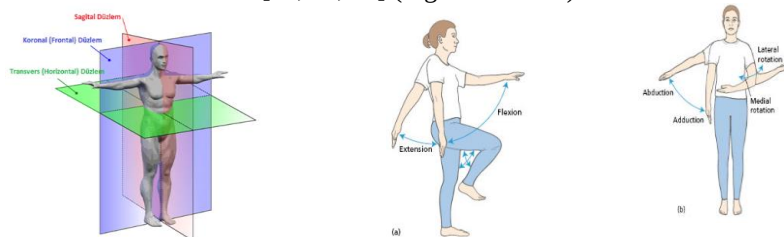


Figure 1 (left): Anatomical planes and axes of the human body [32]

Figure 2 (middle): Flexion and extension movements [26]

Figure 3 (right): Abduction movement [26]

4. EXPERIMENTAL

4.1. Materials

In this study, the control samples were constructed from plain-woven cotton sheeting fabric, whereas the experimental samples were produced using four different knitted fabrics. The control fabric was a finished, firm-handle cotton fabric with a mass per unit area of 138 g/m², a fabric cover factor of 24 × 18 (24 ends/cm and 18 picks/cm) and was woven from Ne 18/1 warp and Ne 20/1 weft 100% cotton yarns. The fabric mass per unit

area was determined in accordance with TSE 251, the warp and weft densities were measured according to TSE 250 EN 1049-2, and the warp and weft yarn lengths were calculated following TSE 254. For the experimental phase of the study, double-knit fabrics were selected based on their suitability for industrial garment manufacturing. The selected fabrics exhibited minimal extension during marker spreading, could be sewn easily on industrial sewing machines, possessed high dimensional stability and structural integrity without excessive stiffness, and had a medium fabric weight. Accordingly, jacquard interlock, Ottoman, three-thread fleece, and rib knit fabrics with a greige fabric weight of 250 g/m² or higher were used (Figure 4).

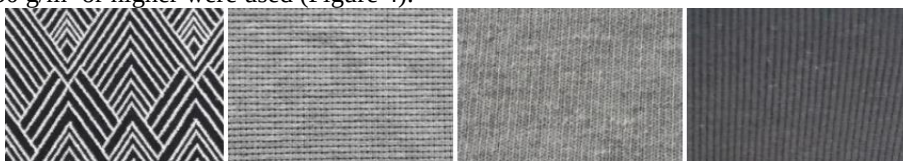


Figure 4 (from left to right): Knitted fabrics used in the study: (a) jacquard interlock, (b) Ottoman, (c) three-thread fleece, and (d) rib knit (Arslan, 2021)

The jacquard interlock fabric had a mass per unit area of 340 g/m² and a greige width of 150 cm. It was knitted using 70-denier polyamide 6.6 covered yarn with a 40-denier elastane core (70/40), Ne 28/1 polyester–viscose (65/35) black yarn, and Ne 30/1 white cotton yarn. The Ottoman fabric had a mass per unit area of 250 g/m² and a greige width of 155 cm. Its composition consisted of 70-denier polyamide 6.6 covered yarn with a 40-denier elastane core (70/40), Ne 28/1 cotton–polyester (50/50) grey yarn, and 150D/48F white polyester filament yarn. The three-thread fleece fabric had a mass per unit area of 265 g/m² and a greige width of 180 cm. It was knitted from Ne 30/1 cotton–polyester (50/50) grey mélange yarn and Ne 20/1 100% carded cotton yarn. The rib knit fabric had a mass per unit area of 280 g/m² and a greige width of 144 cm. It was knitted from Ne 30/1 cotton–polyester (50/50) black yarn.

4.2. Methods

An experimental comparative study with a control group was conducted to investigate the effects of dart manipulation techniques on the dynamic fit of circular knitted garments. Three control garments were produced from woven fabric using three dart manipulation techniques, while twelve experimental garments were prepared by applying the same techniques to four circular knitted fabric types. All samples were developed under standardized conditions and marked with temporary reference lines to facilitate visual evaluation. Each garment was fitted to a standardized mannequin and photographed during four fundamental arm movements: abduction, elevation, flexion, and extension. Dynamic garment performance was assessed through visual analysis of neckline shape, dart behaviour, armhole fit, side-seam alignment, fabric tension, garment conformity, and surface deformations such as folds, waviness, and wrinkles. Observations were recorded using standardized evaluation forms and compared across fabric types and dart manipulation techniques.

4.3. Model Selection and Body Measurements

A healthy female model whose body measurements closely matched the Müller Patternmaking System (size 40) was selected for garment evaluation. Since size 40 represents the average body size of Turkish women, it was adopted as the reference size, and other size groups were excluded from the study. The research focused exclusively on the effects of dart manipulation techniques; therefore, body morphology was controlled by using a single model throughout the experiments. Body measurements required for pattern development were obtained directly from the model using standard anthropometric measurement procedures while maintaining a natural standing posture. All garment samples were developed according to these measurements (Table1). Based on the anthropometric assessment, the model exhibited an apple-shaped endo-ectomorphic body type, characterized by greater fat distribution in the upper body than in the lower body.

4.4. Preparation of the Control and Experimental Samples

The bust darts, shoulder seams, and side seams were sewn with a 2.5 mm stitch length, while standard presser foot pressure and thread tension settings were maintained throughout. To ensure consistency, the knitted fabric samples were produced using the same machine settings and construction procedures, and no non-extensible tape or fusible interfacing was applied to the bust darts. Based on the model's body measurements, a basic bodice pattern was developed according to the Müller Patternmaking System, after which three dart manipulation techniques were applied to generate the experimental pattern variants (Figure 5).

Table 1: Comparison of the standard body measurements of the Müller Patternmaking System (Size 40) and the model's body measurements.

Müller Patternmaking System (Size 40 Standard Women's Body Measurements)		Model's Measurements	
Height	164	Height	161
Bust Circumference	100	Bust Circumference	96
Waist Circumference	76	Waist Circumference	79
Hip Circumference	106	Hip Circumference	104
Sleeve Length	59	Sleeve Length	61



Figure 5: Appearance of the basic bodice, constructed according to the model's body measurements, on the model (Arslan, 2021).

5. RESULTS

This section presents the dynamic fit performance of three dart manipulation techniques (P1: shoulder transfer, P2: centre-front transfer, and P3: side-seam transfer) applied to four circular knitted fabrics and a woven control fabric during four upper-limb movements. The findings are organized according to the research objectives, with detailed visual evaluation results presented in Tables 2–4.



5.1. Findings for Dart Manipulation Technique 1 (Shoulder Transfer)

No neckline deformation was observed in either the woven control or knitted fabric samples during any of the evaluated arm movements (Table 2). The behaviour of the bust dart apex varied according to fabric type. The woven control sample exhibited a **3 cm** upward displacement during all movements, whereas the displacement was limited to **1 cm** in the jacquard interlock, Ottoman, and three-thread fleece fabrics, and **0.5 cm** in the rib knit fabric. Although minor folds developed around the dart during movement, dart geometry remained stable. The reduced displacement observed in the knitted fabrics indicates that their inherent elasticity better accommodated body movement, with the rib knit showing the best performance. The woven control sample exhibited noticeable tension around the armhole, side seam, and body reference line during most movements, with the greatest discomfort reported during extension. In contrast, none of the knitted fabrics showed perceptible tension, regardless of differences in fabric structure or mass (250–340 g/m²). Surface analysis showed pronounced folds in the woven control sample throughout all movements. The knitted fabrics generally exhibited fewer and less severe surface deformations, with the rib knit displaying the least visible folds because its rib structure effectively concealed surface irregularities (Table 3).

5.2. Findings for Dart Manipulation Technique 2 (Centre-Front Transfer)

No neckline deformation was observed in either the woven control or knitted fabric samples during any of the evaluated arm movements (Table 4). The displacement of the bust dart apex varied according to fabric type. The woven control sample exhibited a 2.5 cm upward displacement during all movements, whereas the knitted fabrics showed a maximum displacement of 1 cm. No displacement occurred in the jacquard interlock fabric during extension, while the three-thread fleece fabric developed localized depressions around the dart. Nevertheless, dart geometry remained stable in all samples. Compared with the woven control, the reduced dart displacement in the knitted fabrics demonstrates their superior ability to accommodate body movement through their elastic loop structure. The woven control sample exhibited slight tension around the armhole and side seam, particularly during extension and frontal-plane movements. In contrast, none of the knitted fabrics showed perceptible tension at the armhole, side seam, or body reference line, regardless of differences in fabric structure or mass. Surface evaluation revealed slight to moderate folds in the woven control and most knitted fabrics, with fold severity varying according to fabric type and movement. Jacquard interlock, Ottoman, and three-thread fleece fabrics exhibited longitudinal folds, particularly during elevation and flexion. In contrast, the rib knit fabric showed no visible surface deformation during any arm movement, indicating that Dart Manipulation Technique 2 (centre-front transfer) provided the most compatible and visually stable solution for this fabric type (Table 5).

5.3. Findings for Dart Manipulation Technique 3 (Side-Seam Transfer)

Examination of the neckline in Dart Manipulation Technique 3 (P3) revealed no neckline deformation in either the woven control sample or any of the knitted fabrics during upper-limb movements (Table 6). Differences were observed in the displacement of the bust dart

apex. In the woven control sample, the dart apex shifted 3 cm upward toward the neckline during both frontal- and sagittal-plane movements, accompanied by pronounced folds around the dart while the overall dart geometry remained stable. Additional shoulder-directed folds appeared during abduction and extension and became more pronounced, extending toward the armhole, during elevation and flexion. In contrast, all knitted fabrics exhibited only a 1 cm upward displacement of the dart apex, with no deformation of the dart geometry. Evaluation of the armhole, side seam, and body reference line showed that the woven control sample exhibited tension along the side seam and body reference line, whereas no perceptible tension occurred in the knitted fabrics. Variations in knit structure and fabric mass (250–340 g/m²) did not influence tension behaviour. Surface appearance analysis revealed slight folds in the woven control sample during abduction and extension and more pronounced folds during elevation and flexion. The jacquard interlock fabric showed minor folds during abduction and extension but developed deep pleat-like folds toward the armhole during elevation and flexion. The Ottoman and three-thread fleece fabrics exhibited deep folds around the shoulder, armhole, and bust dart during most movements, although only slight folds occurred during extension in the three-thread fleece fabric. The rib knit fabric showed pronounced folds during frontal-plane movements, slight folds during flexion, and no visible folds during extension. These findings indicate that Dart Manipulation Technique 3 (side-seam transfer) was particularly compatible with the rib knit fabric during extension (Table 7).

Table 2: Appearance of the samples prepared using dart manipulation technique 1 during upper-limb movements

	Woven Fabric	Jacquard Interlock	Ottoman	Three-thread Fleece	Rib Knit
Abduction					
Elevation					
Flexion					
Extension					

Table 3: Dynamic fit performance of dart manipulation technique 1 (shoulder transfer)

Evaluation Criteria	Control (Woven)	Jacquard Interlock	Ottoman	Three-thread Fleece	Rib Knit
Neckline deformation	None	None	None	None	None
Bust dart apex displacement	+1 cm	+1 cm	+1 cm	+1 cm	+0.5 cm
Dart geometry	Maintained	Maintained	Maintained	Maintained	Maintained
Perceived tension	Present	Absent	Absent	Absent	Absent
Surface folding	Pronounced	Very slight	Dependent on movement type	Dependent on movement type	Dependent on movement type

Table 4: Appearance of the samples prepared using dart manipulation technique 2 during upper-limb movements

	Woven Fabric	Jacquard Interlock	Ottoman	Three-thread Fleece	Rib Knit
Abduction					
Elevation					
Flexion					
Extension					

Table 5: Dynamic fit performance of dart manipulation technique 2 (centre-front transfer)

Evaluation Criteria	Control (Woven)	Jacquard Interlock	Ottoman	Three-thread Fleece	Rib Knit
Neckline deformation	None	None	None	None	None
Bust dart apex displacement	+2.5 cm	+1 cm*	+1 cm	+1 cm	+1 cm
Dart geometry	Maintained	Maintained	Maintained	Maintained	Maintained
Perceived tension	Very slight	Absent	Absent	Absent	Absent
Surface folding	Dependent on movement type	Dependent on movement type	Present in all movement types	Dependent on movement type	Absent

Table 6: Appearance of the samples prepared using dart manipulation technique 3 during upper-limb movements

	Woven Fabric	Jacquard Interlock	Ottoman	Three-thread Fleece	Rib Knit
Abduction					
Elevation					
Flexion					
Extension					

Table 7: Dynamic fit performance of dart manipulation technique 3 (Side-seam transfer)

Evaluation Criteria	Control (Woven)	Jacquard Interlock	Ottoman	Three-thread Fleece	Rib Knit
Neckline deformation	None	None	None	None	None
Bust dart apex displacement	+3 cm	+1 cm	+1 cm	+1 cm	+1 cm
Dart geometry	Maintained	Maintained	Maintained	Maintained	Maintained
Perceived tension	Very slight	Absent	Absent	Absent	Absent
Surface folding	Dependent on movement type	Dependent on movement type	Dependent on movement type	Dependent on movement type	Dependent on movement type



6. CONCLUSION

This study investigated the effects of three dart manipulation techniques on the dynamic fit performance of garments produced from four circular knitted fabrics and one woven control fabric. Garment performance was qualitatively evaluated during abduction, elevation, flexion, and extension. The neckline remained stable regardless of fabric type, dart manipulation technique, or movement. In contrast, the woven control fabric exhibited considerably greater dart apex displacement (+2.5–3 cm) than the knitted fabrics, where displacement was generally limited to +1 cm. The rib knit showed the best dynamic conformity under Technique P1 (+0.5 cm), while localized depressions in the three-thread fleece under Technique P2 indicated that fabric bulk also affected deformation.

Noticeable tension occurred only in the woven control sample, whereas none of the knitted fabrics exhibited perceptible tension under any dart manipulation technique, demonstrating the superior dynamic comfort provided by their structural elasticity.

Surface deformation depended on the interaction between dart manipulation technique and fabric type. The centre-front transfer (P2) produced the best performance in the rib knit, with no visible deformation, whereas the Ottoman fabric developed pronounced folds under the same technique. The side-seam transfer (P3) generated deep armhole folds in the jacquard interlock and three-thread fleece fabrics, indicating reduced aesthetic performance. Overall, the centre-front transfer (P2) is recommended for rib knit fabrics, the shoulder transfer (P1) appears suitable for smoother knitted structures, and the side-seam transfer (P3) should be used cautiously because of its tendency to create armhole folds. Future research should incorporate quantitative evaluation methods, larger participant groups, and additional dart types to further improve understanding of dynamic garment fit.

REFERENCES

- [1] Shen, L. (2005). *Encyclopedia of clothing and fashion*. Thomson Gale, United States of America.
- [2] Boğday Saygılı, B. (2012). *Erkek ceketinde vücut-giysi kalıp uyum problemlerinin belirlenmesi ve kalıp önerisi* Doctoral dissertation, Gazi University).
- [3] Tama, D., Cüreklibatır Encan, B., Utkun, E. & Öndoğan, Z. (2013, September 27-29). *Üniversite öğrencilerinin ergonomik açıdan giysilerden beklentilerinin belirlenmesi* [Conference presentation].19. Ulusal Ergonomi Kongresi, Balıkesir Türkiye.
- [4] Çileroğlu, B., Çivitci, Ş. & Özeren, F. (2009, October 22-24). *Kadın pantolon üretimi açısından kalça ve uyluk çevresi ölçülerinin incelenmesi* [Conference presentation].15. Ulusal Ergonomi Kongresi, Konya Türkiye.
- [5] Havenith, G. (2002). The interaction of clothing and thermoregulation. *Exogenous Dermatology*, 1(5), 221–230.
- [6] Çeğindir, N. Y. & Kolcu, N. (2009). Postür problemlili kişilerde giysi ile vücut uyumunun incelenmesi. *Konfeksiyon Teknik*, 173, 68–74.



9. Međunarodna naučna konferencija
„Savremeni trendovi i inovacije u tekstilnoj industriji“
17-18. septembar 2026. Beograd, Srbija

- [7] Şener, H. F & Atmaca, Z. (2009, October 22-24). *Ergonomik açıdan giysilerde yaşanan problemler* [Conference presentation]. 15. Ulusal Ergonomi Kongresi, Konya, Türkiye.
- [8] Dönmez Türkmen, E. & Çeken, F. (2018). Yuvarlak örme makinelerinde kumaş gramajına etki eden faktörler. *Tekstil ve Mühendis*, 15 (71), 32 – 40.
- [9] Balcı Kılıç, G. (2022). Süprem örme kumaşların transfer, geçirgenlik ve gözeneklilik özelliklerinin karşılaştırmalı olarak incelenmesi. *Tekstil ve Mühendis*, 29 (128), 238-248.
- [10] Cüreklibatır Encan, B. & Yıldız, E. Zeynep (2023). Örme kumaşlarda dikim işleminin kumaş özelliklerine etkisinin incelenmesi. *Tekstil ve Mühendis*, 30 (132), 281 – 288.
- [11] Huang, J. (2006). Thermal parameters for assessing thermal properties of clothing. *Journal of Thermal Biology*, 31, 461–466.
- [12] Watkins, P. (2011). *Improving comfort in clothing*. Woodhead Publishing.
- [13] Otieno, R. B. (2008). *Advances in apparel production*. Woodhead Publishing.
- [14] Petrova, A. (2007). *Sizing in clothing developing effective sizing systems for ready-to-wear clothing*. Woodhead Publishing.
- [15] Öztürk, F. & Ok, E. (2011 October, 14-16). *Hazır giyim ürünlerinde kadınların alt-üst beden ölçü farklılıklarından doğan uyumsuzlukların belirlenmesi* [Congress presentation]. 17. Ulusal Ergonomi Kongresi, Eskişehir, Türkiye.
- [16] Mete, F. (2001). Doğrudan vücut ölçülerine dayalı, vücuda tam oturan yeni bir bayan üst beden temel kalıp hazırlama tekniğinin geliştirilmesi. *Dokuz Eylül Mühendislik Fakültesi Fen ve Mühendislik Dergisi*, 3 (2), 69-82.
- [17] Kaftan, H. (2007). *Bayan giysi triko giysi üretimine yönelik kalıp hazırlama, kalıp serileştirme ve kalıpların analizi* [Master's thesis, Selçuk University]
- [18] Taylor, P. J. & Shoben, M. M. (1995). *Giyim sanayi için serileştirme, kuram ve uygulama*. Milli Eğitim Bakanlığı Yayınları.
- [19] Shoben, M. M. & Ward, J. P. (1995). *Kalıp hazırlama ve uygulama profesyonel bir yaklaşım*. Milli Eğitim Bakanlığı Yayınları.
- [20] Ergür, A. (2002). *Tekstil terimleri sözlüğü*. Boğaziçi Üniversitesi Yayınevi.
- [21] Ambrose, G. & Harris, P. (2002). *Görsel moda tasarımı sözlüğü*. Literatür Yayınları.
- [22] Smith, A. (2010). *Dikiş teknikleri*. Truva Yayıncılık.
- [23] Joseph-Armstrong, H. (2010). *Patternmaking for fashion design*. (5th ed.). Pearson Education.
- [24] Jeffreys, C. (2006). *The complete guide of sewing*. Dorling Kindersley.
- [25] Kenhub (2020, August 8) Types of movements in the human body. <https://www.kenhub.com/en/library/anatomy/types-of-movements-in-the-human-body>
- [26] Movement terminology. Musculoskeletal Medicine (nd). Movement terminology. <https://musculoskeletalkey.com/movement-terminology/>
- [27] Erdoğan, Ç. (1999). Bebek-çocuk-genç yaş gruplarında vücut ve giysi ölçülerinin standardizasyonu. *Tekstil ve Konfeksiyon*, 9 (6), 453-460.
- [28] Cottle, F. S., Ulrich, P. V. & Teel, K. P. (2014, October 21-22). *Framework of understanding somatological constructs relative to the fit of apparel* [Conference



- presentation]. 5th International Conference on 3D Body Scanning Technologies, Switzerland.
- [29] Bogović, S., Stjepanović, Z., Cupar, A., Jevšnik, S., Rogina-Car, B. & Rudolf, A. (2019). The use of new technologies for the development of protective clothing: comparative analysis of body dimensions of static and dynamic postures and its application. *AUTEX Research Journal*, 19 (4), 301-311.
- [30] Marmaralı, A., Özdil, N. & Dönmez Kretzschmar, S. (2007). Elastik iplikli düz örme kumaşların ısı konfor özellikleri. *Tekstil ve Konfeksiyon Dergisi*, 17 (3), 178-182.
- [31] Su, B. Ali (2001). *Ergonomi*. Atılım Üniversitesi Yayınları.
- [32] Ölmez, C. (2020, August). Düzlem-eksen ve hareketler. <https://cengizolmez.com/duzlem-eksen-ve-hareketler/>
- [33] Anatomical terms of movement. (2025, September). <https://teachmeanatomy.info/the-basics/anatomical-terminology/terms-of-movement/>
- [34] Köksüz, A. (2019). Her alanda ergonomi. *Sürdürülebilir Mühendislik Uygulamaları ve Teknolojik Gelişmeler Dergisi*, 2(1), 3-24.
- [35] Lumen learning (2020, August). Types of body movements. <https://courses.lumenlearning.com/suny-ap1/chapter/types-of-body-movements/>