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A Study on the Application of Slanted Chest in Women's Clothing Pattern Making from an Ergonomic Perspective

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ABSTRACT

The application of ergonomics in the field of clothing design is becoming increasingly important. This paper focuses on the bust dart technique in women's clothing pattern making, combining ergonomic principles to analyze its anatomical basis, technical classification, and application scenarios. It explores the dynamic comfort evaluation indicators of bust dart design from an ergonomic perspective and its functional optimization and technological innovation in well-fitting clothing design. Through literature review, experiments, and case analysis, this study explores the dynamic comfort evaluation criteria for bust dart design and its functional optimization and technological innovation in fitted garment design. The research finds, that reasonably allocating bust dart volume and optimizing process treatment can significantly enhance the garment's fit and movement adaptability. Additionally, intelligent pattern-making technology can precisely match female body characteristics, achieving personalized and intelligent garment design. Future research should further deepen interdisciplinary collaboration, explore the application potential of adjustable bust dart structures, and promote the continuous innovation and improvement of women's apparel structural pattern-making technology.

KEY WORDS: Ergonomics; Women's apparel; Structural pattern-making; Bust dart technology; Form-fitting

1. Introduction

1.1 Research Background

Clothing serves as the "second skin" of the human body, requiring a balance between functionality and aesthetics. Women's clothing, with its complex body curves and dynamic requirements, places particular emphasis on structural design. As consumers increasingly demand both comfort and aesthetics in clothing, the application of ergonomics in clothing design has become a growing research focus. In the field of clothing design, the application of ergonomics is becoming increasingly important. Traditional pattern-making relies heavily on experience and lacks quantitative analysis of human dynamic characteristics, often resulting in clothing that fits well statically but restricts movement dynamically. While existing research has addressed static garment dimensions, studies on the adaptability of garments to human dynamic characteristics remain insufficient. For example, issues such as the sensation of restriction on the body and friction between fabric and skin during movement have not

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been adequately resolved. In this context, exploring the application of ergonomics in clothing design, particularly in the critical process of bust darting in women's garment pattern making, has become increasingly urgent.

1.2 Research Purpose

This paper aims to explore the integration of ergonomic principles and the technique of bust darting in women's clothing pattern making. By analyzing the anatomical basis, technical classification, and application scenarios of bust darting, a scientific dynamic comfort evaluation index system is constructed. Based on this, an innovative intelligent pattern making technology is proposed to achieve personalized and intelligent clothing design, thereby providing consumers with clothing products that better meet human body needs, while also promoting the continuous advancement of women's clothing pattern making technology.

2. Research Questions

i. How are dart techniques applied in different women's clothing styles and what effects do they achieve?
ii. How do human dynamic characteristics affect dart volume and processing in women's clothing?
iii. What is the synergistic relationship between fabric performance and dart techniques?

3. Literature Review

3.1 Core Ergonomics Principles and Clothing Design Integration

Traditional pattern making relies on static dimensions, while ergonomics requires dynamic parameters, such as 3D scanning-derived chest circumference differences to optimize armhole depth (Karasawa, Furukawa, & Sasaki, 1993). Dart techniques, key for handling chest stereoscopic shaping, adjust front clothing piece dart distribution to eliminate excess fabric caused by chest protrusion, ensuring clothing fits chest curves (Li, 2012).

This is crucial for solving chest-induced clothing airiness and adapting to different styles. Ergonomics emphasizes the coordination of the "human-clothing-environment" system, requiring clothing design to meet physiological (e.g., pressure distribution, breathability) and psychological (e.g., aesthetics, security) comfort. Its applications in clothing include static, dynamic, and environmental adaptation. For static adaptation, Deng (2018) suggests precise chest and shoulder measurements to establish standardized body databases for basic clothing dimensions. For dynamic adaptation, Karasawa et al. (1993) propose analyzing muscle stretching and joint ranges during movement to optimize fabric allowances and structural lines. For environmental adaptation, Huang (2020) recommends selecting functional fabrics based on temperature, humidity, and friction coefficients.

3.2 Application of anthropometry in plate making and classification of chest slanting techniques

Dart techniques are categorized into positive, negative, and composite darts based on application scenarios.

Positive darts suit collarless, loose styles, avoiding front neckline airiness and maintaining simplicity and comfort (Zhu & Cao, 2022). For example, in sporty collarless tops, positive darts prevent chest compression during movement while ensuring good ventilation.

Negative darts, common in fitted women's suits, enhance lapel fitting by dispersing chest darts to armholes or side seams, reducing lapel lifting and enhancing clothing stereoscopic and refinement (Tang, 2020). In business formal wear, negative darts provide sufficient movement space while reducing discomfort from posture changes.

Composite darts combine gathering and dart transfer to balance static shaping and dynamic allowance, meeting both static aesthetics and dynamic adaptability (Ryu & Song, 2022). They are suitable for modern casual suits requiring both appearance and dynamic comfort, enabling multi-functionality across scenarios. Human anthropomorphic also involves analyzing different body types. For individuals with wide chest spacing (>18cm), increasing side seam dart volume prevents front door overlap, ensuring clothing fit and comfort (Feng, 2018). This highlights the importance of personalized adjustments in clothing design based on individual differences. Precise measurement and analysis enable designers to provide suitable solutions for diverse consumers.

Future research can explore integrating intelligent sensor technologies to monitor real-time movement data, body posture, and physiological signals for personalized pattern making (Huang, 2025). However, challenges like technology costs, data processing complexity, and consumer privacy protection persist, necessitating strengthened interdisciplinary industry collaboration to advance ergonomic applications in practice.

3.3 Existing Research Progress and Limitations

Current research focuses on 3D modeling and virtual fitting, dynamic adaptation optimization, and process innovation. Karasawa et al. (1993) used human contour modeling to generate 3D fabric pieces, verifying the rationality of dart volume distribution. Avadanei et al. (2020) proposed geometric corrections for shoulder support structures based on biomechanics to address armpit wrinkles during arm elevation. Tang (2020) experimentally validated that combining negative darts with chest dart dispersion improves lapel fitting, enhancing the appearance and experience of fitted women's suits. However, these studies often focus on single technical aspects, lacking integrated analysis of multi-dimensional ergonomic indicators. Existing research rarely combines physiological and psychological comfort indicators, which are critical for comprehensive clothing adaptation and comfort assessment (Shinozaki, 2002).

Additionally, research on dart techniques across different fabrics, human dynamics, and multiple styles remains insufficient. Fabric properties like elasticity, thickness, and hardness significantly impact dart processes, yet research often focuses on specific fabrics, neglecting dart applications in diverse materials. Similarly, human dynamic research is often limited to single actions or postures, failing to comprehensively address complex human activities.

Future research should deepen interdisciplinary collaboration to explore adjustable dart structures and promote innovation in women's pattern making. Integrating intelligent sensor technologies can enable personalized pattern making based on real-time monitoring of wearer data, enhancing clothing adaptation to human dynamics and improving the wearing experience. However, challenges such as technology costs, data processing complexity, and consumer privacy protection need to be addressed through strengthened interdisciplinary industry cooperation. Existing research on dynamic adaptation has limitations, with insufficient consideration of individual differences in clothing adaptation. There is significant room for

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research in personalized customization, and future studies should integrate multi-disciplinary knowledge to overcome limitations and drive the development of clothing design toward greater intelligence and professionalization.

4. Research Methods This study employs the following methods:

i. Experimental Method: Utilizing advanced CAD software for virtual design and combining it with mannequin draping experiments.

ii. Ergonomic Analysis Method: In-depth analysis of female chest structure and physiological characteristics, comparing male and female chest differences to explore their impact on clothing structure design.

iii. Data Analysis Method: Integrating subjective evaluations and objective measurements. Collecting wearer feedback on clothing comfort and aesthetics, conducting objective measurements, and processing data with statistical software to uncover the relationship between dart design and clothing adaptation, verify design optimization effects, and determine optimal dart design schemes and process parameters.

5. Experimental Process

5.1 Dart Design Key Points Discussion

5.1.1 Chest Dart Dispersion

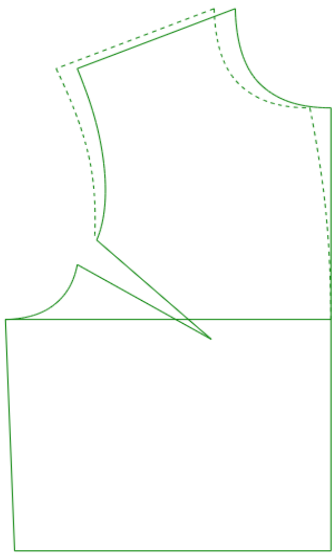


Figure 1: Chest pattern

Figure 2: Effect of shaping the fabric according to the pattern

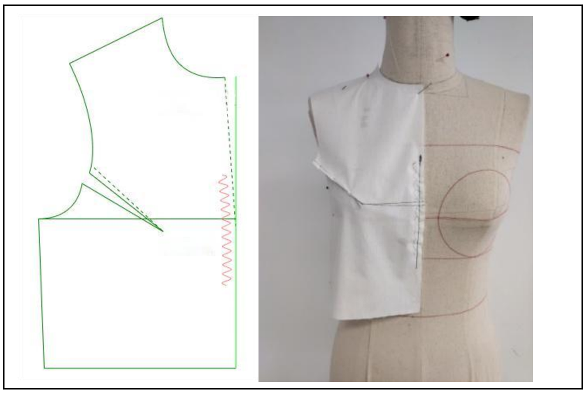
Figure 3: Effect of shaping the fabric according to the pattern

Source: Drawn by the researcher.

In women's clothing shaping, dart volume originates from chest dart changes. Research shows that scientifically decomposing a 2.5cm chest dart into a 1.2cm armhole dart and a 1.3cm side seam dart can reduce lapel lifting and enhance lapel fitting (Tang, 2020). This dispersion optimizes clothing structure balance, improving overall aesthetics and comfort. Male and female chest structures differ fundamentally. In men's clothing design, darts aim to highlight broad shoulders and a full chest to showcase masculinity. In contrast, chest darts in women's clothing are key to shaping natural chest contours, offering flexible forms.

Practical research has shown that in the production of fitted women's clothing, good structural effects can typically be achieved through methods such as bust darts and dart transfers, generally without the need for additional bust dart adjustments. It is also inadvisable to directly adopt men's clothing bust dart design methods. If bust darts are forcefully incorporated into the structure of women's clothing, it may result in excessive extension of the front placket length, leading to issues such as mismatched shoulder width, front chest width, and front shoulder projection, giving the garment an overly robust appearance that conflicts with the feminine, delicate aesthetic. Additionally, in cases where the chest is already naturally curved, extra bust darts can cause gaps at the front placket and an uneven neckline, severely affecting the garment's fit and aesthetic appeal (see Figures 1, 2, and 3).

5.1.2 Scientific Calculation of Dart Volume



Figures 4 and 5: Utilizing the eating position and retraction to flatten the front center chest measurement.

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Source: Drawn by the researcher.

Determining dart volume through scientific calculation is crucial. Research shows a significant positive correlation between chest protrusion and dart volume, with a correlation coefficient of R2=0.78. Chest protrusion is a key factor affecting dart volume. However, fabric elasticity significantly impacts actual dart effects. Therefore, when calculating dart volume, the fabric elasticity coefficient K must be considered. The formula is: S=B×K×0.8, where S is the actual dart volume, B is the chest protrusion, and K is the fabric elasticity coefficient. This provides a theoretical basis for precise dart volume calculation, allowing designers to scientifically determine dart volume based on human characteristics and fabric performance.

For example, for highly elastic knitted fabrics with a large elasticity coefficient K, dart volume can be increased to leverage fabric elasticity, enhancing clothing fit and comfort. For low or non-elastic fabrics like cotton, the small elasticity coefficient K requires reduced dart volume to prevent surface wrinkles and improve aesthetics and comfort.

In this way, designers can accurately determine the amount of bust darting in different design scenarios (see Figures 4 and 5) based on specific human body characteristics and fabric properties, thereby achieving the best fit for clothing in both static and dynamic states.

5.2 Process and Material Synergy

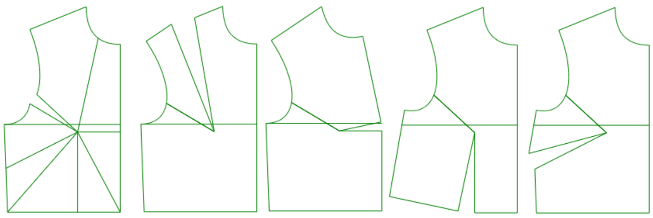

Figure 6: Direct collection method for provincial road transfers

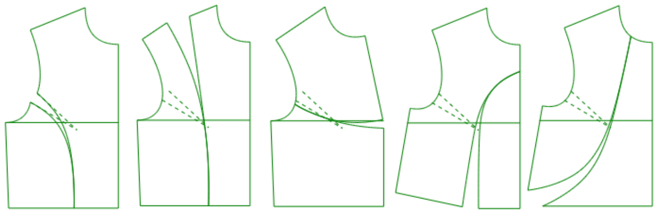

Figure 7: Direct collection method for provincial road segmentation

From the perspective of clothing design, the characteristics of different fabrics significantly influence the application of the bust dart technique, specifically manifested in the following two aspects:

Application of wool-blend fabrics in formal clothing designs: Wool-blend fabrics, due to their high elasticity, are particularly suitable for the bust dart technique. When adjusting the bust dart allowance, this fabric better maintains the three-dimensional shape and dimensional stability of the garment. For example, when designing tailored women's suits or business formal wear, this characteristic of wool-blend fabrics ensures that the garment maintains a consistent fit and elegant appearance throughout wear. The stability and elasticity of this fabric enable the shaping technique to effectively enhance the overall elegance and durability of formal wear.

The application of cotton fabrics in casual clothing styles: Unlike wool-blend fabrics, cotton fabrics have relatively poor elasticity. Therefore, when applying the bust dart technique, it is necessary to reduce the amount of dart transfer to avoid wrinkles on the garment surface, which could affect both aesthetics and comfort. For example, when designing casual shirts or loose dresses, excessive dart transfer may cause cotton garments to wrinkle during wear, reducing the garment's visual appeal and wearing experience (Feng, 2018). Therefore, designers should carefully consider the distribution and treatment of darts when working with cotton fabrics to ensure the garment's smoothness and comfort (see Figures 6 and 7).

5.3 Dart Optimization in Collarless Designs

Table 1: Optimization Scheme for Slanted Chest in Collarless Designs

Method	Description	Advantages	Limitations	Applicable Fabric	Optimal Correction Scheme
Rear Neck Width Adjustment	Transfers dart volume to rear neck to avoid front neckline airiness	Avoids front neckline airiness	May affect rear neck comfort; low overall score	Not specified	Poor
Shoulder Line Lowering	Corrects shoulder slope to eliminate allowance; suitable for lightweight fabrics.	Good comfort enhancement	Limited fabric adaptability; moderate aesthetics	Lightweight fabrics	Poor
Front Center Allowance Collection	Hides allowance indoor line as an invisible dart	Balances simplicity and functionality; highest overall score	No obvious limitations	Highly elastic knitted fabrics	Optimal

Source: Drawn by the researcher.

In studying the optimization of the slanted chest in collarless designs, this study identified three methods for handling excess fabric in straight-neck collarless designs and analyzed their respective advantages and disadvantages. First, the back neckline width adjustment method effectively avoids the problem of the front neckline gaping by transferring the slanted chest allowance to the back neckline. But it may affect rear neck comfort, resulting in a low overall score. Second, the shoulder line lowering method corrects shoulder slope to eliminate allowance, suitable for lightweight fabrics and effective in enhancing comfort. However, it has limited fabric adaptability and moderate aesthetics (Huang, 2020). Third, the front center allowance collection method hides allowance in the door line as an invisible dart, balancing simplicity and functionality.

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Experimental results show the highest overall score, particularly suitable for highly elastic knitted fabrics, achieving good comfort and aesthetics (Li, 2012). Thus, the front center allowance collection method proves optimal for collarless designs (see Table 1).

In clothing design, considering users' body differences is crucial for personalization and comfort. For individuals with wide chest spacing （over 18cm), their body characteristics demand higher requirements for clothing fit. Designers need to precisely increase the side seam dart volume during the dart process to avoid front door overlap, ensure fit, and enhance comfort. This fine-tuned adjustment reflects the value of ergonomics in modern clothing design. Ergonomics emphasizes a human-centered approach, using precise measurements and analysis of human dimensions to offer suitable solutions for consumers of different body types. Designers can use 3D scanning technology to obtain detailed human data for accurate pattern making and cutting (Karasawa, Furukawa, & Sasaki, 1993).

In summary, the application of ergonomics in clothing design, especially personalized adjustments for body-shape differences, can enhance clothing fit, wearing comfort, and consumer satisfaction. In the future, with the development of smart sensing and 3D modeling technologies, clothing design will better adapt to human dynamic changes. This will achieve personalized customization, meet consumer needs, and promote the clothing industry's development towards intelligence and human-centeredness (Shinozaki, 2002; Huang, 2025).

6. Discussions

The Application of the Picked-Up Chest Technique in Diverse Garment Styles: While this study has examined the application of the picked-up chest technique in several common styles such as collarless and fitted women's suits, the actual garment market features a wide variety of styles that are constantly evolving and innovating. How to better integrate the sloping chest technique into more innovative and complex design styles, such as pleated designs, asymmetrical structures, and three-dimensional cutting, remains a topic worthy of further exploration. Additionally, factors such as the target consumer groups and wearing occasions for different styles must be considered to ensure the harmonious integration of functionality, aesthetics, and market acceptance in clothing design.

Future Trends in Intelligent and Personalized Pattern Making: With the continuous advancement of technology, intelligent sensing technology has brought new opportunities to clothing pattern making. Future research can further explore how to integrate intelligent sensing technology to real-time monitor the wearer's movement data, body posture, physiological signals, and other information, achieving true personalized pattern making. This not only meets the personalized needs of different consumers but also enables clothing to more accurately adapt to the dynamic changes of the human body, enhancing the wearing experience. However, this field currently faces challenges such as technical costs, data processing complexity, and consumer privacy protection. The industry needs to strengthen interdisciplinary collaboration to tackle these challenges and drive the deep transformation of ergonomics from theory to industrial practice.

7. Conclusion

This study confirms that the ergonomic approach to bust darting can effectively balance the static aesthetic appeal and dynamic functionality of clothing. By reasonably allocating the amount of bust darting and optimizing the manufacturing process, the fit, comfort, and movement adaptability of clothing can be significantly improved across various types of women's apparel styles, providing scientific theoretical foundations and practical guidance for women's apparel design. However, the application of the bust dart technique must also consider factors such as style diversity, intelligent trends, and individual differences. Future research should move toward more comprehensive, personalized, and intelligent directions to meet the ever-changing market demands and consumer expectations, driving the continuous innovation and improvement of women's apparel structural pattern-making technology.

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