A Comparative Study on the Influence of Body Shape on the Fit and Functionality of Stretch Knit Garments

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Abstract

Stretch knit garments have gained popularity for their adaptability, comfort, and ability to accommodate diverse body shapes. However, ensuring an optimal fit remains a challenge, particularly given the variability in the wearer's body shapes, specifically in women's upper body garments. This research explores the correlation between body shape and the fit and function of stretch knit garments.

Garment fit is a multifaceted concept that encompasses both design aesthetics and alignment with the wearer's body contours, which is especially crucial for stretch fabrics. Achieving the right fit requires optimisation between body shapes, measurements, and ease allowance. The garment design should complement the natural curves and contours of the body, ensuring wearer comfort and aesthetic appeal. This study examined the impact of body shape on the fit and functionality of stretch knit garments, utilising three Alvanon dress forms (UK sizes 10, 12, and 14) utilizing Cole (2015) pattern drafting method tailored for stretch knit garments. Body measurements were obtained using a size stream 3D body scanner, informing pattern development. Fit was accessed visually using digital Alavforms and Browzwear VStitcher.

The findings underscored the critical role of considering the wearer's body shape in garment design and pattern development. Neglecting this aspect can lead to critical fit issues, indicating a gap in current pattern drafting methods. Moreover, this study highlights the necessity of engineered fit solutions tailored to diverse body shapes, rather than relying on generalised approaches. By establishing the intricate interplay between body shape and garment fit and function, this research contributes to the development of more inclusive and accurately fitting stretch knit garments, enhancing wearer satisfaction, comfort, and functionality at the same time employing advanced digital tools.

Keywords: Anthropometry, biomechanics, digital prototyping, women's stretch knit pattern cutting, garment fit, virtual try-on

1. Introduction

The integration of stretch garments into the apparel industry has revolutionised fashion by offering a seamless blend of comfort, fit, and style. Stretch fabrics, defined by their ability to extend and recover, have become indispensable in modern wardrobes, catering to a wide array of activities ranging from everyday wear to high-performance athletic gear [1, 2] . Elastomeric fibres such as spandex and Lycra have been pivotal in this transformation, enabling garments to accommodate various body movements and shapes without compromising aesthetics [3, 4] . As the apparel industry continues to evolve, stretch fabrics will inevitably remain central to advancements in clothing technology and design, ensuring that comfort and style are intricately linked. Given the rising consumer demand for both comfort and functionality in clothing, understanding the influence of body shape on the fit and performance of stretch garments is essential for driving innovation and enhancing user satisfaction.

The analysis of body shape is essential, as individuals with identical key measurements may possess different body shapes, necessitating distinct clothing designs for an optimal fit [5, 6]. Moreover, existing systems for producing custom clothing may not be able to modify patterns in areas that require extreme pattern alteration to accommodate participants with significantly different body shapes from the original body chart and fit model. Body scanning technology is capable of capturing detailed data on points, lengths, surfaces, shapes, and volumes, surpassing the capabilities of other measurement systems.

This comprehensive data collection provides a deeper understanding of body proportions and their interaction with clothing [7, 8], for a proper analysis of body shape.

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1.1. Clothing biomechanics

Biomechanics is a field of study that focuses on analysing the mechanical properties of the human body, including its kinematics, dynamics, and behaviour during physical activity. Its applications involve examining the mechanical structure, strength, and mobility of humans for engineering purposes. Since clothing is in close contact with the human body, mechanical interactions occur between clothing, muscles, skin, and tissue at various body parts during movement and activity [9]. The shape and fit of the garment in relation to the human body, as well as the pressure and friction exerted by the garment on the body, are among the factors that affect this aspect [10].

Clothing serves not only as a covering for the body, but also as an element that interacts with the body and its movements in a biomechanical manner [11]. The pressure exerted by clothing on different body parts depends on the mechanical properties of those parts, with fleshy regions generally being better at withstanding pressure compared to bony areas. However, it is crucial to meticulously consider the distribution and magnitude of pressure to prevent the restriction of blood supply and the onset of discomfort or debilitation [12]. Designers must be aware of the sensitivity of body parts where major blood and lymph vessels lie, as disregarding these considerations can lead to unpleasant sensations such as rubbing, chafing, localized pressure development, and restriction of movement [9,11]. Therefore, biomechanical considerations are crucial in the design of clothing, especially for specialized clothing classes such as sportswear and body sculpting garments [11, 10].

1.2. Aims and objectives

This study analyses how variations in body shape, particularly the concave and convex contours of women’s body, affect the fit and functionality of stretch knit garments. The findings will contribute to the development of more accurate and adaptable pattern drafting techniques for stretch knit garments that can improve fit across different body shapes.

2. Methodology

This study involved the drafting and analysis of body shape on fit of stretch knit parametric patterns for women’s upper torso garments using the Alvaforms in sizes UK 10, 12, and 14. The pattern drafting process was guided by Cole's (2015) method [15], which is specifically tailored for stretch knit fabrics. The patterns were drafted using the Seamly2D pattern design software. Initially, a base pattern was drafted for the Alvaform size 12 model. This served as the foundational pattern, from which the size 10 and size 14 patterns were derived. The latter patterns were generated by updating the measurement chart within the Seamly2D software to reflect the respective measurements for sizes 10 and 14.

Measurements for the dress forms were captured using Size stream body scanner, following the guidelines provided by the authors of the three selected pattern drafting methods. This approach ensured the preservation of the originality and integrity of the method guidelines. The drafted patterns were applied to Alvanon digital Alvaforms corresponding to UK sizes 10, 12, and 14 for visual fit evaluation. Browzwear VStitcher was utilised for digital fit assessment, considering pressure map readings visually.

2.1. Shape Analysis

To analyse the body shapes represented by the different Alvaform sizes, the slice tool in Size Stream software was used to capture circumferential measurements at various key body locations: chest at underarm, bust, under bust, waist, stomach, abdomen, and hip and exported as dxf files. Then the exported dxf files were imported to CorelDraw software for further processing and analysis. The analysis focused on comparing the differences between circumference measurements and height measurements across the different Alvaform sizes. This allowed for an in-depth understanding of how body shape variations within and between the Alvaforms influence garment fit. Table 1. depicts the measurements which were used to extract the relevant measurements. The reference codes used in Table 1. will be used in the main text, figures and the tables.

Table 1. Measurements considered for shape analysis.

	Size stream reference name		Reference code
Measurement name	**Circumference(Circ)**	**Height(CircH)**	
Chest at underarm	C01c_Chest_at_Uarm	C01xly_Underarm_Height_L	Ch_Uarm_Circ/CircH
Bust	B01c_ChestBust_Circ_TM_072c	B01h_ChestBust_Circ_Height_072h	Bust_Circ / CircH
Under bust	U01c_UnderBust_Circ_TM_075c	U01h_UnderBust_Circ_Height_075h	Un_Bust_Circ/ CircH
Waist	W01c_Waist_SoB_2_Circ_TM_105c	W01h_Waist_SoB_2_Circ_Height_105h	Waist_Circ / CircH
Stomach	S20c_Stomach_Circ_TM_083c	S20h_Stomach_Circ_Height_083h	Stomach_Circ / CircH
Abdomen	A01c_Abdomen_Circ_TM_084c	A01h_Abdomen_Circ_Height_084h	Abdomen_Circ / CircH
Seat	S01c_Seat_CircTM_086c	S01h_Seat_Circ_Height_086h	Seat_Circ / CircH
Hip	H01c_Hip_CircTM_085c	H01h_Hip_Circ_Height_085h	Hip_Circ / CircH

The visual pressure map data generated during the fit evaluation were then compared with the results from the shape analysis. This comparison was aimed at understanding the relationship between body shape, fit, and the functional performance of the garments.

3. Results and discussion

3.1. Influence of body shape on clothing fit

The drafted patterns showed misfits in various areas, especially the shoulder (deltoid area), upper arm circumference, lower arm circumference, and wrist (Fig.1). The main reason behind these was the improper engagement of the garment to the dress form shape, size, and proportions. In the shoulder area, particularly over the deltoid region, the patterns did not adequately accommodate the convex shape of the shoulder, leading to a tight, restrictive fit. This issue arose from the pattern's inability to capture the rounded, prominent form of this region, which will result in discomfort and limited mobility in dynamic environments.

Similarly, the upper and lower arm circumferences presented fit problems because the patterns did not fully account for the natural curvature and tapering of the arm. The upper arm, with its convex shape, and the lower arm, which transitions from a convex to a more concave form toward the wrist, require careful consideration in pattern design. The failure to incorporate these shape variations will lead to garments that are either too snug, restricting movement, or loose, disrupting the intended silhouette and causing the fabric to bunch or sag. Therefore, it is imperative that a pattern designed for an individual's body is harmonious with the body shape and proportions of that specific individual.

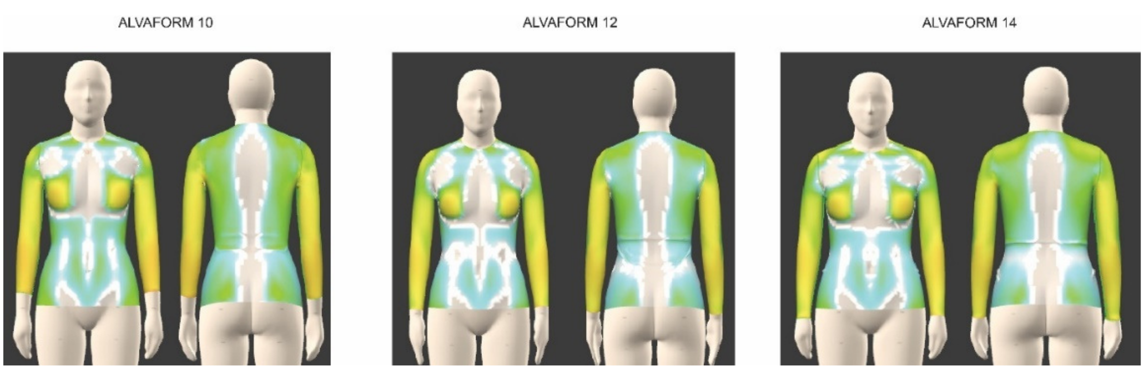

Fig. 1. Digital pressure map visualisation of the drafted patterns.

3.2. Dress form circumference cross-sectional analysis

The analysis of the selected Alvaforms' circumference measurements illustrates the variations in circumference measurements across three different Alvaform sizes 10, 12, and 14. The analysis highlighted several key insights into the proportional changes in body shape across different sizes as demonstrated in Table 2.

The analysis of circumference measurements across sizes 10, 12, and 14 revealed several patterns. The difference between Ch_Uarm_Circ -Bust_Circ shows a reduction, where size 14 indicates a larger bust. The Bust_Circ - Un_Bust_Circ difference is consistently positive across all sizes, indicating a proportional expansion in the bust area relative to the under-bust as size increases (Fig.2).

The Un_Bust_Circ -Waist_Circ difference is consistently positive, with size 12 showing a slightly larger tapering effect. Waist_Circ -Stomach_Circ and Stomach_Circ -Abdomen_Circ circumference measurements show increasing negative differences with size, indicating larger stomach and abdomen circumferences compared to the waist, particularly in larger sizes. Finally, the Abdomen_Circ -Seat_Circ and Seat_Circ -Hip_Circ display negative differences, with the seat circumference slightly larger than the hip circumference, especially in sizes 10 and 14, suggesting more significant expansion in these areas.

Table 2. Circumference measurements variation within and between the Alvaforms UK size 10,12, and 14 (cm).

				ALVAFORM SIZE		
Circumference measurement name	**10**	**12**	**14**	**10 and 12**	**12 and 14**	**10 and 14**
Ch_Uarm_Circ -Bust_Circ	1.53	0.41	-0.49	1.12	0.91	2.03
Bust_Circ - Un_Bust_Circ	12.25	12.27	12.27	-0.02	-0.01	-0.03
Un_Bust_Circ -Waist_Circ	4.83	5.14	4.83	-0.31	0.31	0.00
Waist_Circ -Stomach_Circ	-8.75	-9.18	-9.82	0.43	0.64	1.07
Stomach_Circ -Abdomen_Circ	-5.81	-6.68	-6.66	0.87	-0.02	0.86
Abdomen_Circ -Seat_Circ	-11.10	-5.23	-10.54	-5.86	5.31	-0.56
Seat_Circ -Hip_Circ	-1.74	-0.45	-0.27	-1.28	-0.18	-1.47

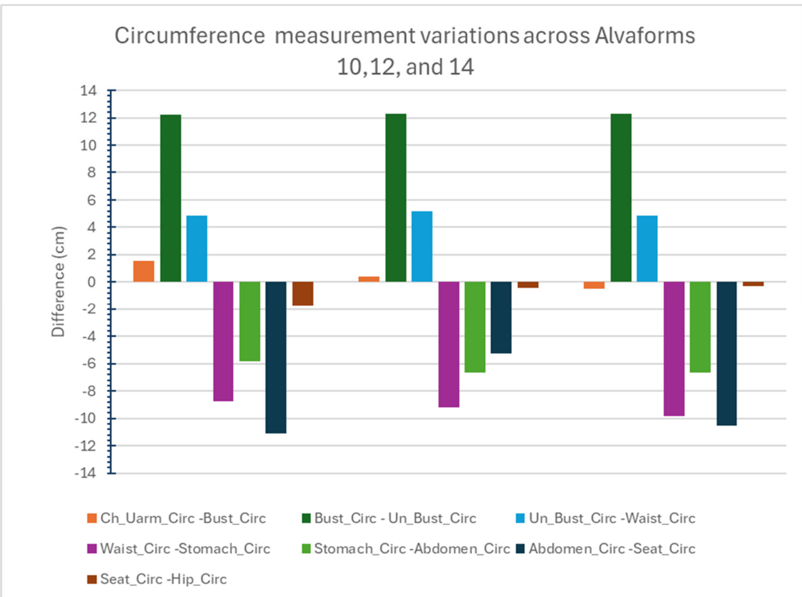

Fig. 2. Circumference measurement variations across the selected Alvaforms.

The women's body exhibits a variety of concave and convex contours, as illustrated in Fig.4. In the process of pattern-making, it is crucial to consider not only two-dimensional measurements but also the complex anatomical curves of the body. Pattern technicians must account for these curvatures to ensure that the garment provides an appropriate distribution of pressure. For example, in the bust circumference; mammary region, the garment's geometric topology should conform to the anatomical shape, balancing the pressure at the bust apex and effectively distributing it across the entire region, extending towards the lateral aspects of the breast. When a garment is worn, the fabric deforms in response to the movements of the underlying skin, especially in close-fitting and body-contouring garments. In the mammary region, the fabric stretches widthwise to accommodate the convex shape of the breast, leading to increased proximity between the skin and the garment. As the fabric extends from the midline of the body (concave) towards the apex point (convex) along the bust span, the proximity between the garment and the skin intensifies, with the closest fit occurring at the apex point (Fig.3.).

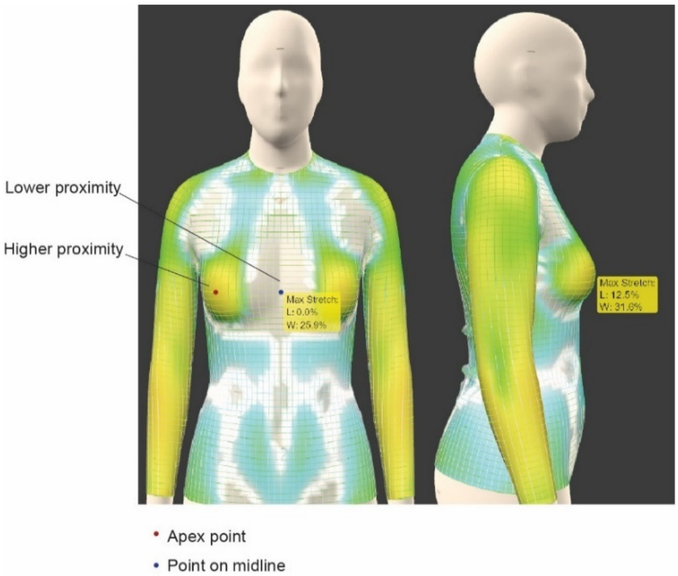

Fig. 3. Engagement of body curves on garment fit.

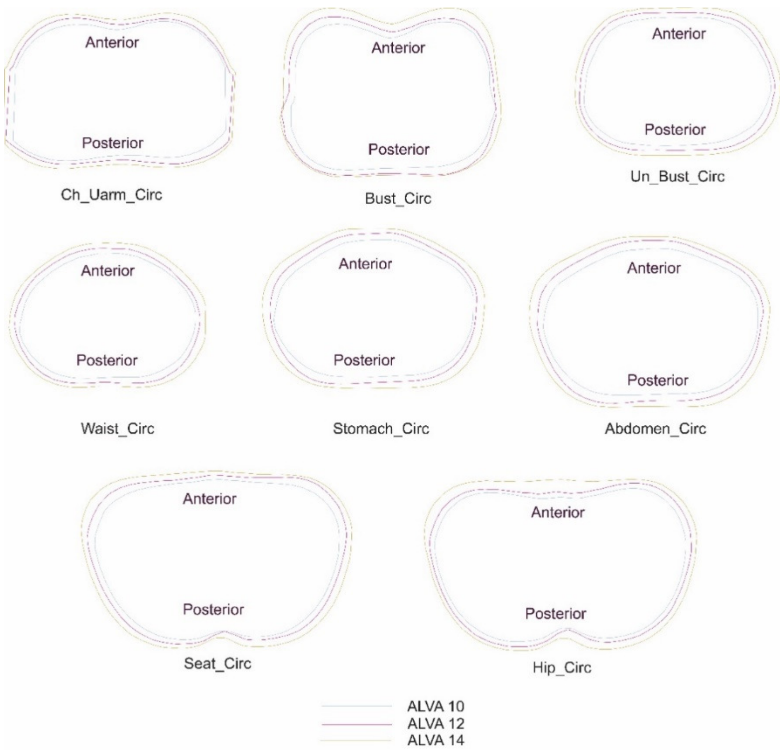

Fig. 4. Cross-sectional views of the circumference measurements of Alvaforms UK size 10,12, and 14.

3.3. Alvaforms circumference measurement height variations

The difference between Ch_Uarm_CircH -Bust_CircH shows a progressive increase in difference as size increases, with the bust height becoming more pronounced in size 14 (Table 3.). This suggests that the upper torso, particularly the bust area, expands significantly as body size increases. In contrast, Bust_CircH - Un_Bust_CirH decreases from size 10 to size 14, indicating a reduction in tapering between these two regions in larger sizes. The bust and under-bust measurements become more similar in size 14, pointing to a more uniform distribution of volume in the upper torso as shown in Fig. 5.

The data for Un_Bust_CircH -Waist_CircH remains relatively consistent across all sizes, with size 12 exhibiting a slightly larger difference. This indicates a more defined waistline in this size compared to sizes 10 and 14, though the differences are small overall. The Waist_CircH -Stomach_CircH shows a clear trend of increasing disparity with larger sizes, with size 14 displaying the largest gap. This suggests that the stomach area expands more than the waist as body size increases, resulting in a less defined waistline, particularly in the larger sizes.

When examining the difference between Stomach_CircH -Abdomen_CircH, the data shows a slight but consistent increase across sizes, reflecting a steady growth in abdomen height. However, the differences remain small, indicating that the relative proportion between the stomach and abdomen remains largely consistent as the body size increases. The difference between Abdomen_CircH - Seat_CircH is more pronounced in size 12 compared to sizes 10 and 14, indicating that size 12 has a more prominent torso region in terms of abdomen and seat height.

Lastly, the Seat_CircH -Hip_CircH shows the most significant change, with a marked decrease as body size increases, particularly from size 12 to size 14. This suggests that the hip region becomes more prominent and fuller in size 14, with the seat and hip measurements converging more closely. The smaller difference between these two measurements in larger sizes points to a more rounded and evenly distributed lower body shape. Overall, the analysis of the circumference differences and circumference height differences reveals that as body size increases, the body becomes fuller and more evenly distributed, with particular emphasis on the torso in size 14.

This implied that as body size increases, the convexity of the body contours also increases, resulting in the garment fitting more closely to the body. Therefore, rather than adhering to fixed numeric values across size ranges, ease should be distributed carefully depending on the body shape of the wearer.

Table 3. Circumference measurements height variation within and between the Alvaforms UK size 10,12, and 14 (cm).

	ALVAFORM SIZE					
Height measurement name	**10**	**12**	**14**	**10 and 12**	**12 and 14**	**10 and 14**
Ch_Uarm_CircH -Bust_CircH	5.81	6.20	6.99	-0.39	-0.79	-1.18
Bust_CircH - Un_Bust_CirH	6.27	5.91	5.47	0.36	0.43	0.80
Un_Bust_CircH -Waist_CircH	7.64	7.97	7.91	-0.34	0.06	-0.28
Waist_CircH -Stomach_CircH	6.50	6.79	6.91	-0.30	-0.11	-0.41
Stomach_CircH -Abdomen_CircH	3.42	3.74	3.79	-0.32	-0.05	-0.37
Abdomen_CircH -Seat_CircH	10.94	11.81	11.54	-0.87	0.28	-0.59
Seat_CircH -Hip_CircH	5.13	3.54	1.77	1.59	1.78	3.36

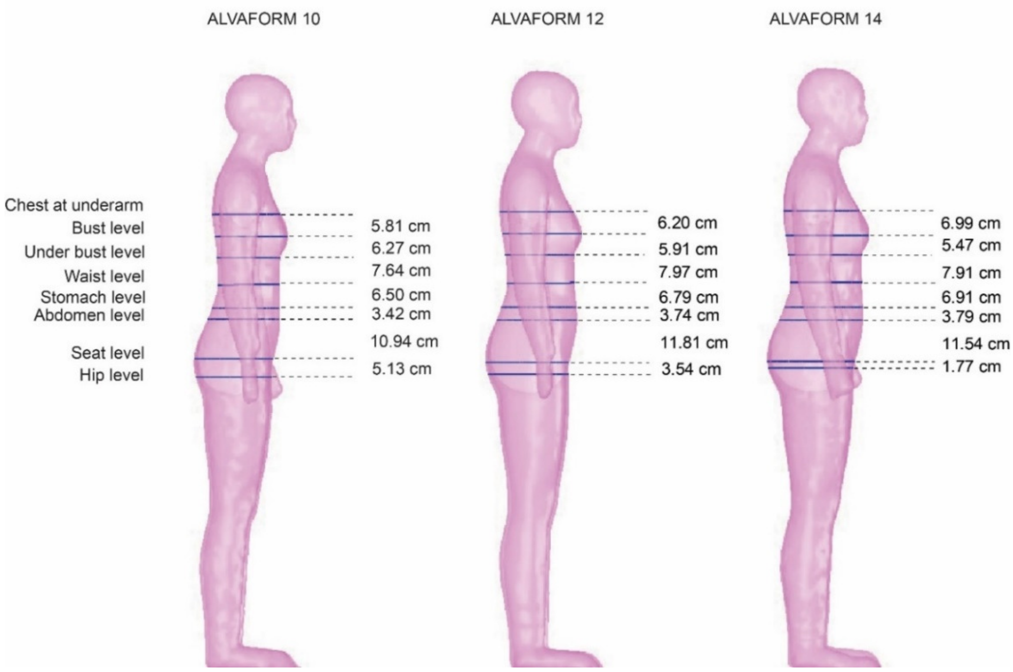

Fig. 5. Side view of the selected Alvaforms respective to the height of the circumference measurements.

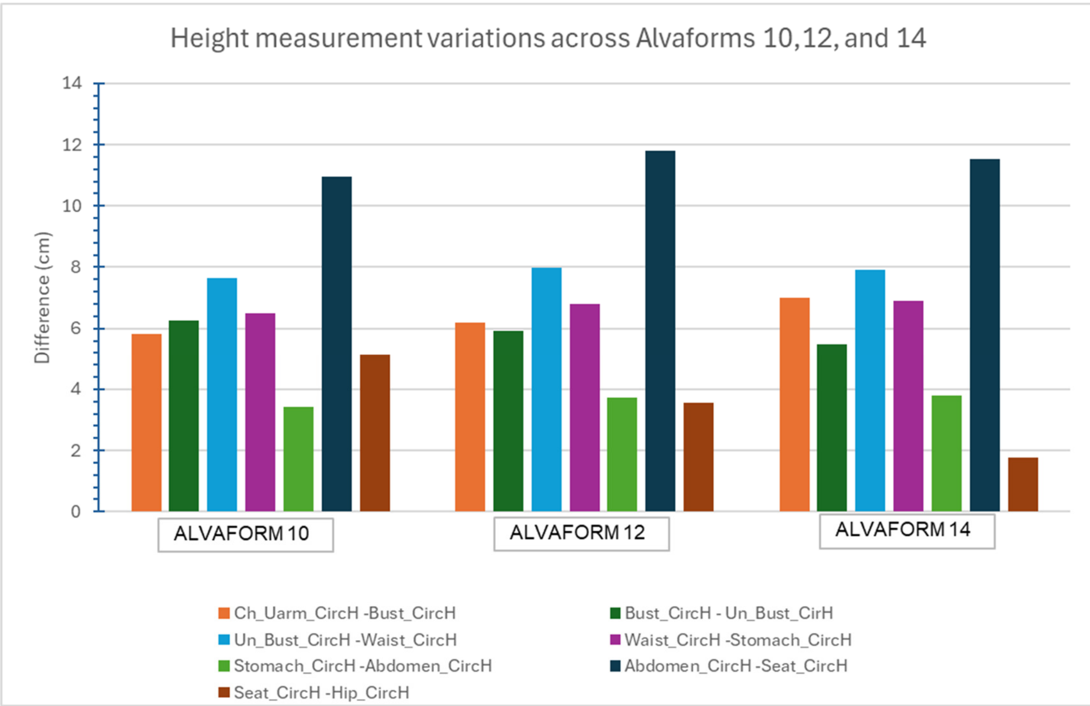

Fig. 6. Height measurement variations across the selected Alvaforms.

4. Conclusion

In conclusion, this study highlighted the critical importance of accounting for nuanced body shapes in the pattern drafting of stretch knit garments. The findings reveal that as body size increases, the proportional differences in both circumference and height measurements across the upper torso become less pronounced, suggesting a more uniform distribution in larger sizes. The consistent expansion of the bust area relative to the under-bust, along with the steady decrease from the under-bust to the waist, underscores the need for precise pattern adjustments to accommodate these changes. Additionally, the more significant expansion of the stomach, abdomen, and seat areas, particularly in sizes 10 and 14, indicates that careful attention must be paid to these regions to ensure a smooth transition and avoid discomfort or poor fit. Rather than rigidly adhering to proportional measurement charts and fixed ease values, garment pattern development should adopt a more realistic and scientific approach by considering the diverse body shapes of individuals.

The study's insights into the relationship between body shape and garment performance have significant implications for enhancing the precision of stretch pattern drafting. By addressing the concave and convex contours of the body, designers can create better-fitting garments that improve comfort, aesthetics, and overall wearer satisfaction. This research is particularly valuable in the fashion industry, where the demand for personalized, well-fitting garments continues to grow, driving the need for innovative approaches to garment design and construction. Furthermore, by increasing the sample size to analyse the variations in body shape, a better understanding of the proportionality of body measurements can be obtained. This will further reinforce the automated pattern creation.

Limitations

The research exclusively examined the standard Alvaforms of UK sizes 10, 12, and 14. As a result, future studies will prioritize an in-depth analysis of body measurement variations within different sizes to better comprehend the integration of anthropometrics and biomechanics in pattern development to achieve optimal engineered garment fit.

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