

Body-to-Pattern Relationships in the Neck–Shoulder Region: A Comparison of 3D Scan-Derived Body Measurements and Fitted Bodice-Block Dimensions

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Abstract

Three-dimensional (3D) body scanning provides detailed anthropometric data, but how individual scan-derived dimensions are re-expressed in a fitted two-dimensional (2D) pattern remains unclear, particularly without deliberate ease. This exploratory study examined selected pattern-body relationships in the neck and shoulder regions of fitted female bodice blocks.

Three Alvanon mannequins (sizes 10, 12, and 24) were each scanned five times using a Size Stream 2020 scanner, and the mean value of each selected scan-derived measurement was used in the analysis. Close-fitting calico bodice blocks were draped without a predefined ease allowance, aligned with scan-derived landmarks, flattened, and digitised in Seamly2D. Body and pattern dimensions were paired by shared landmark endpoints and matching geometric functions, and pattern-to-body ratios were compared descriptively. An angle-matched reference construction evaluated the angular component associated with the open bust dart in front shoulder drop.

Across all cases, the front and back neck-depth pattern-body ratios ranged from 77.12% to 85.25% and from 47.73% to 61.61%, whereas the corresponding neck-width pattern-body ratios ranged from 104.68% to 115.01% and from 114.38% to 122.51%. Front shoulder length remained near numerical equivalence (98.61%–100.00%), while back shoulder length was greater (117.90%–119.41%). The unadjusted front shoulder-drop pattern-body ratio ranged from 141.67% to 208.79%; the angle-referenced range was 76.92%–83.62%, reducing the cross-case range by approximately 90%.

The selected dimensions were therefore not transferred through uniform scaling. Body-pattern differences may include flattening- and construction-mediated positional effects and should not automatically be classified as garment ease. The proposed landmark-aligned procedure supports systematic examination of 3D-to-2D dimensional translation, but based on three mannequin cases, does not establish universal ratios or a predictive pattern-construction method.

Keywords: 3d body scanning, digital avatar, human measurement, apparel engineering

1. Introduction

Conventional drafting methods and sizing systems have long underpinned clothing manufacture, using proportional rules, ease allowances and grading techniques to produce garment blocks across a broad range of body sizes [1]–[3]. However, the range of body measurements used to derive these blocks remains limited and was established largely through manual anthropometry. Consequently, the relationship between a particular body reference that is difficult to capture manually and its corresponding pattern dimensions is not always explicit. McKinney et al. [4], for example, found inconsistent body-to-pattern measurement and shape relationships in women's trouser drafting methods and associated these inconsistencies with the use of non-corresponding or standard measurements, proportional ease, and trueing and blending procedures. More recent analysis of women's upper-torso drafting methods has similarly indicated that traditional drafting rules involving limited use of direct body measurements do not always make body-to-pattern relationships sufficiently explicit for automated digital prototyping [5].

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Three-dimensional (3D) body scanning has become an important tool for apparel anthropometry, body-shape analysis, sizing-system development, virtual fitting and made-to-measure garment development. Compared with manual anthropometry, 3D scanning provides a richer digital representation of the body surface, including landmark coordinates, circumferences, widths, depths, heights and surface arcs, thereby providing more detailed information about body dimensions and morphology [6]–[9]. Research using 3D body data has demonstrated several routes for generating or adjusting garment patterns. Kim and Kang [10] generated two-dimensional (2D) garment patterns from body-scan and garment-surface data through geometric modelling and surface mapping. Griffey and Ashdown [11] developed an automated basic skirt-block process from 3D scans, while Gill et al. [12] examined how the larger set of measurements available from body scanning could better inform traditional block construction.

Yan and Kuzmichev [13] provide the most directly relevant precedent for the neck region. Their virtual e-bespoke men's shirt method extracted pattern-oriented variables from 3D body meshes, including neck circumference width and front and back neck depths. The scan-derived neck width was then converted into pattern indices by direct combination with predefined ease allowances to generate the front and back neck widths of the shirt pattern, respectively. This work established a useful correspondence between neck-region body measurements and front and back neckline features. Together, these studies establish the feasibility of scan-informed pattern generation. Their emphasis, however, was on pattern generation rather than on isolating how an individual 3D body dimension is geometrically re-expressed as its corresponding 2D pattern dimension. This distinction is important because the human torso is generally a non-developable surface, whereas conventional garment panels are cut from flat textile sheets. Surface-flattening research has shown that deformation, darts, material anisotropy, grain direction, seams and distortion constraints can affect the planar representation of a fitted 3D surface [14]–[16]. Consequently, where predefined ease is incorporated, an observed body–pattern difference may contain both the geometric effects of 3D-to-2D translation and intended ease, making these two components difficult to isolate.

Additionally, although 3D body scanning provides substantially richer information about body geometry and several scan-to-pattern routes have been demonstrated [10]–[12], existing studies have not established a generally accepted basis for selecting which scan-derived variables should drive individual pattern features [4], [5], [12], [17]. Standardised scan-derived measurements are defined primarily through anthropometric landmarks, reference planes and body-surface geometry to support consistent body description and anthropometric databases [9], [18]; these definitions do not, by themselves, specify how a body measurement should be incorporated into garment-pattern construction. Consequently, two related questions remain insufficiently investigated: which scan-derived body measurements should correspond directly to particular pattern dimensions, and how these body references are geometrically re-expressed when a fitted three-dimensional surface is represented by a two-dimensional pattern [4], [5], [12], [17]. Addressing these questions requires examining the relationship between a 3D body surface and the flattened pattern of a fitted textile bodice without a predefined ease allowance, while retaining the darts and other construction features required to accommodate body form.

Accordingly, this exploratory study investigates how selected scan-derived body dimensions are re-expressed as corresponding 2D pattern dimensions in the neck and shoulder regions of fitted bodice blocks. Close-fitting calico bodice blocks were physically draped on three scanned mannequins without a predefined ease allowance, then flattened; the scan data were used for comparison with pattern rather than for pattern generation. In this respect, the study adopts Yan and Kuzmichev's [13] general principle of associating neck-region body references with corresponding front and back pattern features but applies that correspondence in a different analytical direction by comparing the draped-and-flattened pattern dimensions back with their body references. Using shared landmarks and matching geometric functions, selected 3D body measurements were paired with corresponding pattern dimensions, and pattern-to-body ratios were used to compare the direction and magnitude of these relationships across the three cases. An angle-referenced comparison further assessed the construction-mediated contribution of the open bust dart to the apparent front shoulder-drop relationship. The study therefore provides an exploratory basis for examining 3D-to-2D dimensional translation while retaining garment-construction logic, rather than proposing a universal pattern-construction method.

2. Methodology

The study comprised five stages: (1) establishment of the selected physical landmark references, which following the Size Stream 2020 scanner system definitions except for the ISO-defined SNP—followed by five repeated scans of each mannequin, generation of the digital avatars, extraction of landmark data, and averaging of selected measurements across scans; (2) draping of a fitted calico bodice block using these established landmark references; (3) transfer of selected body landmarks onto the calico; (4) flattening and Seamly2D digitisation while preserving the landmark positions and pattern geometry; and (5) landmark-aligned body–pattern dimension pairing, ratio calculation, and visual comparison. The descriptive analysis was limited to the neck and shoulder regions of the bodice block.

2.1. Samples and 3D Body Scanning

Three Alvanon mannequins (sizes 10, 12, and 24) were selected as controlled comparative cases, enabling pattern-body dimension relationships to be examined across size variation without the posture or movement variability associated with human participants. Each mannequin was scanned five times using a Size Stream 2020 (SS20) 3D body scanner. Each scan generated a digital avatar containing the system-default landmarks and 200 custom measurements. For every selected SS20-derived measurement, the five scan values were averaged, and the arithmetic mean was used as the corresponding body measurement (M_i) in the subsequent pattern-body comparisons and ratio calculations. The SS20 scanner was provided by the Apparel Design Engineering (ADE) group at the University of Manchester, which also defined the custom measurement set. The OBJ scan files were opened in Size Stream Studio (v5.2.9) for landmark inspection and measurement extraction.

The SS20 coordinate system was established during scanner calibration. The X-, Y-, and Z-axes corresponded approximately to the left-right, vertical, and anterior-posterior directions, respectively, and each landmark was recorded by its X, Y, and Z coordinates. The coordinate datum (X_0 , Y_0 , Z_0) was defined by the scanning system: Y_0 represented ground level, while X_0 and Z_0 were determined by the fixed calibration-board position; the Z datum lay close to the anterior-posterior position of the crotch point. Scan-derived measurements included inter-landmark arcs that subdivided circumferences, circumference and landmark heights, transverse widths, and anterior-posterior depths. Because the calibration board and mannequin position remained fixed during scanning, this common datum supported consistent landmark-based comparison across the three avatars.

With the exception of the side neck point (SNP), the selected physical landmarks corresponded directly to their SS20-derived positions and required no positional adjustment. The SNP was defined separately on each mannequin before scanning, in accordance with ISO 8559-1:2017 [18], as the intersection of the neck-base line and the anterior border of the trapezius muscle, with reference also to the neck-landmark interpretation adopted by Yan and Kuzmichev [13]. The same ISO-defined SNP was used for the relevant scan-derived measurements and subsequently transferred to the fitted calico bodice block, thereby maintaining a common landmark reference between the body and pattern dimensions. Table 1 defines the selected landmarks, and the left panel of Fig. 1 illustrates their alignment and transfer.

2.2. Fitted Bodice Draping and Flattening

A close-fitting calico bodice block was produced on each mannequin by three-dimensional draping with minimal deliberately added ease, allowing the textile to conform closely to the body while retaining the construction features of a practical bodice block. The selected landmarks were manually transferred from the mannequin onto the calico while the bodice remained on the body. After draping, each calico bodice block was removed from the mannequin, flattened, and transferred to pattern paper without seam allowance, while preserving the neckline, shoulder lines, dart geometry, and transferred landmark positions. This process is also illustrated in Fig. 1, using Alva 10 as the representative case. The apex was included solely as an alignment reference and was not analysed in the present study.

The physical patterns were subsequently digitised and reconstructed in Seamly2D. The transferred landmarks and essential construction points were recreated from the corresponding pattern lines, retaining the common landmark alignment required to pair each selected SS20 body measurement with its digital pattern counterpart. Accordingly, each selected dimension was represented as a 3D scan-derived body measurement (M_i) and a corresponding 2D digital pattern dimension (P_i). Seamly2D facilitated consistent measurement and direct comparison of these paired dimensions. Fig. 1 also shows the selected pattern dimensions for Alva 10; their definitions and corresponding body-dimension pairings are specified in Section 2.3.

Table 1. SS20 Landmarks usage for study [17],[19].

SS2020 Measurement	Code	Measurement Description
Neck Back	NKB	The point where the back of the neck base intersects the shoulders [19]
Neck Front	NKF	The Point where the front of the neck base intersects the shoulders [19]
Side Neck Point	SNP	The point where the left and right side of the neck intersects the chest, just in front of the shoulder spine [19]; The SNP is the intersection of the neck base line and the anterior border of the trapezius muscle [17].
Neck Base Circumference	NK Circ	Neck base circumference go through NKF, SNP Left, NKB and SNP Right [19].
Shoulder Point	SHD	The point of greatest curvature along the front silhouette of the shoulder on left and right [19].

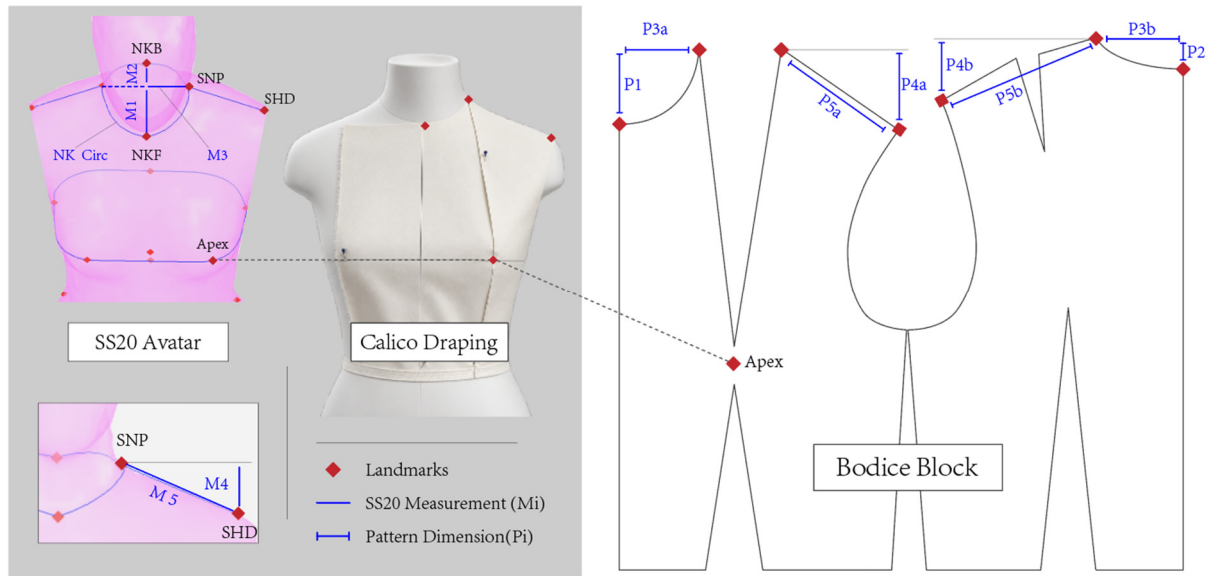


Fig. 1. Alignment and transfer of selected neck-shoulder landmarks from the scan-derived body geometry to the fitted calico bodice block (left), and the corresponding dimensions on the flattened bodice block (right), illustrated using Alva 10.

2.3. Pattern-Body Definition Pairs and Ratio Definition

To establish directly comparable variables between the 3D body and the flattened bodice block, selected SS20 body measurements were paired with 2D pattern dimensions using shared landmark endpoints and a matching geometric function (depth, width, drop, or length). Body measurements are denoted by M_i , and the corresponding pattern dimensions by P_i . Each pair defines an analytical correspondence and does not assume numerical equality or a predefined ease allowance. Pattern dimensions were measured on the analysed half-bodice map, while bilateral body references were reduced using the region-specific rules stated below.

For each established pattern-body pair, the proportional relationship between the 2D pattern dimension and the corresponding 3D body measurement was quantified as:

$$R_i = \frac{P_i}{M_i} \quad (1)$$

In Eq. (1), i is a generic index identifying any one of the selected pattern-body dimension pairs included in the analysis, rather than a mannequin or sample number. For an individual mannequin, R_i indicates whether and to what extent the pattern dimension is proportionally expanded ($R_i > 1$), approximately equivalent ($R_i \approx 1$), or compressed ($R_i < 1$) relative to its body reference. For the same dimension pair, comparison of R_i across the three mannequins was used to identify cross-case directional trends in its 3D-to-2D translation. An increasing, decreasing, or relatively stable sequence therefore indicates a change in the proportional pattern expression of that body dimension, rather than a change in the absolute pattern or body measurement alone. These trends were interpreted descriptively and were not treated as population-level morphology coefficients. Additionally, letter suffixes in the dimensional labels (e.g., a, b) distinguish multiple pattern expressions paired with the same body measurement. For

example, the front and back neck-width relationships are evaluated as P3a/M3 and P3b/M3, respectively. The region-specific construction of each pattern-body pair is described below.

2.3.1. Neck Region

The front and back neck dimensions (P1-P3b) were paired with SS20 measurements derived from the neck-base region. As illustrated in Fig. 2, the neck base was operationally represented as front and back surface regions separated by the transverse chord joining the left and right side neck points (SNPs). Half the length of the SNP-to-SNP chord defined the common body neck-width reference (M3).

At SS20 system, a bilateral mean SNP reference was established by averaging the X-, Y-, and Z-coordinates of the left and right SNPs. From this averaged position, the sagittal-plane straight-line distances to the neck front point (NKF) and neck back point (NKB) defined the front and back neck-depth references M1 and M2, respectively. The common junction shown in Fig. 2 therefore represents the projected bilateral mean SNP position rather than a separately assumed intersection of the three measurements. This representation drew on the neck-region concepts reported by Yan and Kuzmichev [13], [17] and was further informed by the regional measurement logic of the custom SS20 measurement set developed by the Apparel Design Engineering (ADE) group.

On the bodice block, P1 and P2 represent the corresponding front and back neck drops, whereas P3a and P3b represent the front and back neck widths. The same M3 reference was paired with both P3a and P3b because the two pattern sections originate from the same transverse body half-width but express it independently after flattening.

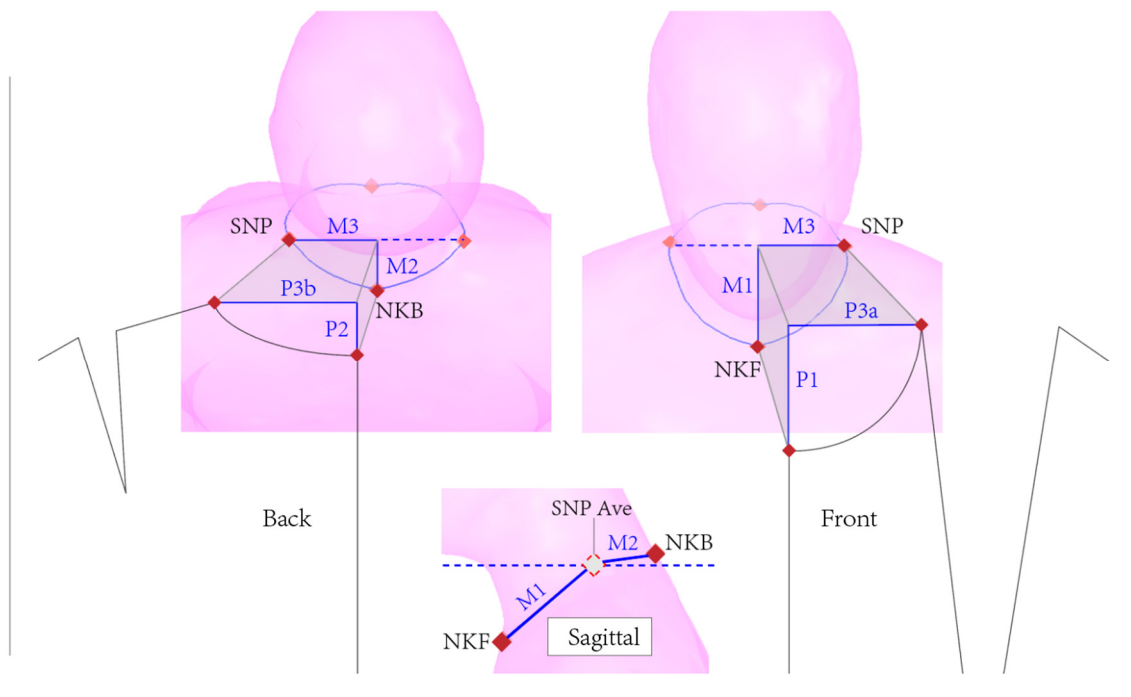


Fig. 2. Landmark-aligned correspondence between the SS20 neck measurements (M1-M3) and pattern dimensions (P1-P3b), illustrated on Alva 10.

2.3.2. Shoulder Region

As Fig.3 illustrated, the shoulder mapping was defined from the bilateral SNP-to-shoulder-point (SHD) landmark pairs. The mean of left and right absolute Y-coordinate differences defined the body shoulder-drop reference (M4), while the mean of the left and right SNP-to-SHD surface-path lengths defined the body shoulder-length reference (M5). Because (M5) follows the shoulder surface and may include slight curvature, it was not treated as a Euclidean straight-line chord. For visual interpretation only, the landmark relationship was represented by a schematic right-triangle projection, in which M4 corresponds to the vertical component and M5 is associated with the general oblique direction of the shoulder surface. The auxiliary projection point was located at the intersection of the horizontal line through SNP and the vertical line through ShD. This conceptual construction support the understand of mapping principle from body to pattern at this region.

On the Bodice Map, P4a and P4b represent the front and back shoulder drops, while P5a and P5b represent the corresponding shoulder lengths. The front and back pattern dimensions were paired with the same M4 and M5 body references, respectively, allowing their independent two-dimensional expressions to be compared.

On the 3D body, the SNP is a single anatomical landmark. In the flattened front bodice map, however, the open bust dart represents this body-referenced landmark through two separated pattern positions: the neck-side position (SNP_N), which terminates the front neckline, and the shoulder-side position (SNP_S), from which the front shoulder line begins. These positions correspond to the same body SNP when the bodice is formed, while their separation records the dart opening in the flattened pattern. Consequently, the original front shoulder-drop dimension P4a also reflects the angular discontinuity between the two dart-adjacent pattern sections.

To account for the angular discontinuity introduced by the open bust dart, an angle-matched reference construction was used (Fig.4). The oriented angle between the horizontal datum through SNP_N and the neck-side dart leg was first determined. The same oriented angle was then reproduced through SNP_S relative to the shoulder-side dart leg, thereby establishing an equivalent shoulder-side reference datum. The perpendicular distance from the shoulder point to this reference line was defined as the angle-referenced front shoulder-drop trace, P4a_{AR}. Only the measurement datum was re-expressed; no dart transfer, dart relocation, or rotation of the pattern section was performed.

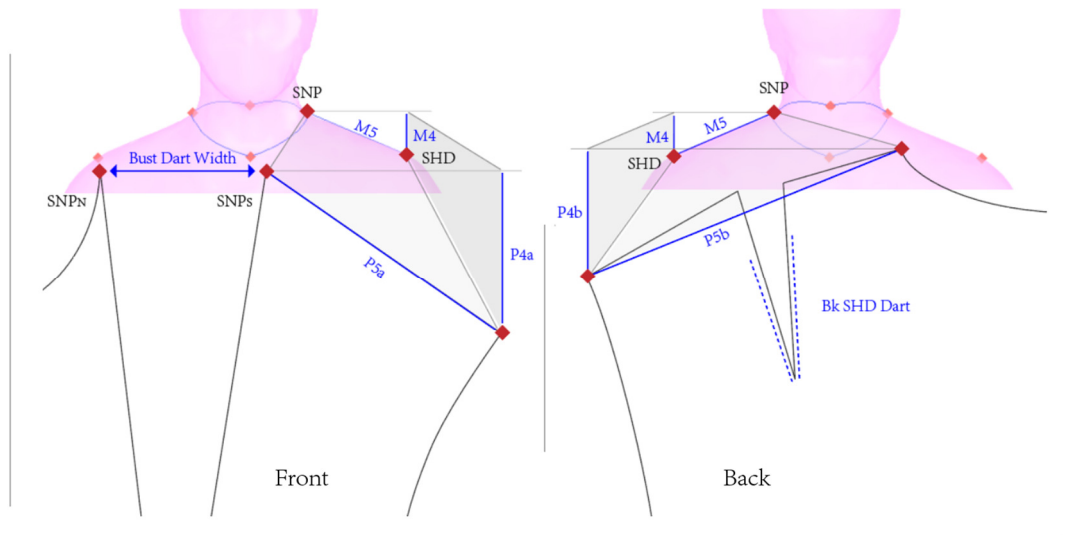


Fig.3. Correspondence between SS20 shoulder reference (shoulder drop M4 and shoulder length M5) and the front and back bodice block dimensions P4a, P4b, P5a and P5b, illustrated on Alva 10.

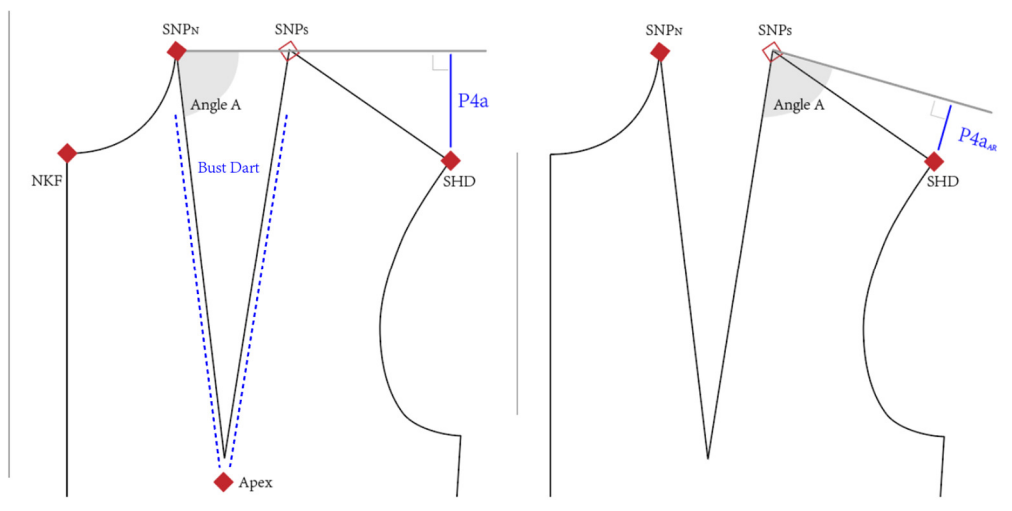


Fig. 4. Angle-matched reference construction for the front shoulder-drop. The body-referenced SNP is represented by SNP_N and SNP_S in the flattened open-dart pattern; reproduced Angle A at SNP_S to its dart leg, and the perpendicular distance from ShD to the resulting datum defines P4a_{AR}.

Table 2. Selected neck-shoulder pattern-body-measurement pairs.

Region	Details	Pattern	Definition	SS20 Mea	Definition
Neck	Drop	P1	Neck front drop	M1	Neck front depth
		P2	Neck back drop	M2	Neck back depth
	Width	P3a	Neck front width	M3	Half Neck Width
		P3b	Neck back width		
Shoulder	Drop	P4a	Shoulder front drop	M4	Average side neck to shoulder points Y difference L&R
		P4a _{AR}	Shoulder front drop (angle-matched)		
		P4b	Shoulder back drop		
	Length	P4a	Shoulder front length	M5	Average shoulder length
		P4b	Shoulder back length		

2.4. Visualisation of Pattern-Body Relationships

The bodice blocks visualised the direction of each selected pattern-to-body ratio by colour-coding the corresponding pattern dimension as proportionally expanded (orange) $R_i > 1$, approximately equivalent (black) $R_i \approx 1$, or compressed (blue) $R_i < 1$ relative to its body reference. The corresponding R_i values from all three mannequins were checked to see whether the ratio relation direction was consistent firstly. Which then were compared to determine whether the magnitude of the same relationship increased, decreased, or remained relatively stable across cases. This visualisation provided an intuitive overview of how the 3D body measurements were redistributed in the flattened 2D pattern representation, across three samples.

3. Result and Discussion

Figure 5 provides an initial visual overview of the selected pattern-to-body relationships. The Alva 10 bodice block is used as a representative geometry, with the retained neck- and shoulder-region pattern dimensions colour-coded according to their calculated R_i categories. The figure presents the direction of each relationship, while the corresponding ratio magnitudes and their variation across the three mannequin cases are examined in Sections 3.1 and 3.2.

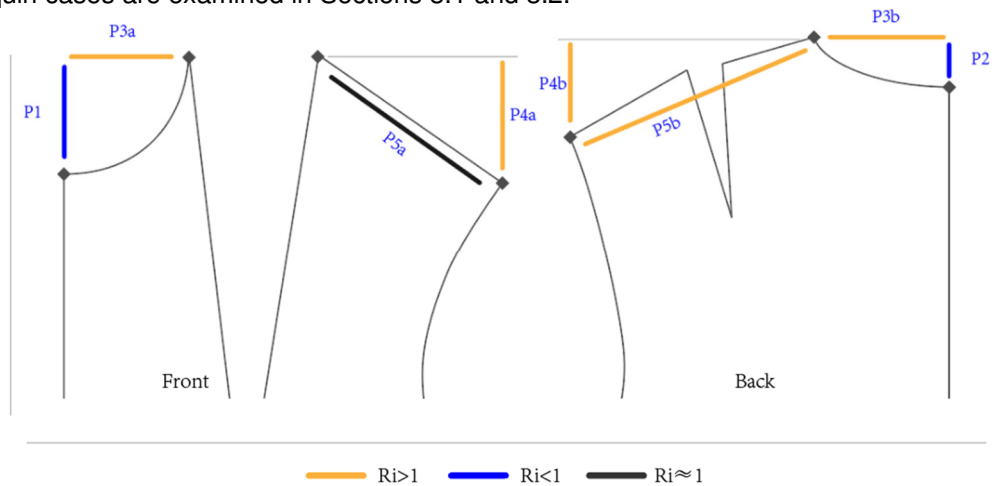


Fig.5. Directional categories of the selected pattern-to-body ratios, shown on the Alva 10 fitted bodice block: $R_i > 1$ (orange), $R_i \approx 1$ (black), and $R_i < 1$ (blue).

3.1. Neck Region

The figures below compare the body-derived neck planes with the corresponding pattern outlines and present the numerical differences between the primary body measurements and their mapped pattern dimensions. These comparisons show consistent directional deviations in the body-to-pattern mapping process. For neck width, the half neck-width measurement (M3) increased when translated into the front and back bodice-map traces (P3a and P3b), indicating a horizontal outward offset of SNP landmarks during mapping. According to Fig. 6 and 7, across all three samples, the back neck-width ratio remained higher than the front neck-width ratio, suggesting that the back neckline required a greater two-dimensional expansion relative to the same primary body-derived width reference.

By contrast, the front and back neck depth measurements (M1 and M2) decreased when represented as the corresponding pattern neck drops (P1 and P2). This indicates a vertical offset mapping effect in which the front and back neck landmarks were repositioned closer to the neck-width baseline on the two-dimensional bodice map. This directional trend was also consistent across the three samples.

Although these directional categories were consistent, the ratio magnitudes did not vary monotonically with mannequin size. Across the three cases, the front neck-depth ratio averaged 80.09% (77.12%–85.25%), while the back neck-depth ratio averaged 52.77% (47.73%–61.61%); both were highest for Alva 10. The front neck-width ratio averaged 108.63% (104.68%–115.01%), and the back neck-width ratio averaged 118.37% (114.38%–122.51%). Both width ratios were highest for Alva 12, and the back ratio exceeded the front ratio for every mannequin (Fig.9). The direction of each relationship was therefore stable across the cases, whereas its proportional magnitude varied among them. Figure 8 complements these numerical comparisons by spatially comparing the body-derived front and back neck references with the corresponding flattened bodice-block neckline outlines, thereby contextualising the observed width and depth differences.

Together, these results indicate that the neck region was not represented by a uniform scale transformation when translated from 3D body geometry into a planar bodice pattern. Width retained its transverse function and depth its vertical neck-drop function, but their proportional expressions differed after flattening. Within each mannequin, the same M3 body reference was paired with both P3a and P3b, yet the back pattern width was consistently proportionally larger than the front. Because no predefined neckline ease term was added in the present procedure, these differences were not produced by an explicit conventional ease allowance.

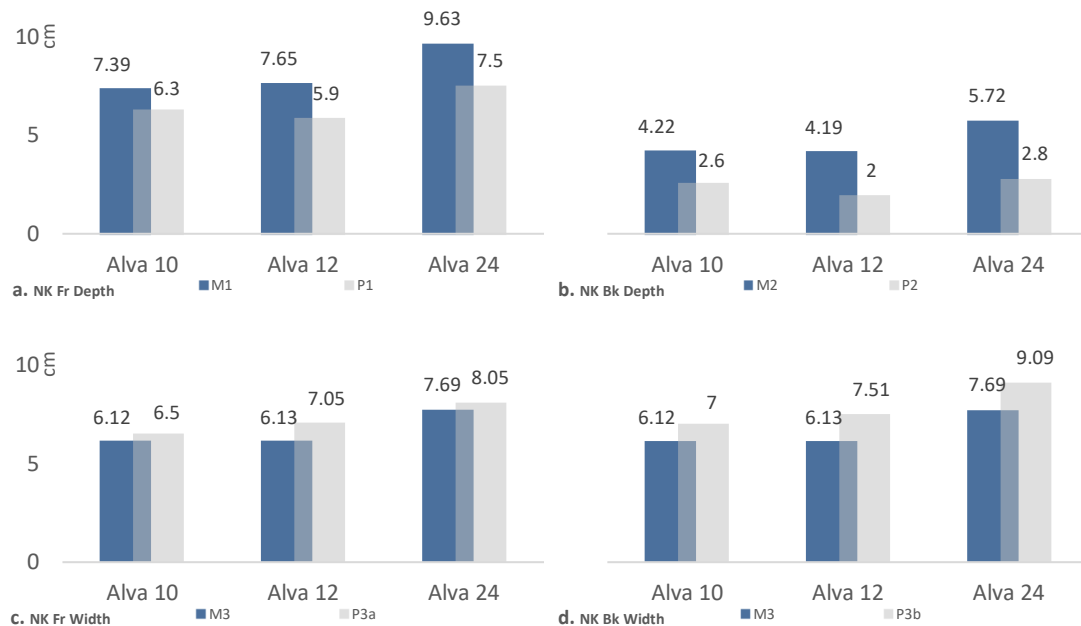


Fig.6. scan-derived body measurements and corresponding bodice-block dimensions for (a) front neck depth, (b) back neck depth, (c) front neck width, and (d) back neck width across the three mannequins.

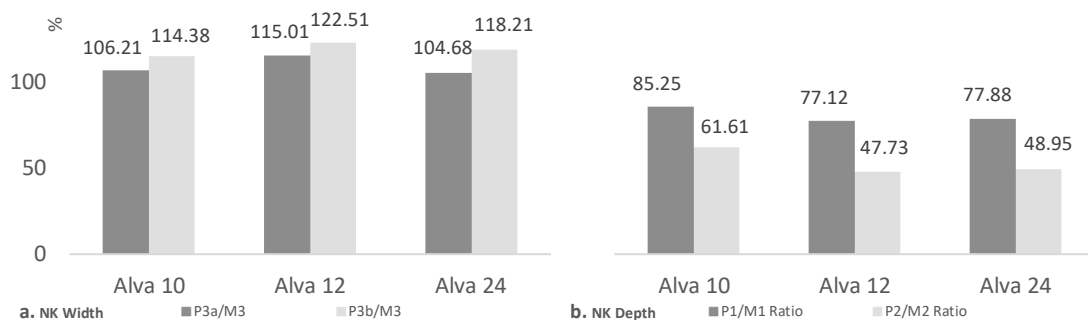


Fig.7. Pattern-to-body ratios for (a) front and back neck width, P3a/M3 and P3b/M3, and (b) front and back neck depth, P1/M1 and P2/M2, across the three mannequins.

This distinction is also relevant when comparing the present results with Yan and Kuzmichev [13]. In a drafting method that combines scan-derived neck width measurement with a predefined shirt ease allowance, the resulting body–pattern difference may contain both the intended garment ease and a positional offset arising from differences between the scan-defined and pattern-defined neck references. The present results do not quantify these two components separately, but indicate that the entire difference should not automatically be interpreted as conventional neckline ease.

Differences in the P_i/M_i ratios of front and back neck dimensions among the three mannequins, further indicate that the primary SS20 measurements alone do not fully explain their corresponding pattern expressions. Local neck-base surface geometry is a plausible contributor to this remaining variation. However, the SS20 measurements available in the present study do not describe the local surface topology around the neck-base circumference in sufficient detail. Further research should therefore develop and evaluate reproducible, neck-specific 3D measurements or surface descriptors and test their relationships with the corresponding pattern dimensions across a larger sample.

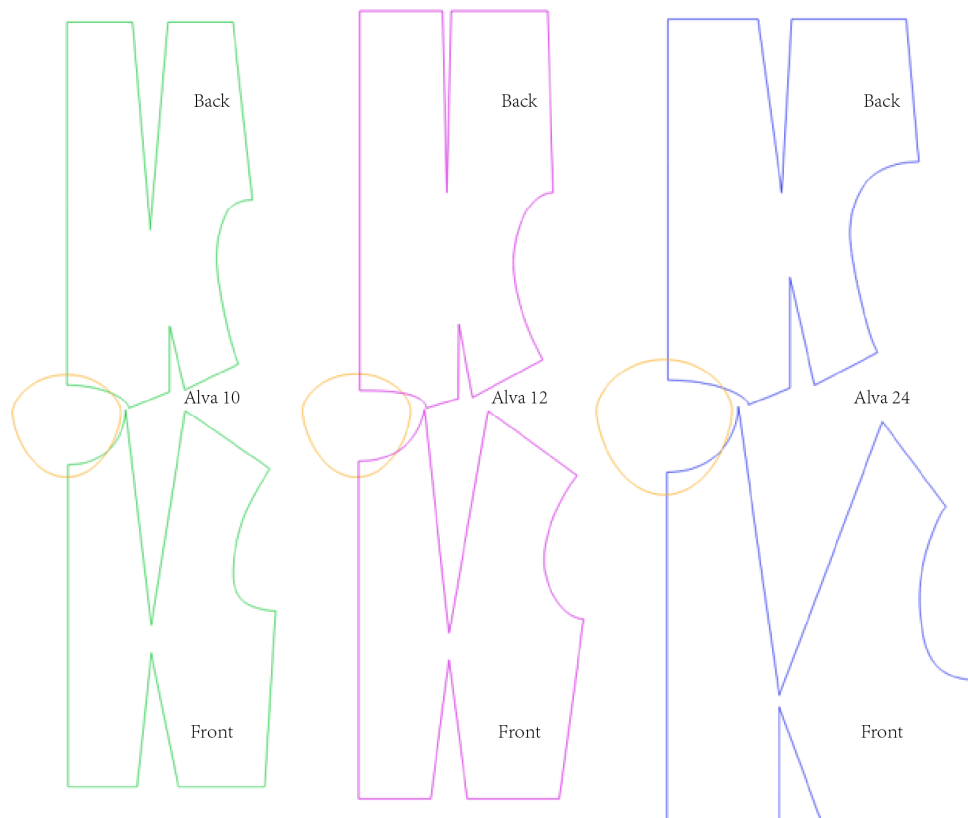


Fig.8. Registered comparison of the conceptual front and back neck planes (orange) and the corresponding flattened bodice-block neckline outline for the three mannequins. All geometries are shown at 50% scale without rotation, with vertical alignment at the SNP level and horizontal alignment at the respective front or back centre-neck datum.

3.2. Shoulder Region

3.2.1. Shoulder Drop

Figures 9 and 10 summarise the shoulder-drop comparisons across the three mannequins. Figure 9 compares the front and back body shoulder-drop measurements with their corresponding pattern dimensions, whereas Fig. 10 presents the resulting pattern-to-body ratios and the change produced by the angle-referenced front construction. Across all three mannequins, the unadjusted front and back pattern shoulder drops were greater than the corresponding body shoulder-drop reference. However, their cross-case ratio magnitudes differed substantially. The front shoulder-drop ratio ($P4a/M4$) averaged 166.27% and ranged from 141.67% to 208.79%. Alva 10 and Alva 12 showed relatively similar ratios, whereas Alva 24 exhibited a substantially larger proportional pattern drop. By contrast, the back shoulder-drop ratio ($P4b/M4$) remained close to the body reference, averaging 107.26% with a narrow range of 105.39%–108.33%. The directional relationship was therefore consistent for both pattern sections, but the unadjusted front shoulder drop exhibited considerably greater variation among the three cases.

According to left of Fig.10, when the bust-dart-mediated angular component was accounted for using the angle-referenced front shoulder-drop dimension ($P4a_{AR}$), the ratio decreased to an average of 79.90% (76.92%–83.62%). More importantly, its cross-case range decreased from 67.12 percentage points for the unadjusted ratio to 6.70 percentage points after adjustment, representing an approximately 90% reduction. The adjusted ratios were consistently below the body reference and showed substantially less variation among the mannequins.

This reduction indicates that bust-dart geometry is an important construction-mediated influence on the original front shoulder-drop dimension. In the flattened front bodice block, the dart opening separates the neck-side and shoulder-side representations of the body-referenced SNP and changes the angular relationship between the neckline and shoulder sections. Consequently, the unadjusted $P4a/M4$ ratio reflects not only the body shoulder drop but also the angular displacement associated with the bust dart. Because the adjustment re-expresses the measurement datum rather than experimentally varying dart width independently, the results identify bust-dart geometry as a major influencing factor within these cases, rather than establishing it as the sole cause of the front shoulder-drop variation.

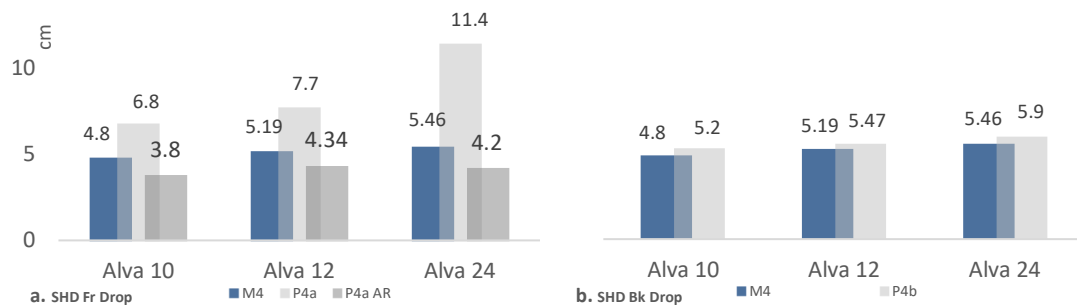


Fig.9. Body shoulder-drop measurement ave M4 and the corresponding (a) front pattern dimensions $P4a$ and $P4a_{AR}$, and (b) back pattern dimension $P4b$, across the three mannequins.

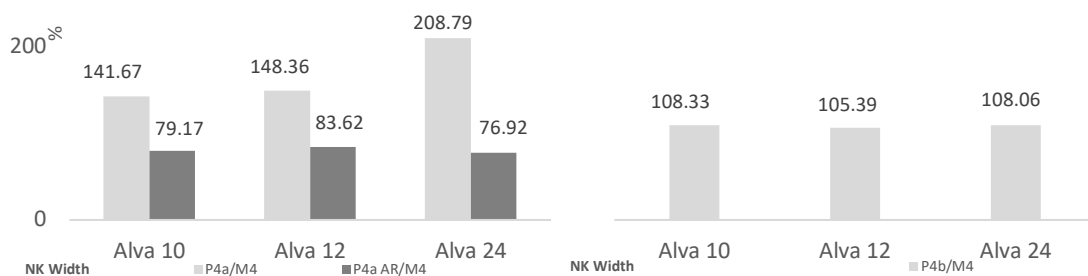


Fig.10. Pattern-body ratios for (a) unadjusted and angle-referenced front shoulder drop, $P4a/M4$ and $P4a_{AR}/M4$, and (b) back shoulder drop, $P4b/M4$, across the three mannequins.

3.2.2. Shoulder Length

Tables 3 and 4 report the paired body and pattern dimensions for shoulder drop and shoulder length, together with their corresponding pattern-to-body ratios, across the three mannequin cases. Overall, the shoulder-length relationships exhibited substantially less cross-case variation than the unadjusted front shoulder-drop relationship. The front shoulder-length ratio ($P5a/M5$) was close to numerical equivalence, averaging 99.27% and ranging from 98.61% to 100.00%. The back shoulder-length ratio ($P5b/M5$) was also highly stable but consistently greater than the body reference, averaging 118.59% with a narrow range of 117.90%–119.41%. As illustrated in Fig.3, the $P5b$ construction spans a back shoulder line interrupted by the open shoulder dart. The consistent pattern extension can therefore be interpreted as a systematic, dart-mediated component of the flattened back shoulder line rather than as substantial variation in the underlying body shoulder length. The back shoulder-drop ratio was similarly stable, averaging 107.26% (105.39%–108.33%). Thus, within the three cases, the back shoulder dart introduced a consistent proportional offset but did not generate appreciable cross-case variation in either the shoulder-length or shoulder-drop relationship.

The stability of shoulder length contrasts with the substantial variation in the unadjusted front shoulder-drop ratio. This suggests that 3D-to-2D translation affected the orientation and vertical expression of the front shoulder more strongly than the shoulder-line length itself, consistent with the influence of anterior torso prominence and bust-dart geometry. Overall, shoulder length showed a stable pattern-to-body relationship near equivalence on the front and a consistent dart-mediated extension on the

back, whereas front shoulder drop must be interpreted in conjunction with bust-dart geometry. These observations are limited to the three mannequin cases and do not establish a universal shoulder-construction rule.

Table 3. Body and Pattern Shoulder Length Ave value and correspond Pattern-Body Ratio on Front.

Alva Size	M5 Shoulder Length _{cm}	P5a Pattern _{cm}	Pattern-Body Ratio
Alva 10	11.65	11.65	100%
Alva 12	12.095	12	99.21%
Alva 24	12.98	12.8	98.61%

Table 4. Body and Pattern Shoulder Length Ave value and correspond Pattern-Body Ratio on Back.

Alva Size	M5 Shoulder Length _{cm}	P5b Pattern _{cm}	Pattern-Body Ratio
Alva 10	11.65	13.80	118.45%
Alva 12	12.01	14.26	117.90%
Alva 24	12.98	15.50	119.41%

4. Conclusion

This exploratory study presents a landmark-aligned procedure for comparing selected SS20 body measurements with corresponding dimensions on digitised fitted bodice blocks across three mannequin cases. For the neck and shoulder regions, its principal contribution is a structured and transparent means of describing both the direction and magnitude of selected pattern-to-body relationships without assuming numerical equivalence between the paired dimensions.

Across the three cases, the pattern neck widths were proportionally greater than their body references, whereas the pattern neck depths were smaller. Front shoulder length remained close to its body reference. By contrast, back shoulder length consistently exceeded the body reference, with P5b/M5 from 117.90% to 119.41%. This stable extension is consistent with the definition of P5b, which includes the open back shoulder dart. While the unadjusted front shoulder-drop ratio showed substantially greater cross-case variation. This variation was markedly reduced after the bust-dart-mediated angular component was accounted for, indicating that pattern-construction geometry can influence how a body dimension is expressed in the flattened pattern. Therefore, required to distinct this kind of specific construction-mediated component out for deep analysis that region' body-pattern relation.

These relationships reflect the geometric accommodation required when a complex three-dimensional neck–shoulder surface is expressed as a flat textile pattern representation (without ease allowance consideration) by several 3D scanning measurements. A difference between a body measurement and its corresponding pattern dimension may include landmark positional changes introduced through flattening and pattern construction and should therefore not automatically be classified as garment ease. Deliberate ease allowance and construction-mediated measurement translation should be specified and analysed as distinct components.

Moreover, the magnitude variation of neck region pattern-person ratio, suggest a implied gap between conventional scan-derived or anatomical body measurements and the geometric information required to explain detailed pattern construction. Since the primary SS20 measurements available in this study do not describe the local surface geometry and topology around the neck-base circumference in sufficient detail for pattern-construction analysis.

Against the proposed the hypothesis that the observed ratio magnitudes vary systematically with body ontology morphology. Future work should investigate the more detailed and morphological based reproduceable body measurement captured strategy to against this observed ratio variation, such as that at neck regions. Additionally, the present findings are descriptive and limited to three mannequin cases, which do not establish universal pattern-to-body ratios trend of the body. The relevant work should further extend the analysis to explicit bust-dart width, the armhole region and the remaining bodice-block dimensions, while including a larger and more morphologically diverse body sample. Eventually support a comprehensive bodice-level analytical framework for examining body-to-pattern relationships, based on the 3D scanning technology. The present study provides an initial methodological basis for that broader investigation rather than the completed framework itself.

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