# Using a 3D virtual clothing system to develop bottom patterns for South Korean women in their 40s

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## ABSTRACT – REZUMAT

### Using a 3D virtual clothing system to develop bottom patterns for South Korean women in their 40s

*This study aimed to analyse the lower body characteristics of South Korean women in their 40s and propose bottom patterns, such as for skirts or pants, using a 3D virtual clothing system. The lower body characteristics of South Korean women in their 40s were identified by comparing them with those of women in their 20s using the Mollison relational deviation line. The CLO software was employed to examine the bottom fits of South Korean women in their 20s and 40s and to analyse pressure points and clothing pressure. The pattern-drafting method was also suggested for South Korean women in their 40s. South Korean women in their 40s had lower height-related body measurements and larger circumference-related body measurements than South Korean women in their 20s. Therefore, the traditional drafting method of using clothing patterns for skirts and pants, such as using only the body measurements of women in their 40s, leads to inadequate fit. When designing bottom patterns for this demographic, the waist, abdomen, hip area, and hip length must be considered. For pants patterns, the crotch, thigh area, and pants silhouette should also be considered. This study is meaningful in that it analysed virtual clothing fit when designing bottom patterns for South Korean women in their 40s.*


***Keywords:*** *middle-aged South Korean women, body characteristics, clothing fit, 3D virtual clothing system, pattern making*


### Utilizarea unui sistem virtual de îmbrăcăminte 3D pentru dezvoltarea tiparelor de articole vestimentare pentru partea inferioară a corpului, destinate femeilor sud-coreene în vârstă de 40 de ani

*Acest studiu a urmărit analiza caracteristicilor părții inferioare a corpului femeilor sud-coreene în vârstă de 40 de ani și propunerea unor tipare pentru fuste și pantaloni utilizând un sistem virtual de îmbrăcăminte 3D. Caracteristicile părții inferioare a corpului femeilor sud-coreene cu vârsta cuprinsă între 40 și 49 de ani au fost identificate prin compararea acestora cu cele ale femeilor cu vârsta cuprinsă între 20 și 29 de ani, folosind linia de deviere relațională Mollison. Software-ul CLO a fost aplicat pentru a examina potrivirea, punctele de presiune și presiunea exercitată de îmbrăcăminte. Rezultatele au indicat faptul că femeile de 40 de ani prezintă valori mai mici ale dimensiunilor legate de înălțime și circumferințe mai mari decât femeile de 20 de ani. În consecință, utilizarea exclusivă a măsurătorilor corporale în construcția tradițională a tiparelor conduce la o potrivire insuficientă. La proiectarea tiparelor de articole vestimentare pentru partea inferioară a corpului pentru această grupă de vârstă, este necesară luarea în considerare a taliei, abdomenului, zonei șoldurilor și lungimii șoldurilor, iar pentru pantaloni, a zonei inghinale, coapselor și siluetei pantalonilor. Acest studiu este relevant prin faptul că analizează potrivirea virtuală a îmbrăcămintei la proiectarea tiparelor de pantaloni pentru femeile sud-coreene în vârstă de 40 de ani.*


***Cuvinte-cheie:*** *femei sud-coreene de vârstă mijlocie, caracteristici corporale, potrivirea îmbrăcămintei, sistem virtual de îmbrăcăminte 3D, construcția tiparelor*

## INTRODUCTION

South Korean women often leave the labour market around childbearing age [1], with some re-entering in their 40s after marriage, childbirth, or childrearing. Women in this age group are therefore actively engaged in society. However, these life events and ageing lead to body shape changes, including reduced breast elasticity, back and posture issues, increased abdominal and hip girth, and decreased height, prompting many women to adjust their skirts and pants to fit their current measurements and social roles. The fashion industry has turned to using a 3D virtual clothing system to consider these patterns. This system allows the creation of virtual bodies without the hassle of scanning a body and creating virtual clothing by drafting clothing patterns [2]. As the system can quickly verify creative designs [3], clothing patterns can be modified by examining virtual fitting images [4]. This system can minimise time and financial losses from producing actual clothing samples. Additionally, it can analyse the pressure on clothing, allowing for an objective assessment of the effects of different clothing designs [5–7]. Currently, many women's fashion brands in South Korea plan clothing products that primarily target women in their 20s rather than those in their 30s and older, and their pattern-drafting methods are generally based on the standard body measurements of

women in their 20s. Hence, developing pattern-drafting methods that reflect the body shapes of South Korean women in their 40s while referencing the fit of women in their 20s can help fashion brands produce better-fitting garments. Accordingly, this study used a 3D virtual clothing system to identify the key body-shape characteristics of South Korean women in their 40s and to propose skirt and pants drafting methods suitable for this age group.

## RESEARCH METHOD

The body measurement data for South Korean women in their 20s (hereinafter referred to as "the 20s") and South Korean women in their 40s (hereinafter referred to as "the 40s") were obtained from the 8th Size Korea [8], which provides data on the body measurements of South Koreans. Avatars were then modelled using CLO software based on these measurements. To compare body shapes between age groups, the Mollison relational deviation line was employed using the body measurements of the CLO avatars and calculated as shown in the following formula. A previous study [9] has used virtual fitting software, such as Israel's Optitex, Japan's i-Designer, and South Korea's CLO, to model avatars based on body types and compare virtual fitting results with actual garment fitting. The study reported that virtual fittings using normal-body-type avatars in CLO closely approximate real-world fit. Based on this evidence, CLO was used to model avatars and conduct virtual fittings for women in their 20s and 40s.

$$\text{Relational deviation} = (A-B)/C$$

A: Reference group measurement (20s)

B: Comparison group measurement (40s)

C: Reference group standard deviation (women in their 20s)

The CLO software was also used for pattern design and virtual fit analysis. A book on drafting women's clothing patterns was used as a reference for comparative patterns [10]. This reference book, *Industrial Pattern Design*, provides pattern templates for both custom-made and ready-to-wear garments, following pattern-drafting methods commonly used in Korea. The pattern drafting method is shown in table 1. Patterns were drafted from the book using the waist circumference (W) and lower hip circumference (H) of women in their 20s and 40s. In South Korean women in their 20s to 40s, the actual hip length generally exceeds 20.0 cm [8]. However, in Korean pattern drafting practices, this measurement is not directly reflected in the pattern dimensions. Instead, a shorter hip length is often used to create a visually higher hip line and achieve a more aesthetically preferred silhouette. Additionally, in Korea, cases in women's apparel pattern drafting have also been reported in which a fixed hip length of 18.0 cm is applied across all sizes for convenience and consistency [11]. Reflecting these conventions, the present study fixed the hip length at 18.0 cm, following the specifications provided in the pattern reference book. Therefore, while modifying the patterns to improve fit, the hip length was fixed at 18.0 cm in accordance with standard Korean drafting practice. Next, the drafted skirt and pants patterns were applied to avatars representing women in their 20s and 40s to generate virtual garments and conduct virtual fitting simulations. In CLO, virtual garment silhouettes, contact point maps, and clothing pressure vary depending on the specified fabric properties, enabling detailed visual analysis [12]. Because CLO provides highly realistic fit simulations based on fabric characteristics and supports objective visual evaluation, the present study analysed and refined patterns using these three components. By using CLO's "Show Pressure Points" tool, the body's contact areas were identified, and the corresponding points on the garment were marked with blue indicators. This tool highlights regions where the garment touches the avatar, with a greater distribution of contact points indicating reduced fabric flexibility [12]. It allows for visual assessment of garment-to-avatar fit and is particularly useful for comparing multiple pattern variations [13]. In this study, the tool was used to visually evaluate the silhouette and fit of both the comparative and developed patterns. Additionally, the "Stress Map" tool was employed to assess clothing pressure. The virtual fabric chosen for pattern evaluation was "Muslin_28×36", as it is commonly used for experimental garments in real-world fit assessments [14]. The physical characteristics of the muslin provided by CLO are shown in table 2. Clothing pressure was measured at points where the skirt or pants closely contact the body, based on previous studies [15]. Table 3 lists the areas for clothing pressure measurement. In CLO, clothing pressure is visualised with colours, and numerical values are also provided. In previous studies, the same avatar and garment were simulated five times to calculate fabric deformation [16]. Following this approach, in the present study, measurements were performed five times in each area, yielding five numerical values for analysis. This process highlighted considerations for 40s women's bottom patterns. Previous research [17] has shown that garment fit must balance ease: excessive fabric can restrict movement and reduce comfort, while insufficient ease can cause tightness, high-pressure zones, and limited mobility. This principle was therefore applied when adjusting the pattern dimensions to ensure both comfort and proper fit. After pattern adjustments, fit was re-evaluated. Clothing pressure was measured five times per pattern, with the mean and standard deviation calculated and compared using a t-test performed with SPSS Statistics 29.0 software.

## RESULTS

Table 4 presents the results of the Mollison relational deviation line analysis. Height-related measurements for women in their 40s ranged from –0.2σ to –0.4σ, generally lower than those of women in their 20s, with low hip height and inseam height showing the

Table 1

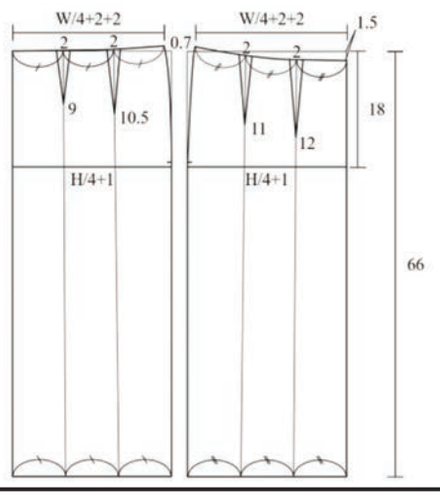
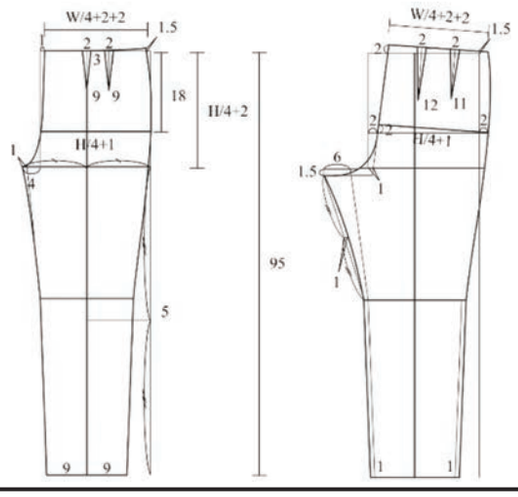
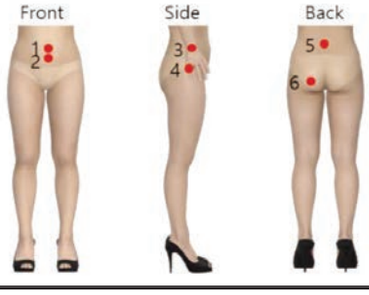
| REFERENCE PATTERN DRAFTING METHODS (UNIT: cm) | |
|---|---|
| **Skirt** | **Pants** |
|  |  |

Table 2

| PHYSICAL PROPERTIES OF FABRIC IN CLO | | | |
|---|---|---|---|
| **Mechanical properties of fabric** | **Value** | **Mechanical properties of fabric** | **Value** |
| Weft stretch | 58.0 | Bias bending (right, left) | 47.0 |
| Warp stretch | 56.0 | Internal damping | 1.0 |
| Shear stretch (right, left) | 18.0 | Density | 11.0 |
| Weft bending | 45.0 | Friction | 3.0 |
| Warp bending | 48.0 | Thickness | 0.4 mm |

*Note:* No units, except for thickness

Table 3

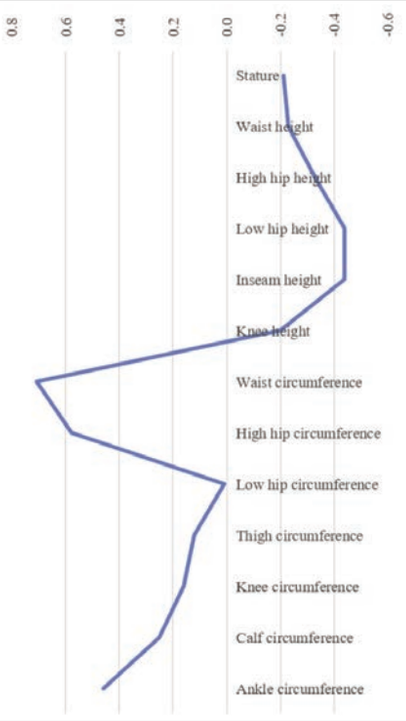
| MEASURING POINTS OF CLOTHING PRESSURE | | |
|---|---|---|
| **Measurement point** | | |
| 1 | Front waist |  |
| 2 | Front abdomen | |
| 3 | Side waist | |
| 4 | Side hip | |
| 5 | Back waist | |
| 6 | Back hip | |

largest decreases (–0.4σ). Circumference-related measurements ranged from 0.0σ to 0.7σ, indicating larger girths in the 40s group, particularly in the waist (0.7σ), hip (0.6σ), and ankle (0.5σ). The difference between waist and lower hip circumferences was 24.9 cm for women in their 20s and 19.6 cm for women in their 40s, showing that a larger waist in the 40s group reduced the waist–hip differential.

Table 5 presents the results of the contact point analysis from virtual fitting of the comparative skirt patterns. The fit differed between women in their 20s and 40s. The 40s group showed wider contact points around the abdominal area and gaps at the waist due to horizontal wrinkles near the hips. Skirt length was also longer for women in their 40s. Fitting issues in women in their 40s can be attributed to morphological changes identified in the body measurement analysis. Table 4 shows that they had larger waist and high-hip circumferences than women in their 20s. The reduced waist–lower-hip difference indicates a less pronounced waist–hip contour, leading to insufficient skirt anchoring and gaps at the back

Table 4

BODY SIZES OF THE 20s AND 40s (UNIT: cm, σ)

| | Item | 20s | 40s | Mollison relational deviation | Mollison relational deviation line |
|---|---|---|---|---|---|
| Height | Stature | 162.0 | 160.9 | –0.2 |  |
| | Waist height | 100.5 | 99.6 | –0.2 | |
| | High hip height | 89.2 | 88.0 | –0.3 | |
| | Low hip height | 79.1 | 77.5 | –0.4 | |
| | Inseam height | 74.2 | 72.6 | –0.4 | |
| | Knee height | 43.1 | 42.7 | –0.2 | |
| Circumference | Waist circumference | 70.4 | 75.9 | 0.7 | |
| | High hip circumference | 86.6 | 90.8 | 0.6 | |
| | Low hip circumference | 95.3 | 95.5 | 0.0 | |
| | Thigh circumference | 57.3 | 57.9 | 0.1 | |
| | Knee circumference | 35.5 | 35.9 | 0.2 | |
| | Calf circumference | 35.0 | 35.7 | 0.3 | |



during virtual fitting. Increased high-hip circumference also concentrates tension around the hips, creating horizontal wrinkles and pushing the garment away from the waistline. These waist gapping and hip wrinkles align with the body shape characteristics identified via the Mollison relational deviation analysis.

Based on these findings, several factors must be considered when drafting skirt patterns for women in their 40s. The 40s group exhibited a back waist area that tended to lift away from the body due to the smaller difference between the waist and lower hip circumferences, tightness around the abdominal area due to a larger waist circumference, wrinkles around the hip area due to fabric tension, and a longer skirt length that made the legs appear shorter.

Accordingly, the pattern was modified as follows: the back waistline was reduced by 0.8 cm to prevent the skirt from lifting away from the body; the front and back waistlines, hip lines, and hemlines were extended by 1.0 cm to provide more room in the abdominal and hip areas; and the skirt length was shortened by 1.0 cm to achieve an appropriate length. Figure 1 shows the revised skirt pattern. Table 6 presents the contact point analysis using virtual fitting on a 40s avatar. The number of contact points decreased overall, and the issues observed in the comparative pattern, including lifting at the back waist, tightness

Table 5

CONTACT POINTS OF THE COMPARATIVE SKIRT FOR THE 20s AND 40s

| Front | | Side | | Back | |
|---|---|---|---|---|---|
| 20s | 40s | 20s | 40s | 20s | 40s |
|  |  |  |  |  |  |

around the abdomen and hips, and excessive skirt length, were resolved. Table 7 shows that the clothing pressures of the developed skirt pattern were significantly lower than those of the comparative skirt pattern for women in their 40s across all measured areas, indicating improved fit.

Table 8 presents the results of the contact point analysis from virtual fitting of the comparative pants patterns. The fit differed between women in their 20s and 40s. The 40s group showed wider contact points in the abdominal and thigh areas, a tight crotch, and a waistline that appeared steeply sloped from the side view. The pants were longer, creating wrinkles along the legs and a deviated leg silhouette.

Based on these findings, several factors must be considered when drafting pants patterns for women in their 40s. The 40s group exhibited a steeply sloped waistline, tightness in the crotch, pressure in the front thigh area, longer pants length, and a deviated leg silhouette. Accordingly, the pattern was modified as follows: the back waistline was lowered by 1.7 cm to level the waist; the front rise was extended by 0.5 cm, the back rise by 1.0 cm, and the crotch point raised

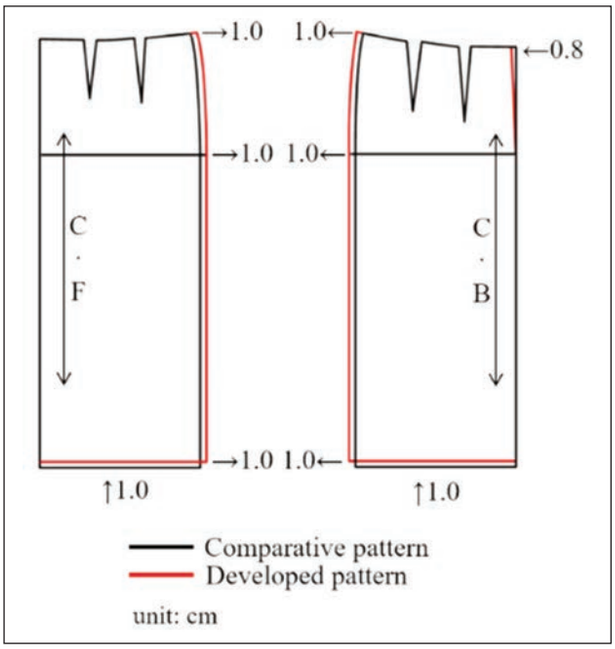



Fig. 1. Overlap of comparative skirt pattern and developed skirt pattern

Table 6

CONTACT POINTS OF THE COMPARATIVE SKIRT AND DEVELOPED SKIRT FOR THE 40s

| Front | | Side | | Back | |
|---|---|---|---|---|---|
| Comparative pattern | Developed pattern | Comparative pattern | Developed pattern | Comparative pattern | Developed pattern |
|  |  |  |  |  |  |

Table 7

CLOTHING PRESSURE OF COMPARATIVE SKIRT AND DEVELOPED SKIRT FOR THE 40s (UNITS: kPa)

| Measurement point | Comparative pattern | | Developed pattern | | t-value | p-value |
|---|---|---|---|---|---|---|
| | M | S.D | M | S.D | | |
| Front waist | 43.6 | 0.4 | 30.0 | 0.0 | 61.060 | 0.000 |
| Front abdomen | 20.9 | 0.3 | 1.6 | 0.2 | 89.501 | 0.000 |
| Side waist | 45.7 | 0.0 | 4.6 | 0.0 | 6164.000 | 0.000 |
| Side hip | 5.5 | 0.1 | 1.7 | 0.4 | 15.309 | 0.000 |
| Back waist | 37.1 | 0.0 | 33.0 | 1.2 | 5.628 | 0.005 |
| Back hip | 10.2 | 0.3 | 7.4 | 2.0 | 4.814 | 0.009 |

by 0.5 cm to relieve abdominal and crotch pressure. This adjustment was made because a higher crotch point results in better-fitting pants [18]. The front knee line and hemline were extended by 1.0 cm, the back knee line by 0.5 cm to improve thigh fit, and the pants length was shortened by 1.0 cm to prevent wrinkles. When the lower body circumference is large, extending the knee line and hemline helps improve the fit;

Table 8

CONTACT POINTS OF COMPARATIVE PANTS FOR THE 20s AND 40s

| Front | | Side | | Back | |
|---|---|---|---|---|---|
| 20s | 40s | 20s | 40s | 20s | 40s |
|  |  |  |  |  |  |

however, unnecessary ease was not added to the back panel to avoid overfitting the front thighs. Additionally, 0.2 cm was added to the mid-hip line between the waistline and hip line to create a more natural line for the back panel's outseam. Figure 2 shows the revised pants pattern. Table 9 presents the contact point analysis using virtual fitting on a 40s avatar. The number of contact points decreased overall, and the issues observed in the comparative pattern were resolved, including a levelled waistline, improved crotch and thigh ease, appropriate length, and an undistorted silhouette. Table 10 shows that the clothing pressures of the developed pattern were generally lower than those of the comparative pants pattern for women in their 40s, indicating improved fit.

## CONCLUSIONS

This study aimed to identify bottom patterns suitable for the body shapes of South Korean women in their 40s. Compared with women in their 20s, women in

Table 9

CONTACT POINTS OF COMPARATIVE PANTS AND DEVELOPED PANTS FOR THE 40s

| Front | | Side | | Back | |
|---|---|---|---|---|---|
| Comparative pattern | Developed pattern | Comparative pattern | Developed pattern | Comparative pattern | Developed pattern |
|  |  |  |  |  |  |

Table 10

CLOTHING PRESSURE OF COMPARATIVE PANTS AND DEVELOPED PANTS FOR THE 40s (UNITS: kPa)

| Measurement point | Comparative pattern | | Developed pattern | | t-value | p-value |
|---|---|---|---|---|---|---|
| | M | S.D | M | S.D | | |
| Front waist | 49.0 | 3.5 | 36.3 | 4.4 | 3.918 | 0.017 |
| Front abdomen | 47.1 | 0.7 | 27.1 | 1.9 | 17.387 | 0.000 |
| Side waist | 51.4 | 5.0 | 35.1 | 4.3 | 4.298 | 0.013 |
| Side hip | 24.3 | 3.4 | 24.3 | 3.4 | 0.000 | 1.000 |
| Back waist | 41.4 | 2.8 | 39.4 | 0.2 | 1.173 | 0.360 |
| Back hip | 13.5 | 2.8 | 7.4 | 0.1 | 3.786 | 0.063 |

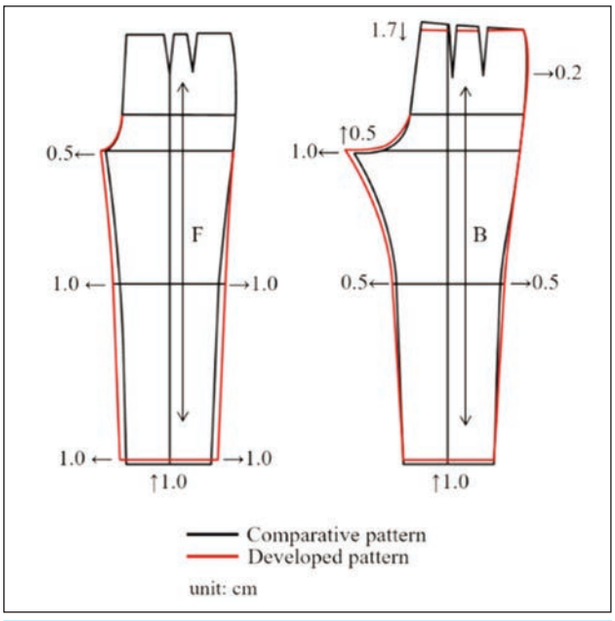



Fig. 2. Overlap of comparative pants pattern and developed pants pattern

their 40s had lower height-related measurements and larger circumference-related measurements, which can result in inadequate fit if traditional drafting methods are applied. Based on these findings, it is proposed that skirt patterns be adjusted by reducing the back waist panel to prevent lifting, adding ease along the side seams to relieve abdominal pressure and prevent hip-area wrinkles, and shortening the length to avoid disproportionate proportions. For pants, it is proposed that the back waistline be lowered to prevent lifting, the crotch and thigh areas be widened to relieve tightness, and the length be shortened to maintain proper proportions and prevent wrinkles, ensuring a straight silhouette from waist to ankle. This study is limited in that all analyses were based on a single average avatar and virtual simulations, and the hip length was fixed during pattern design; physical prototyping and human fitting are needed to confirm real-world validity. Using one representative body form also cannot capture the diversity of somatotypes among women in their 40s, so future research should develop and evaluate pattern blocks for multiple body-shape groups.

## ACKNOWLEDGEMENTS

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