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Comparison between Measured and Proposed Body Rise Length Distance for Trouser Pattern Block Construction

Primerjava med merjenimi in predlaganimi vrednostmi globine sedala za razvoj osnovnega kroja hlač

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Abstract

The aim of this study was to compare body rise distances (crotch depth) from contemporary construction systems with the measured body rise (BRise) distances of the young Slovenian female population to establish which body rise presented in different contemporary construction systems fits best to the body dimensions of that specific target market group. A total of 180 female students (aged 19 to 27 years) from the University of Ljubljana (Slovenia) volunteered in the study. The results showed that measured body rise distances differed significantly from those obtained from most tables of contemporary construction systems or calculated as a secondary measure according to some authors. Measured BRise distances were the same in all size groups and did not increase as the size group increased as is the case with all analysed contemporary construction systems. The range of measured BRise distances within each size group was substantial (SD from 1.47 to 2.75 cm), while the Müller system, as the most frequently used pattern construction system in Slovenia, gave the lowest values of BRise distances for all size groups. In conclusion, the values for body rise distances proposed by different contemporary construction systems differ significantly from those measured in the young Slovenian female population. It is suggested that body rise distance be included as a directly measured parameter for trouser pattern block construction when producing made-to-measure clothes.

Keywords: pattern construction, anthropometric measurements, body rise, trousers, basic pattern block

Povzetek

Cilj študije je bil primerjati vrednosti globine sedala (GSe) iz sodobnih konstrukcijskih sistemov z izmerjenimi GSe mlade slovenske ženske populacije, da bi ugotovili, katera vrednost GSe, ponujena v različnih sodobnih konstrukcijskih sistemih, najbolj ustreza tej specifični tržni skupini. V raziskavo se je prostovoljno vključilo 180 študentk Univerze v Ljubljani (starost od 19 do 27 let). Rezultati so pokazali, da se izmerjena povprečna GSe bistveno razlikuje od vrednosti GSe iz tabel mer večine sodobnih konstrukcijskih sistemov ali izračunanih kot sekundarna mera z enačbo, ki jo ponujajo nekateri avtorji. Izmerjene vrednosti GSe so bile v vseh velikostnih skupinah enake in se niso povečevale s povečevanjem velikostne številke, tako kot pri vseh predstavljenih sodobnih konstrukcijskih sistemih. Razpon (korak) izmerjenih GSe v vsaki velikostni skupini je bil precejšen (SD od 1,47 do 2,75 cm). Müllerjev sistem, kot najbolj razširjen konstrukcijski sistem v Sloveniji, je ponudil najmanjše vrednosti GSe pri vseh velikostnih številkah. Ugotavljamo, da se vrednosti GSe, ki jih ponujajo različni sodobni konstrukcijski sistemi, pomembno razlikujejo od izmerjenih vrednosti GSe mlade slovenske ženske populacije. Zato predlagamo, da se GSe vključi med neposredno merjene parametre, potrebne za razvoj osnovnega kroja hlač pri izdelavi oblačil po meri.

Ključne besede: razvoj krojev oblačil, antropometrične meritve, globina sedala, hlače, osnovni kroj

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1 Introduction

Trousers represent an indispensable piece of apparel in every woman's wardrobe. Because the expectations of today's customers are increasing steadily and are accompanied by an excessive offer of trousers by different producers and retailers, proper size and fit is important. Good garment fit is crucial to customer satisfaction, as it contributes to both confidence and the comfort of wear [1]. Dissatisfaction with fit is one of the most frequently stated problems with garment purchases in the ready-to-wear sector [2]. The fit of clothes is closely linked with the body dimensions incorporated in basic pattern blocks of clothes, while all garment production requires the development of corresponding patterns. As a rule, measurement tables and basic block patterns in industry are already set and fixed, but are not necessarily the best reflection of the body dimensions of target market groups [3, 4].

Body rise (BRise) distance is typically the first measure required in the development of a trouser pattern block, and plays an important role in creating the proper fit of trousers between the levels of the natural waist and crotch line. If the BRise is shorter than the actual BRise, the trouser waist level will be lower than the natural waist level where waist girth is measured. As a result, trouser waist girth will be too small because body girth increases below the natural waist. If the BRise is longer than the actual BRise, the crotch seam of the trousers will hang down from the crotch level of the body. The greater the difference between the real value of body rise distance and the body rise distance incorporated in the basic block pattern of trousers, the more distinctive this deviation would be. The impact of body rise distance on the fit of trousers on the body is often overlooked in contemporary construction systems. In Slovenian educational and industrial practice, body rise distance is frequently defined as a secondary measure that can be calculated using an equation from hip girth [5, 6] (see equation in the section Methods). Moreover, most contemporary construction systems include it in their measurement tables. The values in those tables differ from one system to another, and increase with changes of bust (and hip) girth [7–13]. Differences in BRise distances from various construction systems set with measurement tables or calculated using the relevant equation raise the question as to which distance fits best to the natural shapes of different target groups of female bodies. One way to arrive at the answer is to compare these distances with those from real subjects. There is no common agreement on how to measure BRise distance, while construction systems offer different measurement methodologies [7, 11, 12, 14]. It seems that the most consistent way to select the proper methodology is to follow the nature of trouser basic pattern block development. In most pattern construction systems, BRise distance is applied in the basic pattern block as the vertical distance from the natural waist level to the crotch level of the body as suggested by the ISO 8559 standard [14]. The methodology used to measure BRise distance in this study followed that standard.

The aim of this study was to compare BRise distances from contemporary construction systems with the measured distances of the young Slovenian female population to establish which BRise distance presented in different contemporary construction systems fits best to the body dimensions of that specific target market group.

2 Methods

2.1 Participants

An anthropometric survey was carried out with 180 female students (aged 19 to 27 years) from the University of Ljubljana (Slovenia) who volunteered in the study. The subjects were selected to fit into a single body height group as suggested by the SIST EN 13402-3 standard [15] (from 164 to 172 cm). They were divided into groups according to the measure of their bust girth, as it is the most important measure in the basic pattern for developing clothes and in size definition. Five major groups were created according to the SIST EN 13402-3 standard [15]. All participants were well informed about the procedures of the experiment. None of them had given birth.

2.2 BRise distances from measurement tables

BRise distances were obtained from the measurement tables of the following contemporary construction systems: Aldrich system [7], Parish system [8], Haggar system [9], Jansen system [10], Armstrong system [11] and Müller system, [12, 13] with its two measurement tables (Müller1 and Müller2). These systems (except the Müller system) followed the same methodology for measuring BRise distances as

the one used in the study. The values obtained from these tables applied to the female population with a body height of between 164 and 172 cm (here reported as an average of 168 cm) and to selected size groups based on bust girth. BRise distance values from the Müller system [12, 13] were also included in this paper, although their measurement methodology differs from the one used in the study. The reason for doing so lies in the fact that the Müller system is the most frequently used pattern construction system in Slovenia, while companies in the Slovenian clothing industry use BRise values from the aforementioned system's measurement tables. According to the Müller system, BRise is measured as the distance between the lower edge of the band, bounded around the natural waist, to the seat following the hip contour on a seated figure, measured using a measuring tape [12].

2.3 Calculated BRise distances (BRise_calc)

Some Slovenian researchers have calculated BRise distance using an equation based on hip girth [5, 6]:

$$BRise\_calc = HG / 4 \quad (1),$$

where HG stands for hip girth.

2.4 Anthropometric survey

During the measurement process, participants stood on level ground in their natural posture, with their feet together and their centre of gravity distributed equally to both legs, or seated on a flat surface with their back straight. Their heads were aligned with the Frankfurt line. During the process, they breathed normally with their abdomen relaxed and arms hanging down freely along the torso or slightly lifted, but in a way that their posture or the body dimensions subject to measurement remained unchanged. Participants were dressed in underwear and barefoot. The survey was conducted in the morning by the same person and an assistant who recorded the data. The values were always repeated before they were entered in the anthropometric form and were rounded up to the next highest value, with an accuracy of 0.5 cm.

The following anthropometric planes on the body were first selected and marked with a 3 mm wide elastic band (left image in Fig. 1): the natural waist level (upper band) between the top of the hip bones and the lower ribs where girth is smallest according to the ISO 8559 standard [14]; hip level (middle band) around the buttocks at the level of maximum circumference according to the same standard [14] and natural crotch level (lower band) (left image in Fig. 1).

The bands were adjusted around the body in a way that the ellipsoid levels of the waist, hips and crotch were perpendicular to the longitudinal axis of the body. None of the bands compressed the soft tissue of the body and thus did not affect the measured values.

Body height, bust girth and hip girth were then measured on a standing figure. Measurements of body height (BH) were performed using an anthropometer as the vertical distance between the crown of the head and the ground, with the subject standing in their natural posture and their feet together.

Bust and hip girth were measured with a dimensionally stable tape-measure. Bust girth was measured as the maximum horizontal girth with the subject standing in her natural posture, with the

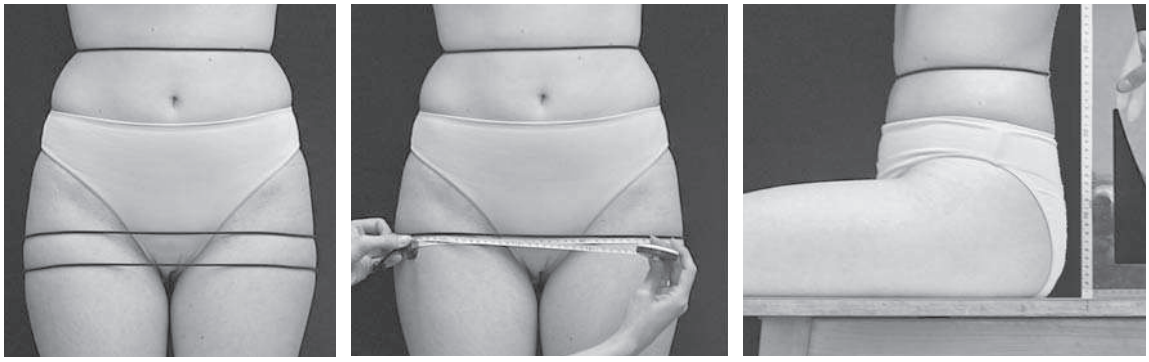

Figure 1: Selection of anthropometric planes on the body (left); measurement of hip girth (middle) and body rise distance (right)

Slika 1: Izbor antropometričnih ravnin na telesu (levo); merjenje kolčnega obsega (sredina) in globine sedala (desno)

tape-measure passing over the nipples, but adjusted around the body in a way that the ellipsoid level of bust girth was also perpendicular to the longitudinal axis of the body. Hip girth was measured precisely below the elastic bands on the marked hip levels (middle image in Fig. 1).

While it is difficult to define the exact level of the natural crotch in a standing position (left image in Fig. 1) using the measuring stand (anthropometer) suggested by the ISO 8559 standard, BRise was measured using a larger perpendicular ruler on a seated figure as shown in the right image in Fig. 1. Both methods resulted in very similar measurements (deviation of 0.5 cm) [16]. Measured persons sat on a flat surface with their back straight. The measure of BRise was taken as the vertical distance between the upper edge of the band around the natural waist level and the sitting level of the flat surface.

2.5 Statistics

Participants with a body height ranging from 164 cm to 172 cm were analysed and arranged into size groups according to their bust girth in intervals of 4 cm as suggested by the SIST EN 13402-3 standard [15]. Five size groups were created with bust girths of 80 cm (from 78.5 to 82 cm), 84 cm (from 82.5 to 86 cm), 88 cm (from 86.5 to 90 cm), 92 cm (from 90.5 cm to 94 cm) and 96 cm (from 94.5 cm to 98 cm).

Basic statistical parameters of analysed variables were calculated for each group. Statistically significant differences between size groups for a single variable were first tested using ANOVA and then using post-hock T-tests for single pairs of size groups (Bonferroni correction). Statistically significant differences between measured and calculated BRise distances within a single size group were tested using a T-test for paired samples. A Pearson correlation coefficient was calculated between measured and calculated BRise. The results were statistically processed using SPSS software (version 22, IBM SPSS, New York, USA). Alpha error was set to 5% (two-tailed).

3 Results

Body rise distances obtained from different tables of contemporary construction systems are presented in Table 1. Among the systems used, the Müller system gave the lowest values for all size groups, while the Parish system provided the highest values for all size groups. Differences between systems were substantial, from 1.5 cm for women with a bust girth of 80 cm, up to 4.3 cm for women with a bust girth of 96 cm. In all presented systems, BRise values increased in conjunction with an increase in bust girth, most notably in the Parish system, where distance changed linearly for 1.1 cm between sizes.

The results of body rise distance (BRise) as measured in this study are presented in Table 2. The most significant difference between the means of size groups was 0.84 cm. There was no statistically

Table 1: Body rise values obtained from the measurement tables of different construction systems for women with different bust girth and similar body height (Max-min represents the difference between maximum and minimum values.)

Preglednica 1: Vrednosti globine sedala iz različnih konstrukcijskih sistemov za ženske z različnim prsnim obsegom in podobno višino telesa (Maks.-min. je razlika med maksimalno in minimalno vrednostjo)

System/ *Sistem*	Size/*Velikostna številka* [cm]					Max-min/ *Maks.-min.* [cm]
	80	84	88	92	96	
Aldrich	26.6	27.3	28.0	28.7	29.4	2.8
Parish	26.8	27.9	29.0	30.1	31.2	4.4
Haggar	26.4	27.2	28.0	28.8	29.6	3.2
Jansen	–	26.5	26.5	27.0	27.0	0.5
Armstrong	–	25.4	26.0–26.7	27.3	27.9	2.5
Müller1	25.5	25.5	26.0	26.5	27.0	1.5
Müller2	25.3	25.7	26.1	26.5	26.9	1.6
Max-min	1.5	2.5	3.0	3.6	4.3	

Table 2: Measured and calculated values for BRise distance from the study's participants (N – number of persons measured; BRise – measured body rise distances; BRise_calc – calculated body rise distances; BRise_diff – difference between BRise and BRise_calc; Sig. – statistically significant differences between groups' means of BRise and BRise_calc; p – statistical significance)
Preglednica 2: Izmerjene in izračunane vrednosti globine sedala udeleženk raziskave (N – število merjenih oseb, GSe – merjena globina sedala, GSe_izrač. – izračunana globina sedala, GSe_razlika – razlika med GSe in GSe_izrač., AS – aritmetična sredina, SO – standardni odklon, p – statistična značilnost)

Bust girth/ *Prsni obseg*	N	BRise/*GSe* [cm]		BRise_calc/*GSe_izrač.* [cm]		BRise_diff/ *GSe_razlika* [cm]		T-test/ *T-test*
		Mean/*AS*	SD/*SO*	Mean/*AS*	SD/*SO*	Mean/ *AS*	SD/*SO*	Sig./*p*
80	18	28.14	1.42	23.40	1.14	4.80	1.70	<0.001
84	66	28.15	2.31	23.53	0.84	4.62	2.13	<0.001
88	47	28.00	2.62	24.15	0.99	3.84	2.50	<0.001
92	29	28.84	2.65	24.92	1.30	3.92	2.32	<0.001
96	20	28.23	2.75	25.48	1.38	2.74	3.07	=0.001
ANOVA	180	p=0.662		p<0.001				

significant difference in mean distances between size groups ($p > 0.05$). However, variability within size groups was much greater, as standard deviations within size groups exceeded 2 cm, except in the 84 cm size group. The opposite was observed in the BRise_calc. There were statistically significant differences in mean distances between size groups ($p < 0.001$). The mean values of BRise_calc increased as bust girth increased. The statistical significance of the mean differences between size groups is presented in Table 3. The greatest mean difference was 2.08 cm between the smallest and the largest size groups. All standard deviations within size groups were less than 1.4 cm. All differences between the mean values of BRise and BRise_calc for the same size group were statistically significant ($p \leq 0.001$). The differences in mean values decreased as bust girth increased, and ranged between 4.80 and 2.74 cm for the smallest and the largest size groups. The relationship between measured and calculated BRise was weak, but statistically significant ($r = 0.283$, $N = 180$, $p < 0.001$).

The differences between measured BRise and other BRise values are presented in Table 4. The most striking observations were differences in the distribution of the mean body rise values of measured BRise on one hand and all other construction systems on the other. BRise values increased as bust girth increased in all construction systems. In small size groups, measured BRise values were higher than the systems' BRise values. In some systems, the measured values for larger size groups were lower than the systems' values. The largest difference exceeded 4 cm, while nearly half of all differences exceeded 2 cm.

Table 3: Statistical significance (p values) for post-hoc T-tests between groups for BRise_calc
Preglednica 3: Statistična značilnost (vrednost p) za post-hoc T-teste med skupinami za GSe_izrač.

Bust girth/ *Prsni obseg*	p values from post-hoc T-tests for different sizes/ *Vrednosti p za post-hoc T-teste med različnimi velikostnimi številkami*			
	80	84	88	92
84	1.000			
88	0.138	0.024		
92	0.000	0.000	0.024	
96	0.000	0.000	0.000	0.716

Table 4: Mean differences between measured BRise and other BRise distances (based on Tables 1 and 2)
Preglednica 4: Razlike med pomerjenimi GSe in drugimi GSe za različne velikostne številke (glede na preglednici 1 in 2)

System/ *Sistem*	Mean differences between measured BRise and other BRise distances for different sizes/ *Razlike med pomerjenimi GSe in drugimi GSe za različne velikosti* [cm]				
	80	84	88	92	96
Aldrich	–1.54	–0.85	0.00	–0.15	+1.17
Parish	–1.34	–0.25	+1.00	+1.25	+2.97
Haggar	–1.74	–0.95	0.00	–0.05	+1.37
Jansen	–	–1.65	–1.50	–1.85	–1.23
Armstrong	–	–2.75	–2.00	–1.55	–0.33
Müller1	–2.64	–2.65	–2.00	–2.35	–1.23
Müller2	–2.84	–2.45	–1.90	–2.35	–1.33
BRise-calc	–4.74	–4.62	–3.85	–3.93	–2.75

As an example, differently obtained BRise distances were used to create the shape of the basic front trouser pattern for a single size number with the aim of presenting obtained differences graphically (Fig. 2). The differences resulting from varying BRise distances affected the shapes of the trouser pattern considerably, in terms of height and width around the natural waist level.

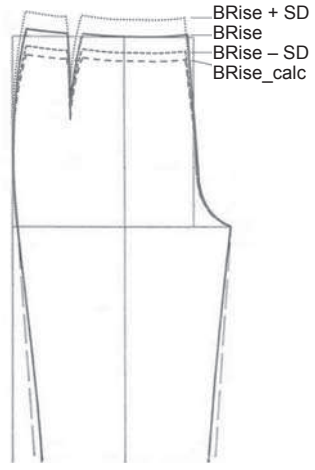

Figure 2: Effect of different BRise distances on the shape of the basic front trouser pattern block within the same size group (bust girth 88 cm). BRise +SD (30.62 cm); BRise (28.0 cm); BRise -SD (25.38 cm); BRise_calc (24.15 cm)
Slika 2: Vpliv različnih vrednosti GSe na obliko sprednjega krojnega dela osnovnega kroja hlač za isto velikostno številko (prsni obseg 88 cm). GSe +SD (30,62 cm), GSe (28,00 cm), GSe-SD (25,38 cm), GSe_izrač. (24,15 cm)

4 Discussion

The main findings of this study were as follows: (i) measured body rise distances differed significantly from those obtained from most of the tables of contemporary construction systems or calculated as a secondary measure according to some authors; (ii) measured BRise distances were the same in all size groups and did not increase as the size group increased as is the case with all analysed contemporary construction systems; (iii) the range of measured BRise distances within each size group was substantial (SD from 1.47 to 2.75 cm); and (iv) the Müller system gave the lowest values of BRise distances for all size groups.
The differences in BRise distances between the analysed systems are smaller in small size groups (1.5 and 2.5 cm) and become substantial in the largest size groups (up to 4.3 cm). It seems to be very important for trouser manufactures which BRise distance they choose to use in trouser pattern block development processes for their specific target group of customers. Differences in BRise distances between size groups within the presented systems were rather significant (except with Aldrich and Haggar in groups 88 and 92), primarily around 1 cm, while BRise distances increased as size group increased. It seems that different contemporary construction systems take a similar approach to setting their BRise distances. In contrast, measured BRise did not follow any trend, while its mean distances did not differ significantly between size groups nor show any tendency of increasing or decreasing as size group increased. Measured BRise distances were closer to

those within larger size groups in the analysed systems than those within smaller size groups. Moreover, the Müller system (which is the most frequently used system in Slovenia) gave the lowest values of BRise distance for all size groups, although it uses a measurement methodology that should provide higher results than other systems. It is thus the only system in this survey that measured BRise distance between the lower edge of the band, bounded around the natural waist, to the seat following the hip contour on a seated figure [12], while all other systems measured BRise as the direct vertical distance between the natural waist line and crotch line.

All of these points to significant discrepancies between proposed and actual BRise values, and raises questions regarding the suitability of the BRise values used in the tables of contemporary construction systems relative to the observed population of young Slovenian females. Differences in values have a significant effect on the fit of trousers around the natural waist level (Fig. 2). The range within size groups in terms of measured BRise values was large (SD from 1.42 to 2.75 cm), which raises questions about the introduction of sub-sizes based on BRise values.

Calculated BRise distances should correspond better to the individual characteristics of subjects than those from pattern construction systems, as they are based on their known dimensions, e.g. hip girth. In this study, however, measured BRise and calculated BRise were only weakly correlated. Additionally, the mean differences between calculated BRise and measured BRise were significant and have a considerable effect on the fit of trousers. This means that the calculated BRise did not reflect the actual BRise dimensions of young Slovenian females. Differences in BRise distance have a considerable impact on the shape of the basic trouser block from the natural waist level to the crotch level as presented in Fig. 2.

BRise distance is not only important in the development of basic trouser pattern blocks in terms of proper fit; it is also important for every garment that covers the part of the body above the natural waist, hip and crotch level (bodysuits, coveralls, etc.). The tighter clothes are, the more important the correct value of BRise distance becomes.

The importance of selecting the actual values of BRise distance is even more significant in the made-to-measure business. The values of the BRise distances of participants in the survey vary significantly. If, for example, we developed a basic trouser pattern block for women with much higher values of BRise distance, ignoring this data and using a value from measurement tables or a calculated value, the trousers would be much lower from the natural waist level where waist girth was measured. The trousers would therefore become too small in this new waist level of the trousers and would thus not fit properly on the body. Alterations would not be possible because of the lack of textile material on the side seam and above the developed waist level of the pattern. This problem would be less significant if the actual value of BRise distance is lower than the one incorporated in the basic block pattern, as it would only cause the very poor fit of the trousers below the crotch seam or in the waist level. Alterations would still be possible and necessary. Nevertheless, the time and energy to make those alterations means lost money and the raising of the prices of products, which in turn would hinder a company's ability to maintain its competitive advantage on the market. This is another reason to include BRise distance in anthropometric surveys as one of the important measures that affect the shape of the pattern block and thus the fit of clothes.

In the past, there was a tendency to reduce the number of primary measures because manual anthropometric surveys are time consuming and costly. However, the issue of proper fit has had such a critical impact on sales that companies have started to apply technological tools to improve apparel fit. Manufacturers and retailers install 3D body scanners and computer aided design (CAD) systems to assist in made-to-measure processes [17]. With the use of 3D body scanners, information about body dimensions can be obtained faster and is more user-friendly. This provides for the possibility of obtaining significantly more measures directly from a body, and those measures should always include body rise distance. Through the introduction of 3D body scanning technologies, many contemporary researchers have begun to investigate different target group of customers and to identify new body dimensions that are important for ensuring better fitting basic clothing blocks [18–21]. Additionally, large data bases of clothing 'customers' worldwide should be created to provide different clothing companies the possibility of extracting only those 'customers' important for their business. In that way, information regarding actual body measurements would give them a competitive advantage on the market, while improving customer satisfaction in terms of the proper fit of garments on their bodies.

5 Conclusion

In conclusion, the values for body rise distances as proposed by different contemporary construction systems differ from the values measured in the young Slovenian female population. Measured BRise distances showed no significant differences in mean values between size groups, while BRise increased systematically in conjunction with bust girth in all other systems. The largest differences with regard to measured BRise were seen in BRise calc. In most cases, the differences from measured BRise were substantial and could significantly affect the fit of trousers between the level of the natural waist and crotch line. It is suggested that body rise distance be included as a directly measured parameter for pattern block construction when producing made-to-measure clothes.

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