METHOD OF CONTROL OF THE COMPATIBILITY OF THE CHILDREN'S CLOTHING DESIGN USING COEFFICIENTS OF DIMENTIONAL FEATURES GRADATION

Alla Slavinskaya, Oksana Dombrovska, Viktoriia Mytsa, Julia Koshevko, Anatolii Dombrovskyi and Tetiana Ivanishena

Khmelnitskyi National University, Institititska str. 11, Khmelnitskyi, Ukraine
juliakoshevko@gmail.com

Abstract: *The problem of controlling the proportionality of clothing design by the gradation method of typical figures of preschool age children is investigated. Set of dimensional features for the determination of intermediate control measurements is analytically grounded. The use of the gradation algorithm for the tasks for scaling the geometric model of the body surface into a geometric model of garment details has been proved. The interrelation of gradation coefficients from dimensional standards with the estimated values of the dimensions of the constructional dimensions of shoulder clothing dimensions is experimentally investigated. The regression analysis confirmed the gradation coefficients for design development and control of the dimensionality of the finished product.*

Keywords: *proportionality, design, children's clothing, gradation, dimensional feature, constructive section, coefficient, age group, formula, regression.*

1 INTRODUCTION

One of the most important tasks facing the manufacturers of clothing is the preparation of high-quality design and technological documentation. The initial stage of creating a sewing product is the development of design drawings, on the basis of which a basic set of pattern parts is created. The unsuccessful choice or incorrect application of the method of making drawings and the further development of the basic patterns of parts, despite the adherence to all principles of design, can significantly affect the quality of the result of the finished sewing product.

A significant place in the design preparation of production is the gradation of patterns of the garments' parts. The use of grading methods to develop patterns of different sizes and heights simplifies and accelerates the process of preparing working documentation for the manufacture of clothing.

There are two principal approaches to the implementation of the gradation: gradation by diagrams and parametric gradation. Modern automated clothes systems provide a fairly rapid construction of templates of various sizes and heights, both according to known gradation schemes, and by the primary algorithm of anthropometric modification of the basic design in a given morphological type of the figure, which simplifies the process of obtaining the template of the required sizes.

Nowadays, the question of the gradation process of clothes patterns for children despite numerous studies, remains open, which is largely due to the lack of methods for checking the quality of gradation of patterns, taking into account the preservation of the anthropometric proportionality of products in the personalized parameterization of the sexual and age groups of the children's population.

2 DISCUSSION OF IDEAS

The construction of the geometric model of the garment surface is based on the logical spatial relationship between the displacements of the anthropometric points of the body surface to the design points of the garment details. The information model of the design details must be identical or close to the property of the proportionality of the surface of the body section [1-3].

The promising application of three-dimensional visualization software products to create an objective system of anthropometric dimensional features is confirmed by works [4-6].

The Julivi Clo 3D program contains electronic mannequins of typical figures of various morphological types, which are re-formatted for children's clothing in an anthropometric database of current national standards [6]. However, the singular dimension of the control measurements

of the dimensions of the structure is not confirmed by the preservation of the coefficients of gradation of dimensional features in the non-uniform scaling of the shape of the product.

An example of the use of non-uniform scaling as a prototype of gradation is considered in the construction of structures of various types of clothing in CAD Julian by calculating the scaling coefficients using the computer program Scale factor [7]. However, in the information database of increments, there is no differentiation of the gradation coefficients for dimensional groups. An analytical way of systematizing the types of figures at the level of classification by factoring of proportionality, considered in [8], complements the anthropometric database of current dimensional standards for the tasks of parameterization of the clothing proportionality.

The mechanism for obtaining projective dimensional features of a person through the use of feedback between the drawing and dimensional features in the CAD of clothing for the technical possibilities of changing the coordinates of the main points of the figure outline is given in [9, 10] on the example of CAD "Gracia".

The disadvantage of using shape outlines to form an anthropometric database is inability to take into account the level of displacement of anthropometric heights in the configuration of sections of the design given by the girths.

Investigations [11] on the construction of shoulder wear for girls in pre-school and junior school groups revealed contractions of contours of the loops in volumes 332, 352 in increments requiring clarification of the calculation formulas of the standardized method of clothing design used by the members of economic assistance matching the use of the dimensional feature of the anterior-posterior diameter of the hand T 57 in calculations of the armhole width.

Analytical study of the same-size features of the typical figures of boys and girls in the preschool age group shows their independent variability, both with change in size and with a change in height [12]. This causes the anthropometric discrepancy of structures constructed on a typological series of dimensions of the gradation coefficients.

Adaptation of anthropometric information to the control measurements of sections of the finished product requires the study of the calculation formulas of the main structural segments. The first priority is the intermediate control of coherence by measurements of length and width, which characterizes the dimensions of the product and confirms the relevance of the research.

3 METHODS

The flat design of the garment details is presented as a set of straight and curvilinear sections forming a closed loop.

Construction of a geometric model of clothing surface is theoretically grounded in the study [1].

In the working documentation for the sewing product, the measurement table provides the quality control of the finished product by measurements in the size-growth groups. The name and number of basic measurements vary from 2 to 21 depending on the range of products [13]. Accordingly, the main design document for manufacturing a product in a given range of size of the groove is a graduation drawing, which must meet the requirements for the quality of the design [14, 15].

While grading patterns changes on certain sections lead to similarity, which belongs to the group of linear and corresponds to the affine method of changing the scale of the contour of the part in the regulated amount of compression (stretching) of the anthropometric sign in the form of the coefficient of gradation [1, 16, 18].

The affine transformation in the gradation of the patterns means any change in the scale of the curve simultaneously in one or two axes. In this case, the straight lines remain linear, parallel - parallel, the ratio of the segments, located on the same straight line (or on parallel lines), remain unchanged, the algebraic order of the curve does not change.

Thus, the principle of gradation is based on the use of a group of linear geometric transformations of the contour of the construction part by increasing the coordinates in the main constructive points [14, 16].

$$(x_1; y_1) \rightarrow [(x_0+\Delta x_0); (y_0+\Delta y_0)] \quad (1)$$

where: x_0, y_0 are the coordinates of the constructive points of the original construction [cm]; Δx_0, Δy_0 - values of moving of corresponding constructive points in a construction of another size.

It is known that the designer anthropometric standard contains information on the uniform increase of subordinate dimensional attributes in a number of typical figures and reproduces sufficiently well the morphological status of different in the age, national and sex characteristics of the population for the problems of the ready-made clothes market.

However, at a significant number of sewing enterprises, designing products for children of nursery and preschool age groups is often performed without taking into account the gender of the child, which has a significant impact on the size and shape of the areas of static contact of clothing and, thus, the quality of planting products on the figure.

Therefore, the main condition of anthropometric studies of the body surface of children for the gradation of patterns is the inclusion of age groups: in particular, preschool one - 3 years – 6 years 11 months [16].

In accordance with the current system of standards for typical children's shapes [13] and taking into account the opportunities of the industry and the conditions of trade for the design of clothing for preschool age children, an optimal number of typical figures is provided, which includes 8 typical male figures and 8 typical female figures of the preschool age group (Table 1).

Table 1 Classification of typical figures of boys and girls of the preschool age group

Dimensional feature	Size of the dimensional feature [cm]		
Chest circumference	52	56	60
Waist circumference	48	51	54
Height	98	98	
	104	104	
		110	110
		116	116

Note: Basic size is highlighted

For children of the preschool age group, the regression equation after linearization of the calculation of subordinate dimensional attributes has the following entries:

Before the linearization:

$$x_i = a+bx_1+cx^2_{16} + ex_1 \times x_{16} \quad (2)$$

After the linearization:

$$x_i = a + b.x_1 + c.x_{16} \quad (3)$$

where: x_i is any subordinate dimensional sign; x_1 is body length (height); x_{16} - chest circumference; *a, b, c* are coefficients of regression.

As a rule, the calculation formulas of the design methods establish the dependence of the size of the structure on the values of dimensional features. In particular, the main type of constructive segments in the standardized method of clothing design used by the members of economic assistance has also a form of linear regression:

$$A\text{-}B = c_nT_i + a_n + A \quad (4)$$

where: c_n is a coefficient, which determines the proportion of dimensional feature in the segment; T_i is the magnitude of the dimensional feature; a_n - free member of the formula with the index of the number of the system of basic structural segments, which take into account the features of the body structure of sex-age groups and *A* - the total value of constructive increments and technological allowances.

Since in the structure of the calculation formulas, constructive increments are constant for all sizes and increments, it is expedient not to consider them in the studies of gradation coefficients.

The system of the main constructive sections of the unified method of designing the clothes of the Council for Mutual Economic Assistance contains information about the segments that are output for the construction of the basis of the design of clothing, and contains a unified sequence and method of construction, the initial solution of the main constructive nodes [16], so it is necessary to study the application of the design of the product of dimensional features and compare with the corresponding gradation factors in the standards.

The express method of analyzing the reasons for the anthropometric inconsistency of gradation increments along the lines of the chest and thighs in the basic designs of shoulder products for preschool age children is based on the verification of the formula for calculating the width of the product along the breast line, since this particular area of the basic structures of the shoulder products determines the overall dimensions of the shoulder products in width [17].

The width of the shoulder product along the line of the chest consists of the width of the back (area/31-33/), the width of the front (area/35-37/) and the width of the perimeter (area/33-35/). The following formulas [15, 16] are used in the calculation of the values of these sections of the design in the only method of designing the clothes of the Council for Mutual Economic Assistance:

$$/31\text{-}33/ = 0.5T47 - 0.5 + A_{31\text{-}33} \quad (5)$$

$$/33\text{-}35/ = T57 + 1.0 + A_{33\text{-}35} \quad (6)$$

$$/35\text{-}37/ = 0.5(T45 + T15 - T14) – 0.5 + A_{35\text{-}37} \quad (7)$$

where: *T47* is the width of the back [cm]; $A_{31\text{-}33}$, $A_{33\text{-}35}$, $A_{35\text{-}37}$ - structural additions to the corresponding sections of the design [cm]; *T57* - anterior-posterior diameter of the hand [cm]; *T45* - breast width [cm]; *T15* - the second circumference of the chest [cm]; *T14* - the first circumference of the chest [cm].

Formula (5) can be attributed to the formulas of the 1st type, because the size of the area is determined by the corresponding dimensional type of the figure and the increase. Formulas of the 1st type provide the correspondence of increments of gradation to gradation coefficients.

Formula (6) refers to the formulas of the 2nd type, since for the calculation of the size of the area of the construction of the size of the product; a dimensional feature that characterizes a certain parameter of the hand is applied. Consequently, on the area of an armhole, the increments of the gradation characterize not the area of the body but the change in the diameter of the hand.

Formula (7) consists of dimensional features that characterize the chest belt, so it also refers to the formulas of the 1st type.

Consequently, from the considered formulas only formula (6) contains the dimensional sign *T57*, which does not characterize the size of the chest belt of the figure. In addition, *T57* is excluded from the current children's size standards [13]. Therefore, it is advisable to establish the dependence of the armhole width on the corresponding area of the chest belt, that is the influence of the dimensional feature of the size of armhole *T109* (Figure 1), which is included in the state standards of the typical figures of the children's population GOST 17916-86, GOST 17917-86.

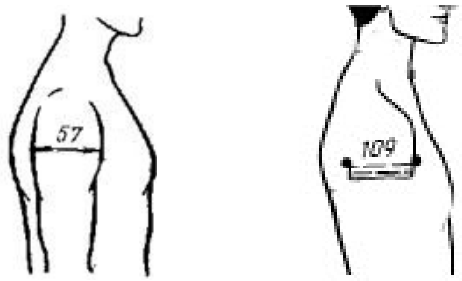

Figure 1 Diagram of measuring the dimensions of the "anterior-posterior hand diameter" (*T57*) and „armhole width" (*T109*) in the typical figures of boys and girls

Since this dimensional feature is included in the circumferential dimensions of the child's chest belt, it can be assumed that the calculated width parameter of the armhole of the basic structure should correspond to the parameters of the body part and, accordingly, the increment of the gradation in the area of the projections will characterize the change in the body area.

Taking into account that the line of transition of the trunk to the upper limb in products with a sewing sleeve characterizes the combination of contours of the holes and the cap of the sleeve, it is necessary to establish the relationship between the parameters of the armhole and the parameters of the sleeve.

In the unified method of designing the clothes of the Council for Mutual Economic Assistance [15], the length of the armhole in shoulder products for children is calculated by the formula:

$$LA = 0.96T38 + (A_{33\text{-}13} + A_{35\text{-}15}) + \\ + 0.57(T57 + 1.0 + A_{33\text{-}35}) + 2/33\text{-}331/ \quad (8)$$

where: T_{38} is an arc through the highest point of the shoulder joint [cm]; /33-331/ - magnitude of the armhole increase [cm].

The width of sleeve cap (*WSC*) in shoulder products for children is calculated by the formula:

$$WSC = T57 + 3.0 + A \quad (9)$$

Consequently, the structure of formulas (8-9) indicates the absence of a section of the width of the plain in the control dimension of the width of the product at the level of the armhole depth, which suggests a mismatch with the gradation coefficients after calculation.

4 EXPERIMENTAL PART

After the replacement of the size feature *T57* into *T109* in formulas (6, 8, 9) the research of anthropometric correspondence of sizes of structural parts along the width of the product along the breast line of shoulder products for children of the preschool age group has been performed.

For this purpose, the size of the sections of the structures along the breast line has been calculated, depending on the size and height of the typical figures of boys and girls of the preschool age group. Then the comparison of the obtained values with the corresponding gradation coefficients has been made.

The dimension of changes in the size of the constructive sections along the breast line on the typical figures of boys and girls in the preschool age group, depending on the change in size, are given in Table 2.

The dimension of changes in the size of the constructive sections along the breast line on the typical figures of boys and girls of the preschool age group, depending on the change in height, are given in Table 3.

Table 2 Estimated coefficient of gradation of constructive sections according to the height of preschool age group

Constructive section		The dimensions of the change in the size of the constructive sections [cm]							
		98		104		110		116	
		52-48 56-51	56-51 60-54	52-48 56-51	56-51 60-54	52-48 56-51	56-51 60-54	52-48 56-51	56-51 60-54
1		2	3	4	5	6	7	8	9
/31-33/	girls	0.65	0.6	0.6	0.55	0.6	0.5	0.55	0.5
	boys	0.6	-	0.65	0.35	0.7	0.45	0.75	0.5
/33-35/	girls	0.4	0.4	0.4	0.4	0.5	0.5	0.6	0.6
	boys	0.5	-	0.5	0.4	0.5	0.5	0.6	0.4
/35-37/	girls	0.55	0.7	0.65	0.7	0.65	0.65	0.6	0.65
	boys	0.6	-	0.6	0.7	0.55	0.75	0.7	0.7
/31-37/	girls	1.6	1.7	1.65	1.65	1.75	1.65	1.75	1.75
	boys	1.7	-	1.75	1.45	1.75	1.7	2.05	1.6

Table 3 Estimated coefficient of gradation of constructive sections according to the size of preschool age group

Constructive section		The dimensions of the change in the size of the constructive sections [cm]								
		52-48			56-51			60-54		
		98-104	*104-110*	*110-116*	*98-104*	*104-110*	*110-116*	*98-104*	*104-110*	*110-116*
1		*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	10
/31-33/	girls	0.25	0.2	0.25	0.2	0.2	0.2	0.15	0.15	0.2
	boys	0.25	0.25	0.25	0.3	0.3	0.3	-	0.4	0.35
/33-35/	girls	0	-0.1	-0.1	0	0	0	0	0.1	0.1
	boys	0	-0.1	-0.1	0	-0.1	0	-	0	-0.1
/35-37/	girls	0	0.05	0.15	0.1	0.05	0.1	0.1	0	0.1
	boys	0.05	0.1	0	0.05	0.05	0.15	-	0.1	0.1
/31-37/	girls	0.25	0.15	0.3	0.3	0.25	0.3	0.25	0.25	0.4
	boys	0.3	0.25	0.15	0.35	0.25	0.45	-	0.5	0.35

Table 4 Comparison of dimensions of changes in size of structural sections with a change in size with coefficients of gradation (girls and boys)

Constructive section	The dimensions of the change in the size of the constructive sections [cm]							
	98		104		110		116	
	52-48 56-51	***56-51 60-54***	***52-48 56-51***	***56-51 60-54***	***52-48 56-51***	***56-51 60-54***	***52-48 56-51***	***56-51 60-54***
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*
/35-37/ girls	1.6	1.7	1.65	1.65	1.75	1.65	1.75	1.75
/35-37/ boys	1.7	-	1.75	1.45	1.75	1.7	2.05	1.6
Coefficient of gradation	2	2	2	2	2	2	2	2

Table 5 Comparison of dimensions of size's change of constructive sections with height change with gradation coefficients

Constructive section	The dimensions of the change in the size of the constructive sections [cm]								
	52-48			56-51			60-54		
	98-104	*104-110*	*110-116*	*98-104*	*104-110*	*110-116*	*98-104*	*104-110*	*110-116*
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	10
/35-37/ girls	0.25	0.15	0.3	0.3	0.25	0.3	0.25	0.25	0.4
/35-37/ boys	0.3	0.25	0.15	0.35	0.25	0.45	-	0.5	0.35
Coefficient of gradation	0	0	0	0	0	0	0	0	0

The comparison of the dimensions of the change in the size of the design sections along the line of the breast, depending on the change in size and height with the gradation coefficients on the typical figures of boys and girls of the preschool age group, is given in Tables 4 and 5.

As a result of the comparison of the dimensions of changes in the size of the design sections along the line of the breast, depending on the change in size and height with the gradation coefficients, it has been found out that the dimensions of change the size of the constructive sections along the breast line does not correspond to gradation coefficients.

In the single method of designing the clothes of the Council for Mutual Economic Assistance, when calculating the width of the front, the dimensional feature "Breast Width" (*T45*) is used and the difference in dimensional features is "first breast chest" (*T14*) and "second breast chest" (*T15*).

Since the measuring tape is located in an inclined plane on the breast area, both in measuring the circumference of the chest of the first one and in measuring the circumference of the second breast, it is assumed that this precludes the inconsistency of increments of the gradation along the width of the product by the coefficients of gradation. Therefore, it is recommended to express the width of the front through the dimensional features: "the third breast" (*T16*), "the width of the back" (*T47*), "the width of the armhole cavity" (*T109*).

Then the formula for calculating the width of the front (section/35-37/) in the basic structures of shoulder products for the typical figures of boys and girls has the following view:

$$/35\text{-}37/ = 0.5(T16 - T47) - T109 + A_{35\text{-}37} \quad (10)$$

The dimensions of the change in the size of the constructive sections along the line of the chest for the typical figures of boys and girls, depending on the change in size, was calculated using the improved formulas for calculating the width of the front and the width of the armhole, and the results are shown in Tables 6 and 7.

Table 6 The dimensions of the change in the size of constructive sections with a size change

Constructive section		The dimensions of the change in the size of the constructive sections [cm]							
		98		104		110		116	
		52-48 56-51	*56-51 60-54*	*52-48 56-51*	*56-51 60-54*	*52-48 56-51*	*56-51 60-54*	*52-48 56-51*	*56-51 60-54*
1		*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*
/31-33/	girls	0.65	0.6	0.6	0.55	0.6	0.5	0.55	0.5
	boys	0.6	-	0.65	0.35	0.7	0.45	0.75	0.5
/33-35/	girls	0.4	0.4	0.4	0.4	0.5	0.5	0.6	0.6
	boys	0.5	-	0.5	0.4	0.5	0.5	0.6	0.4
/35-37/	girls	0.95	1.0	1.0	1.05	0.9	1.0	0.85	0.9
	boys	0.9	-	0.85	1.25	0.8	1.05	0.65	1.1
/31-37/	girls	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
	boys	2.0	-	2.0	2.0	2.0	2.0	2.0	2.0

Table 7 The dimensions of the change in the size of the constructive sections with the change in height

Constructive section		The dimensions of the change in the size of the constructive sections [cm]								
		52-48			56-51			60-54		
		98-104	*104-110*	*110-116*	*98-104*	*104-110*	*110-116*	*98-104*	*104-110*	*110-116*
1		*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	10
/31-33/	girls	0,25	0,2	0,25	0,2	0,2	0,2	0,15	0,15	0,2
	boys	0,25	0,25	0,25	0,3	0,3	0,3	-	0,4	0,35
/33-35/	girls	0	-0,1	-0,1	0	0	0	0	0,1	0,1
	boys	0	-0,1	-0,1	0	-0,1	0	-	0	-0,1
/35-37/	girls	-0,25	-0,1	-0,15	-0,2	-0,2	-0,2	-0,15	-0,25	-0,3
	boys	-0,25	-0,15	-0,15	-0,3	-0,2	-0,3	-	-0,4	-0,25
/31-37/	girls	0	0	0	0	0	0	0	0	0
	boys	0	0	0	0	0	0	-	0	0

Comparison of changes in the width of the design along the breast line, depending on the change in size and height with coefficients of gradation for the typical figures of boys and girls, confirmed the retention of the gradation coefficient for the width of the product /31-37/, which is 2.0 cm.

Thus, the change in the structure of the calculation formulas of the design methodology, namely, the calculation of the width of the perimeter due to the dimensional feature "armhole width" (*T109*), and the calculation of the width of the front, due to the dimensional features of the "third breast" (*T16*), "back width" (*T47*) and "armhole width" (*T109*) ensures the correspondence of the constructive dimensions changes in width of the product, which improves the proportionality of shoulder products for typical figures of boys and girls of the preschool age group.

5 RESULTS

The results of the research are presented by the conditions for ensuring the reliability of the parameters of the anthropometric correspondence of the values of the structural dimensions of the measurement of the product width after making changes to the structure of the calculation formulas of the methodology of clothes' design of the Council for Mutual Economic Assistance [16].

The first condition is compliance with the gradation rules when choosing a calculation and analytical method for grading the structural sections of the width of the product along the chest line. Since the constructive sections /11-31/, /31-33/, /33-37/ after the changes are located in a rectangular coordinate system, the gradation value is defined as the difference between the points of a certain graded row $\Delta X_z\Gamma_j$ and ΔX_zE_j (Figure 2). So, the dimensions of gradation of points are calculated by the formulas:

$$\Delta X_z\Gamma_j = 1/k(X_z\Gamma_j^{\kappa} - X_z\Gamma_j^{0}) \quad (11)$$

$$\Delta X_zE_j = 1/k(Y_z\Gamma_j^{\kappa} - Y_z\Gamma_j^{0}) \quad (12)$$

where: k is the serial number of the size, counting from the zero initial size of a certain graded row; $X_z\Gamma_j^{\kappa}$, $X_z\Gamma_j^{0}$, $Y_z\Gamma_j^{\kappa}$, $Y_z\Gamma_j^{0}$, the coordinates of points of k-th size and zero initial size; z - index of major dimensional features *T1, T16*.

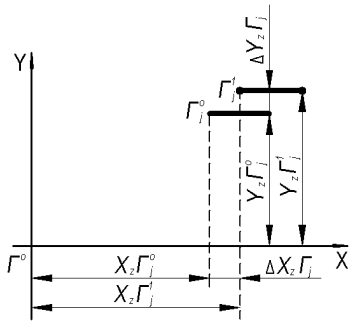

Figure 2 Scheme for determining the dimensions of the gradation $\Delta X_z\Gamma_j$ and ΔX_zE_j

In the calculation-analytical method, grading figures are calculated on the basis of gradation coefficients, which, in the anthropometric (constructive) standard, fix the difference between the values of dimensional characteristics, in particular for children of the preschool age group, between adjacent sizes, heights and their combinations. Dimensions from standards are called anthropometric coefficients of gradation.

By the experimental studies of the constructive sections of the product's width on the breast line /11-37/ (Tables 2 and 3) of the product the calculative coefficients of gradation parts have been defined.

For the consideration of the plane of the oblique section in the area of the posterior angle of the armhole, in which the *T15* (Figure 3) is measured, the calculations are performed according to the recommendations [16].

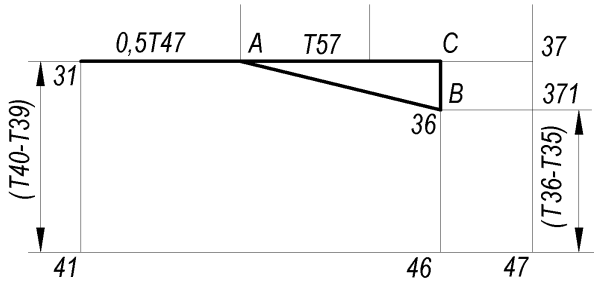

Figure 3 Scheme for determining the width of the front at the posterior angle of the armhole

In accordance with Figure 3:

$$AB = 0.4(T15 - 0.5T47) \quad (13)$$

$$BC = (T40\text{-}T39) - (T36\text{-}T35) \quad (14)$$

$$AC = \sqrt{AB^2 - BC^2} = a_8 \quad (15)$$

The indices of the dimensional features *T* correspond to the dimensional standards; the free member a_8 is the serial number of the system of the main structural segments. The dimension a_8 defines a decrease in the size feature *T15* for matching the width of the front along the horizontal line.

Calculations are made on the base size 110-56-51 for children of preschool age group using 1st standard – state one (anthropometric 1986), the second standard - branch one (designer 1977). These standards are used to study dimensional characteristics. After calculations the following values of a_8 are received:

For boys: (1)a_8 = 0.057; (2)a_8 = 0.037;

For girls: (1)a_8 = 0.05; (2)a_8 = 0.04.

The second condition is the observance of the necessary accuracy of the allowable deviations at the design stage of the product.

In accordance with the system of allowances [16], the average figures of allowances in the design process are 0.05 cm, rounding at design calculations up to 0.05 cm.

Consequently, the value a_8 < 0.1 cm which confirms the expediency of the exclusion of a_8 from the calculation of the width of the front for the younger children and the use of the dimensional feature *T16* instead of *T15*. Then the formula has the form:

$$35\text{-}37 = 0.5(T45 + T16 - T14) + A_{35\text{-}37} \quad (16)$$

The third condition is to ensure the unification of constructive elements of construction of approximating curves.

The analysis of the geometric construction of the conjugation of the armhole [1.1] confirms the expediency of replacing the dimensional feature *T57* with *T109*, since t. 352, which fixes the armhole width in the segment /33-35/, in the calculations shifts towards the narrowing for the base size 110-56-51 (to 0.5 cm for boys and 0.7 cm for girls). This is confirmed by Figure 4.

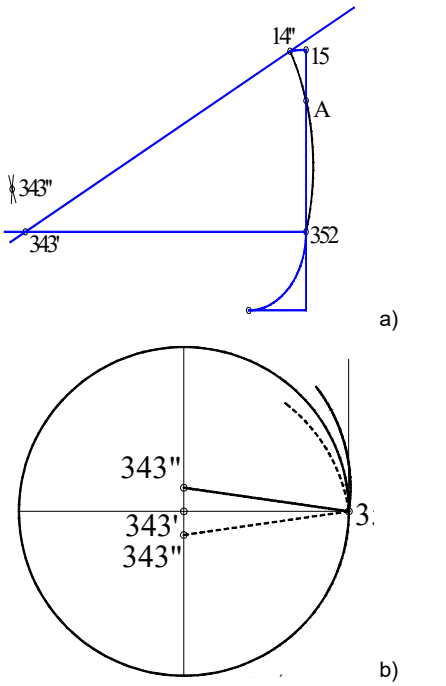

Figure 4 Scheme of contraction of the conjugation of the radiusography of the armhole contour: a) on the example of the design, b) possible variants

With the use of *T109*, the center of the circle for the design of the upper part of the armhole is on the extension of the contours from the points of change of the contour 332 (back), 352 (in front) as the vertex of an equilateral triangle. The method for drawing up the contour of the upper portion

of the armhole is shown in Figure 5 and definitely ensures the conjugation of the lower and upper parts of the armhole.

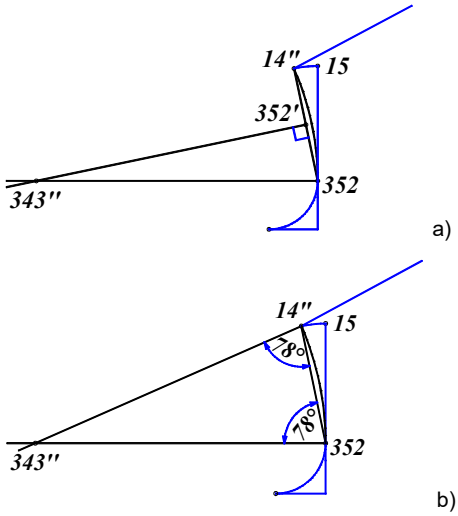

Figure 5 The design of the contour of the upper part of the armhole: a) the first way; b) the second method

Since in the formula (8) for calculating the width of the armhole the dimension *T57* is replaced by the dimensional feature *T109*, then the structure of the calculation formula for the *LA* and *WSC* takes the following form:

$$LA = 0.96T38 + (A_{33\text{-}13} + A_{35\text{-}15}) + \\ + 0.57(T109 + 1.0 + A_{33\text{-}35}) + 2/33\text{-}331/ \quad (17)$$

or

$$LA = 0.96T38 + (A_{33\text{-}13} + A_{35\text{-}15}) + \\ + 0.57/33\text{-}35/ + 2/33\text{-}331/ \quad (18)$$

$$WSC = T_{109} + a_{71} + A \quad (19)$$

The verification of these formulas is performed for the base size 110-56-51. According to the recommendations [16] a_{71} = 3.0 cm, and is calculated by the formula:

$$a_{71} = 0.5T_{28} - T_{57} \quad (20)$$

As the research shows $a_{71} = 0.5T_{28} - T_{109}$

respectively for T_{57} a_{71}^{G} = 2.4; a_{71}^{B} =2.3;

and for T_{109} a_{71}^{G} =2.9; a_{71}^{B} =2.6.

So, for T_{57}, T_{109} $a_{71} < 3.0$. The value of the deviation for T_{57} does not meet the condition of observance of accuracy A_{gen} = 0 3 mm. For T_{109} there is a compromise. Then for T_{109}:

WSC_G = 8.9 cm; WSC_B = 8.7 cm.

The minimum sleeve width is checked with:

$$WSC = T_{28} + A_{min} \quad (21)$$

where: A_{min} allows to bend the arm at the elbow.

The results of checking the design and minimum width of the sleeves confirmed the condition:

$WSC^{calc}{}_G$ = 8.9 cm; $WSC^{con}{}_G$ = 8.9 cm;

$WS^{calc}{}_B$ = 8.7 cm; $WSC^{con}{}_B$ = 8.7 cm.

Therefore, we support the recommended formula (19).

The condition of the approximation of the contour is achieved by the unification of the centers of radiusography.

The fulfilment of the formulated conditions ensures the check how the measurements of the width of the product along the chest line and the width of the sleeve under the armhole correspond to the coefficients of the anthropometric gradation in the values of the calculated grading coefficients.

A systematized number of sizes of structural segments in typical size groups of leading dimensional features and basic sizes of typical figures for girls and boys are given in Table 8 and thus, forms an anthropometric database for controlling the dimensions of the product.

Table 8 Anthropometric base of output dimensions of the main structural segments (without allowances) of shoulder clothes for typical figures of young children

Constructive section	Dimensions [cm]							X	S	BF1	BF2	BF3
T1	98		104		110							
T16	52	56	52	56	52	56	60	55.75				
T18	48	51	48	51	48	51	54					
/31-33/	11.05 11.05	11.7 11.65	11.3 11.3	11.9 11.95	11.5 11.7	12.1 12.25	12.6 12.7	g 12.26 b. 12.0	0.4 0.5	12.5 12.6	12.5 12.75	12.5 12.75
/33-35/	6.7 6.6	7.1 7.1	6.7 6.6	7.1 7.1	6.6 6.6	7.1 7.0	7.6 7.5	g 7.12 b. 7.05	0.6 0.5	6.7 6.5	6.7 6.5	6.0 6.0
/35-37/	8.75 8.65	9.7 9.75	8.5 8.4	9.5 9.45	8.4 8.35	9.3 9.25	10.3 10.25	g 9.41 b. 9.45	0.5 0.5	10.9 10.9	11.1 11.0	10.65 10.7
/31-37/								g 28.79 b. 28.5	1.5 1.5	30.1 30.0	30.3 30.0	29.15 29.45

Deviations /31-37/ from *T15* is for girls – 0.3 and for boys – 0.4, which correspond to the second condition. According to the specified method, the design sections are calculated according to the formulas:

$$31\text{-}33 = 0.5T47 - 0.5 + A \quad (22)$$

$$33\text{-}35 = T109 + 1.0 + A \quad (23)$$

$$35\text{-}37 = 0.5(T16\text{-}T47) - T109 + A \quad (24)$$

The arithmetic mean and the *S* variance confirmed the expediency of using the segment /31-37/ of the base figure to detect patterns of segments change /33-35/ in the parameters of the sleeve.

A criterion estimation of the influence of gender on the dimensional features was made by regression analysis of the dimensions of structural segments in the set of basic figures of the researched dimensional row: *X, BF1, BF2, BF3* (Figures 6 and 7).

According to the results of studies of the constructions 110-56-51 for girls and boys, a gender variability of 0.3 cm has been found, which corresponds to the value of the total allowance.

Anthropometric coefficients of gradation of dimensional features for the control of design stages of products for preschool age children are shown in Table 9.

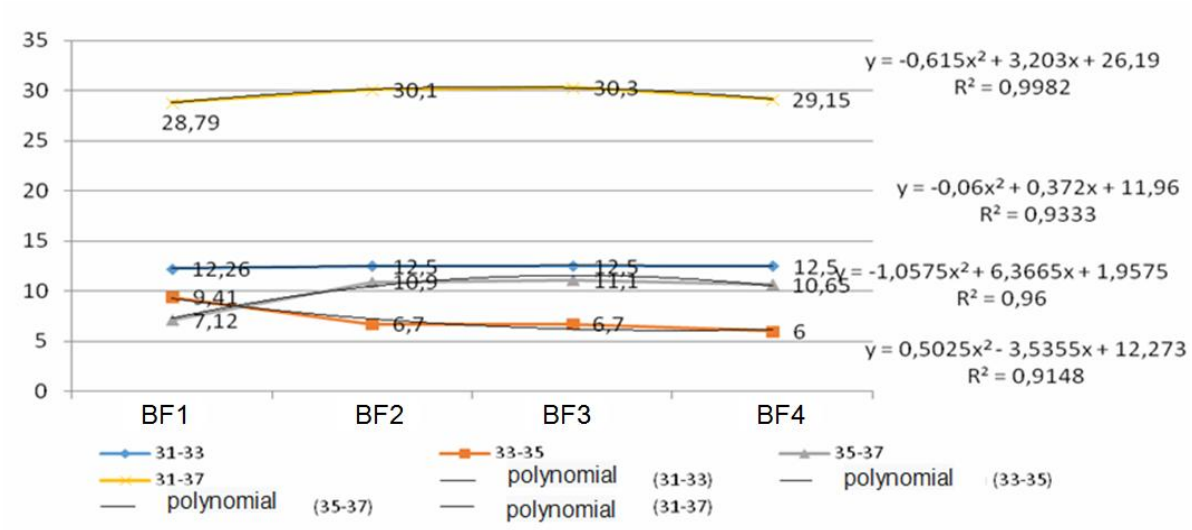

Figure 6 Regression dependences of gender changes in dimensional characteristics of girls

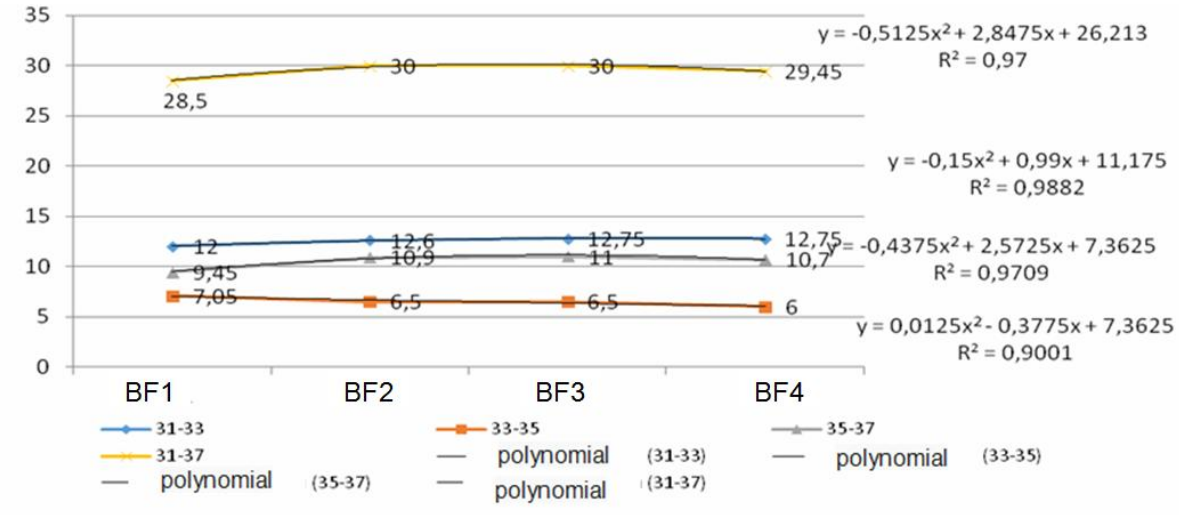

Figure 7 Regression dependences of gender changes of boys' dimensional characteristics

Table 9 Gradation coefficients of dimensional characteristics of control measurements of the shoulder product, size 110-56-51

Dimensional feature	Girls			Boys			Common		
	T1	*T16*	*T1+T16*	*T1*	*T16*	*T1+T16*	*average value*		
T29	0	0.5	0.5	0	0.5	0.5	0	0.5	0.5
T15	0.4	3.6	4.0	0.2	3.8	4.0	0.3	3.7	4.0
T57	0	0.6	0.6	0	0.5	0.5	0.5	0.55	0.55
T15	0.2	3.8	4.0	0.4	3.6	4.0	0.3	3.7	4.0
T45	0.4	1.0	1.4	0.2	1.0	1.2	0.3	1.0	1.3
T47	0.6	0.8	1.4	0.6	1.0	1.6	0.6	0.9	1.5
T40	1.1	0	1.1	1.1	0.2	1.3	1.1	0.1	1.2
T39	0.5	-0.2	0.3	0.5	-0.3	0.2	0.5	0.05	0.25
T109	0	0.8	0.8	0	0.6	0.6	0	0.7	0.7
T36	1.1	0.5	1.6	1.0	0.7	1.7	1.05	0.6	1.65
T35	0.6	0.2	0.8	0.5	0.6	1.1	0.55	0.4	0.95

6 CONCLUSIONS

As a result of the use in the method of design the improved formulas for calculating the parameters of the width of the armhole and the width of the front, the concordance of the values of the change in the size of the structural sections along the width of the product and along the breast section with the corresponding grading coefficients in the basic structures of the shoulder products for the typical figures of boys and girls of the preschool age group has been achieved.

Completed developments can be used for baby clothing design techniques that use an anterior-posterior hand diameter to calculate armhole widths.

In order to ensure the relationship between the width of the armhole and the parameters of the sleeve, the relationship between the armhole width of and the armhole length of the product's armhole and the width of the armhole and the width of the sleeve's cap have been established.

The representativeness of the method for assessing the reliability of control measurements in the structure construction is confirmed by the quadratic equations of variability of leading standard features.

This allows using the algorithm to verify the proportionality of the products in the choice of chart grading patterns, taking into account design techniques and current dimensional standards.

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