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## DEVELOPMENT OF SIZE RANGE OF SHOES FOR YOUNG MEN OF ZHAMBYL REGION

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*The work has developed a size and full range of shoes for young men in the Zhambyl region. The measurement data of the feet of teenagers in the Zhambyl region were used to calculate the size range of shoes. The calculation of the structure of the size range of footwear for teenagers was based on the assumption that the normal distribution law accurately described the random variability of foot lengths. The results of calculations of a rational size range of shoes are described in detail and given in the tables. The structure of the size assortment of shoes was determined based on anthropometric studies of the shape and size of the feet of the teenagers and the results of the analysis of the distribution of the length of the feet. In this way, the average shoe size is 275mm for young men in the Zhambyl region. It was revealed that 14% of the young men required shoes in size 260, and the remaining 5% of the young men had a foot size of 290mm. The measurements obtained in the study will make it possible to design shoes corresponding to the feet of teenagers for various purposes. The result of this study will be to provide teenagers in Kazakhstan with comfortable and fit shoes that correspond to non-standard feet, while preventing the appearance of various pathologies, thereby preserving the health of the younger generation.*

**Keywords:** anthropometry, foot, last, shoe, size range.

## ЖАМБЫЛ ОБЛЫСЫНЫҢ ЖАСӨСПІРІМДЕРІНЕ АРНАЛҒАН АЯҚ КИІМДЕРІНІҢ ӨЛШЕМДІК АССОРТИМЕНТІН ҚҰРАСТЫРУ

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*Жамбыл облысындағы жас жгіттерге арналған аяқ киімдердің өлшемдік-толықтық ассортименті әзірленді. Аяқ киімнің өлшемдік ассортиментін есептеу үшін Жамбыл облысындағы жасөспірімдердің табандарының өлшем деректері пайдаланылды. Жасөспірімдерге арналған аяқ киімнің өлшемдік ассортиментінің құрылымын есептеу табан ұзындығының кездейсоқ өзгермелілігі қалыпты таралу заңымен дәл сипатталған деген болжамға негізделген. Табанның рационалды өлшемдік ассортиментін есептеу нәтижелері егжей-тегжейлі сипатталған және кестелерде келтірілген. Жасөспірім табандарының пішіні мен өлшемін антропометриялық зерттеулер негізінде және табан ұзындығының*

таралуын талдау нәтижелері бойынша аяқ киімнің өлшемдік ассортиментінің құрылымы анықталды. Осылайша, Жамбыл облысындағы жас жігіттер үшін аяқ киімнің орташа өлшемі 275 мм болды. Жас жігіттердің 14% -ы 260 өлшемді аяқ киімді қажет ететіні, ал қалған 5% жас жігіттердің аяқ өлшемі 290 мм болатыны анықталды. Зерттеу барысында алынған өлшемдер әртүрлі мақсаттағы жасөспірімдердің табандарына сәйкес келетін аяқ киімді жобалауға мүмкіндік береді. Бұл жұмыстың нәтижесі Қазақстандағы жасөспірімдерді ыңғайлы, яғни стандартты емес аяққа сай келетін аяқ киіммен қамтамасыз ету, бұл ретте әртүрлі патологиялардың пайда болуының алдын алу, сол арқылы өскелең ұрпақтың денсаулығын сақтау болмақ.

**Негізгі сөздер:** антропометрия, табан, аяқ киім қалыптары, аяқ киім, өлшемдік ассортимент.

## РАЗРАБОТКА РАЗМЕРНОГО АССОРТИМЕНТА ОБУВИ ДЛЯ ЮНОШЕЙ ЖАМБЫЛСКОЙ ОБЛАСТИ

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*В работе разработан размерно-полнотный ассортимент обуви для юношей Жамбылской области. Для проведения расчета размерного ассортимента обуви были использованы данные обмеров стоп подростков Жамбылской области. Произвольная изменчивость длины стопы человека в точности представлена законом нормального распределения для вычисления структуры размерного ассортимента обуви для подростков. Результаты расчетов рационального размерного ассортимента обуви подробно описаны и приведены в таблицах. На основе антропометрических исследований формо-размеров стоп подросткового населения и результатов анализа распределения длины стоп определена структура размерного ассортимента обуви. Таким образом для юношей Жамбылской области средний размер обуви составляет 275мм. Выявлено, что у 14% парней требуется обувь размером 260, а остальные 5% парней имели размер стопы 290мм. Обмеры, полученные в ходе исследования, дадут возможность спроектировать обувь, соответствующую стопам подростков различного назначения. Результатом данной работы будет обеспечение подростков Казахстана удобной, то есть впорной обувью, которая соответствует нестандартным стопам, при этом предотвращая появление различных патологий, тем самым сохраняя здоровье молодого поколения.*

**Ключевые слова:** антропометрия, стопа, обувные колодки, обувь, размерный ассортимент.

### *Introduction*

In the mass production of shoes of various assortments, it is important not only to design shoes of the correct shapes and sizes but also to produce individual sizes in the quantity required for the population of Kazakhstan [1-7].

It is known that the population has feet with different dimensional characteristics: these are the length and the width of the bundles, the width of the heel, and the girths of the foot. The numerical ratio of shoes of different sizes and widths is called the size range. In the size range, the relative number of shoes of various sizes and widths is fixed [8-10].

The basis of the method of constructing a size range of shoes is a regularity that obeys the normal distribution law.

According to the metric system, the size of shoes and lasts is equal to the length of the foot for which this shoe is made. Related shoe sizes differ in length by 5 mm [11-13].

The distribution of feet along the length in any team obeys the normal distribution law. Therefore, knowing the average length of the foot "a", for a given team, the interval between sizes and the range of fluctuations of the feet along the length "σ", the equation can be used to calculate the required number of produced shoes according to the size range.

### *Materials and research methods*

The size range of footwear was determined by utilizing data on the measurements of teenagers feet in the Zhambyl region.

The calculation of the structure of the size range of shoes for a specific age group  $\Omega_L$  is based on the assumption that the random variability of the length of the foot  $X_1$ . The normal distribution law (NDL) with the parameters «a» and «σ» quite accurately describes size characteristics of a given age, and the probability density function has the form:

$$f(x) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{(x-a)^2}{2\sigma^2}} \quad (1)$$

The initial data for calculating the size range are the sample mean value  $\bar{x}$  and the sample standard deviation  $S(x)$  of the foot length  $X_1$ , obtained for elementary age groups [14]. Since the volume of the considered samples is quite large ( $N = 150$ ), we can assume that the “a” and “σ” normal distribution parameters’ strange values (1) are generally equal to the  $\bar{x}$  and  $S(x)$  sample characteristics, it means  $a \approx \bar{x}$  and  $\sigma \approx S(x)$ .

Dividing the admissible values’ area of the foot’s length  $X_1$  into spaces that match to the indifference intervals for concrete shoe sizes is basic for measuring shoes’ size (Figure 1). The relative interval for the j-th shoe size  $\alpha_j$  will be equal to the probability that the normal distribution of the random variable  $X$  will fall into the corresponding j-th interval  $(x_j^H, x_j^B)$ , where  $x_j^H$  and  $x_j^B$  are the lower and upper boundaries of the j-th interval [15].

$$\alpha_j = P(x_j^H < x < x_j^B), \quad (2)$$

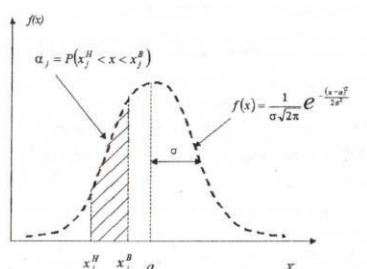


Figure 1 – The curve of the methodology for calculating the rational size range of shoes

The probability of a normally distributed value  $X$ , parameters  $a$  and  $\sigma$  falling into a given interval  $(\alpha, \beta)$  is determined by the following relation [15]:

$$P(\alpha < x < \beta) = \hat{\Phi}(Z_\beta) - \hat{\Phi}(Z_\alpha) \quad (3)$$

where  $\Phi(Z) = \frac{1}{\sqrt{2\pi}} \int_0^Z e^{-\frac{z^2}{2}} dz$  - the Laplace function, and the values of the normalized normal random variable  $Z$ , which is determined by the following formula:

$$Z_\alpha = \frac{\alpha - a}{\sigma}, Z_\beta = \frac{\beta - a}{\sigma} \quad (4)$$

So,  $a \approx \bar{x} \approx S(x)$ ,  $\alpha = x_j^H$ , и  $\beta = x_j^B$ , transform (2) and (3) as

$$\alpha_j = P(x_j^H < x < x_j^B) \approx \Phi(Z_j^B) - \Phi(Z_j^H), \quad (5)$$

Where

$$Z_j^B = \frac{x_j^B - \bar{x}}{S(x)} \quad \text{и} \quad Z_j^H = \frac{x_j^H - \bar{x}}{S(x)} \quad (6)$$

Using the presented formulas (5) and (6) and taking into account that the Laplace function is odd, which means  $\Phi(-Z) = -\Phi(Z)$ , it is possible to calculate the theoretical values of the share  $\alpha_j$  of the j-th shoe size [15].

The Laplace function’s values  $\Phi(Z)$  are measured from concrete tables shown in manuals on mathematical statistics and possibility theory. The formula number 2 measures the  $\alpha_j$  values with

an exactness of 0.01. The calculation results are summarized in Table 1.

The completeness of the  $\alpha_j$  values received by (2) for total elaborated size positions is the calculated structure of a size range assortment of shoe, which is fully consistent with the data of a selective anthropometric survey of the frequency distribution of the foot length  $X_1$  for the considered elementary sex and age group  $\Omega_L$  of the population.

It is known that the size of the fluctuation of the feet along the length, characterized by the standard deviation, is approximately the same in all the studied groups ( $\sigma = 10.3-12.2$  mm), therefore,  $\sigma = 11$  mm was taken to calculate the distribution of the feet along the length.

**Results and their discussion**

$$\alpha \approx x \approx 268 \text{ мм}$$

The calculation of the structure of the size range of shoes for teenagers is based on the assumption that the random variability of foot lengths is quite accurately described by the normal distribution law with parameters  $\alpha$  and  $\sigma$ , and the probability density function has the form:

$$\sigma \approx S(x) \approx 11 \text{ мм.}$$

By dividing the area of acceptable values of the leading feature X into indifference intervals with a width of  $\Delta X=5$ mm centered at points 255,

260, 265, and 270. Then using formulas (7) and (8) calculated the values of the relative x shares  $\alpha$ .

The results of calculations of a rational size range of shoes are shown in Table 1 and Figure 2.

$$Z_j^H = \frac{x^H - 268}{11} \tag{7}$$

$$Z_j^B = \frac{x^B - 268}{11} \tag{8}$$

Table 1 – Estimated structure of a rational size range of shoes

Size of shoe	Boundary values of feature x, mm		Normalized value Z		Values of the Laplace function $\Phi(Z)$		Relative share $\alpha_j$
255	252,4	256,5	-1,41	-1,045	0,420	0,426	0,005
260	256,4	260,5	-1,05	-0,681	0,353	0,251	0,102
265	260,4	264,5	-0,69	-0,318	0,254	0,125	0,129
270	264,4	268,5	-0,327	0,045	0,125	0,015	0,157
275	268,4	272,5	0,036	0,409	0,015	0,187	0,195
280	272,4	276,5	0,400	0,772	0,155	0,264	0,116
285	276,4	280,5	0,933	1,388	0,323	0,416	0,093
290	284,4	288,5	1,377	1,833	0,414	0,466	0,052
295	288,4	292,5	1,822	2,277	0,465	0,488	0,023
Total							1

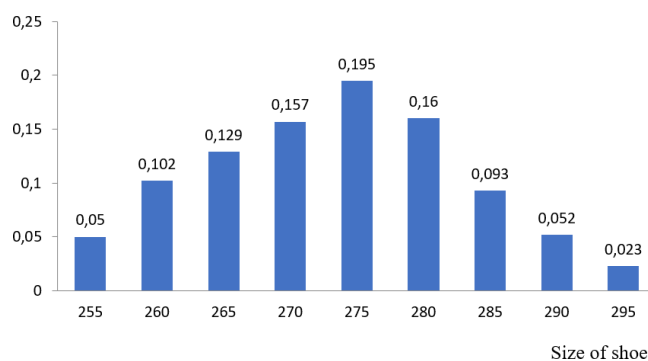


Figure 2 – Structural size range of shoes for teenagers

Based on anthropometric studies of the shape and size of the feet of teenagers and the results of the analysis of the distribution of the length of the feet, the structure of the size range of shoes was determined.

In this way, for the young men of the Zhambyl region, the average shoe size is 275, which is observed in 17% of the measured people.

Therefore, 14% of young men need shoes in size 260, respectively, 5% of young men in size 290.

**Conclusions**

The work developed a size range of shoes for teenagers in the Zhambyl region based on anthropometric studies of the size of the feet. The measurements obtained in the study can make it possible to design shoes corresponding to the feet of teenagers for various purposes. Since the result

showed that teenagers in the Zhambyl region have non-standard foot sizes, it is proved that providing teenagers in Kazakhstan with comfortable and fit shoes that correspond to non-standard feet, will prevent the appearance of various pathologies, thereby preserving the health of the younger generation.

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### ҚОРҒАНЫШ ҚАСИЕТТЕРІ БАР МЕТАЛДАҒЫРЫЛҒАН ТЕКСТИЛЬ МАТЕРИАЛДАРЫНЫҢ ФИЗИКА-МЕХАНИКАЛЫҚ ҚАСИЕТТЕРІН ЗЕРТТЕУ

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*Зерттеу нысандары ретінде 1030 артикулды 100% мақта матасы және келесі химиялық препараттар қолданылды: лимон қышқылы, натрий цитраты, мыс (II) сульфаты (CuSO<sub>4</sub> · 5H<sub>2</sub>O), натрий гипофосфиті NaH<sub>2</sub>PO. Эксперименталдық жұмыс нәтижесінде қорғаныш қасиеттері бар металдан-*