IRSTI 64.41.81

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https://doi.org/10.55956/VGXP4110

DETERMINATION OF THE REGULARITY OF THE DISTRIBUTION OF THE ADOLESCENTS FEET SIZE

Abstract. The study of the anthropometric characteristics of the feet of young men living in the Zhambyl region is an important step towards optimizing the design of shoes for adolescents. Collecting comprehensive data on foot sizes allows not only to identify medium-scale trends, but also to establish the specifics of this demographic group.

Strict anthropometric measurement methods are used to achieve accurate results, which guarantees the reliability of the data. The analysis of the information obtained during the study can reveal significant patterns, such as the distribution of certain sizes – length, width and shape of the feet. This, in turn, makes it possible to develop innovative shoe pads that will match the unique anatomical features of adolescents' feet.

Keywords: anthropometry, foot, young people, shoe lasts, dimensional characteristics, comfortable properties.

Yussupova L.Kh., Yeldiyar G.K., Baidildayeva A.K., Jumabekova G.B., Abzalbekuly B. Determination of the regularity of the distribution of the adolescents feet size // Mechanics and Technology / Scientific journal. – 2024. – No.3(85). – P.375-383. https://doi.org/10.55956/VGXP4110

Introduction. The comfort of footwear stands as a paramount determinant of its overall quality, significantly influencing the normal functioning and development of the human foot, particularly during its growth stages. The well-being of the foot, in turn, plays a pivotal role in regulating the overall health and integrity of the entire organism. The emergence of irregularities or abnormalities within the foot's structure can precipitate a cascade of disruptions throughout the body. Consequently, the design of shoes demands a heightened degree of attention to not only the shoe's shape but also the precise correspondence between the footwear's shape and the dimensions of the wearer's foot. This intricate alignment of shoe form and foot size, encompassing the optimization of internal shoe dimensions, particularly their full dimensions, has garnered increased recognition in the context of shoe design [1,2].

Nevertheless, despite the acknowledged significance of this alignment, the practical implementation of optimal full dimensions within shoes has often been

overlooked, even in accordance with established standards. This oversight has the potential to yield adverse consequences, particularly when ill-fitting shoes are worn, a scenario notably prevalent among adolescents. The utilization of footwear with inappropriate sizing, particularly during the critical stages of growth, can precipitate a spectrum of foot deformities and pathologies [3,4]. Importantly, many of these afflictions become enduring and intractable as individuals' progress into adulthood. Pathological conditions acquired in childhood often persist throughout an individual's lifespan, contributing to persistent discomfort and diminished quality of life.

This introduction underscores the profound implications of footwear comfort and sizing, emphasizing the far-reaching consequences of neglecting proper shoe fitment, particularly among the youthful population [5,6]. The subsequent sections of this study delve into the critical aspects of optimizing shoe dimensions, focusing on anthropometric studies of foot size in young men within the Zhambyl region. These investigations aim to shed light on the importance of tailoring footwear design to regional anatomical variations and ultimately enhancing the comfort, well-being, and long-term health of the local population.

Materials and methods. The present study was conducted to address the imperative of providing comfortable footwear to the population of the Zhambyl region, Kazakhstan, with a specific focus on young men. In light of existing literature highlighting the prevalence of foot pathologies and the consequential need for preventive or orthopedic footwear [8,9], this investigation sought to assess the sizes and shapes of young men's feet in order to inform the design of footwear that would better accommodate their specific anatomical characteristics. The city of Taraz was selected as the study location due to its prominence as the home to major higher education institutions, encompassing a substantial segment of the young male population [10-12].

The study participants comprised young men aged 16 to 19, drawn from various higher educational institutions in Taraz, Zhambyl region. This age group was chosen to capture the foot dimensions during a critical period of growth and development.

Anthropometric measurements of the participants' feet were obtained utilizing standardized methods. To create a plantogram of the foot, the overall contour was meticulously outlined, and key foot dimensions were recorded, including foot length, foot width along both the outer and inner ball, and heel width [13-15]. These parameters were measured with precision to ensure the accuracy of the collected data.

The dataset comprising the foot measurements was subjected to rigorous statistical analysis. The statistical methods employed included mathematical statistics techniques to process and interpret the acquired data. In particular, a correlation-regression method was employed to establish relationships and patterns among the dimensional characteristics of the feet. This method enabled the identification of the presence, strength, and form of connections between the measured characteristics. Furthermore, the significance of the observed results was assessed, aiding in the formulation of comprehensive insights into the relationship between foot dimensions among the young male population of the Zhambyl region.

It is essential to note that the Zhambyl region, with a total population of 1,218,000 individuals, of which 427,356 reside in urban areas, includes 74,228 young men within its demographic composition [7]. These demographic figures underscore the relevance of the study, given its focus on addressing the specific footwear needs of this sizable and influential segment of the population.

In summary, the research methodology employed in this study was designed to comprehensively assess the foot sizes and shapes of young men in the Zhambyl region through precise measurements and rigorous statistical analysis.

Research results and discussion. In order to comprehensively characterize the variability of anthropometric characteristics among the studied cohort, was initiated the analysis by constructing a variation series. This variation series, a fundamental tool in statistical analysis, consists of a double series of numerical values grouped into distinct classes. In the present research, it was conducted an examination involving 500 young men aged between 15 and 19 years. Subsequently, from the gathered data, both the maximum and minimum values for key foot indicators, specifically foot length, the width of the internal and external ball, as well as heel width. These extremal values, which encapsulate the range of variability of each trait within the sample, are presented in Table 1.

To gain deeper insights into the interrelationships among various anthropometric dimensions of the foot, was employed a well-established method. As an illustrative example, Table 1 displays the correlation grid between the length and width of the ball of the foot.

Table 1

Correlation grate of the relationship between foot length and ball of foot width

X intermediate limits of characters in a group	Intermediate Group Average Limit	Intermediate limits of groups in the sign Y, intermediate average limits of groups												1	2	3	4	5	6
		70-72	73-75	76-78	79-81	82-84	85-87	88-90	91-93	94-96	97-99	100-102	103-105	P_x	a_x	$P_x a_x$	$P_x a^2{}_x$	$P_x a_y$	$P_x a_y a_x$
		71	74	77	80	83	86	89	92	95	98	101	104						
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
259-261	260	16	10	8	12	8	7	4	2					67	-8	-536	4288	-20234	-161872
263-266	265	4	2	5	9	8	8	5	5					46	-7	-322	2254	-6716	-47012
269-271	270		1	1	1	6	5	3						17	-6	-102	612	-782	-4692
273-276	275			1	4	9	9	8	8	1				40	-5	-200	1000	-3080	-15400
279-281	280			2	3	6	4	14	8	8	2			47	-4	-188	752	-2538	-10152
283-286	285		1		3	1	5	2	4					16	-3	-48	144	-528	-1584
289-291	290				3	3	12	15	12	9	3			57	-2	-114	228	-2565	-5130
293-296	295				2	2	2	4	12	5				27	-1	-27	27	-459	-459

In addition to the correlation grid between foot length and ball width, this study explored relationships between foot length and other pertinent foot dimensions, including heel width, ankle height, and ball girth. The aim was to elucidate potential associations between these key anthropometric measurements, contributing to a comprehensive understanding of foot morphology in the study population.

From the extensive dataset collected, the minimum and maximum values for foot length were determined. The smallest recorded foot length was 260 millimeters, while the largest was measured at 292 millimeters. Consequently, the range of variability in foot length within the sample was calculated as follows: 292-260 = 31

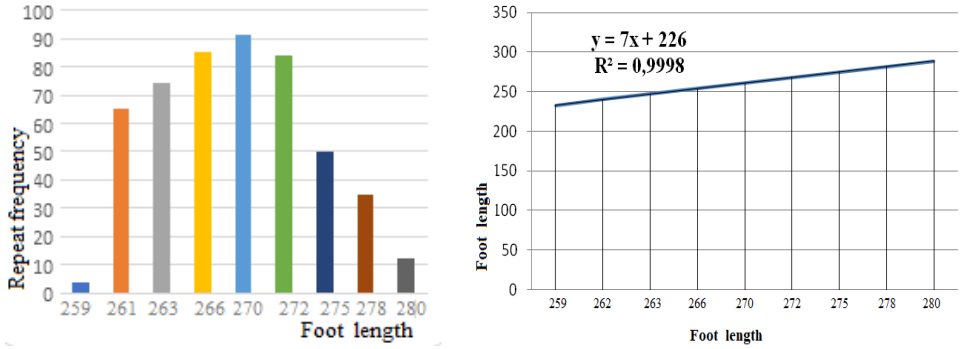
millimeters, denoting a standard deviation (dx) of 5 millimeters. These parameters were instrumental in the subsequent calculation of correlation coefficients and regression equations.

For the construction of correlation grids and regression equations, foot length was designated as the primary parameter, with ball width as the secondary parameter. The primary parameter, foot length, was categorized into 17 intervals, while the secondary parameter, ball width, was divided into 12 intervals. The relationships between these two indicators were quantitatively assessed, and the frequency of occurrence of specific measurements within each interval was documented as markings in the correlation grid.

To efficiently process the extensive measurement data and visualize the findings, a specialized software program, "Project," was employed. This program facilitated the determination of measurement frequency repetitions and streamlined data analysis. The results were subsequently presented in graphical format, offering clear and concise representations of the interplay between foot length and ball width, as well as other relevant foot dimensions.

The utilization of advanced software tools, such as "Project," expedited data processing and enabled the presentation of results through informative diagrams, ensuring the accessibility and usability of the study's findings.

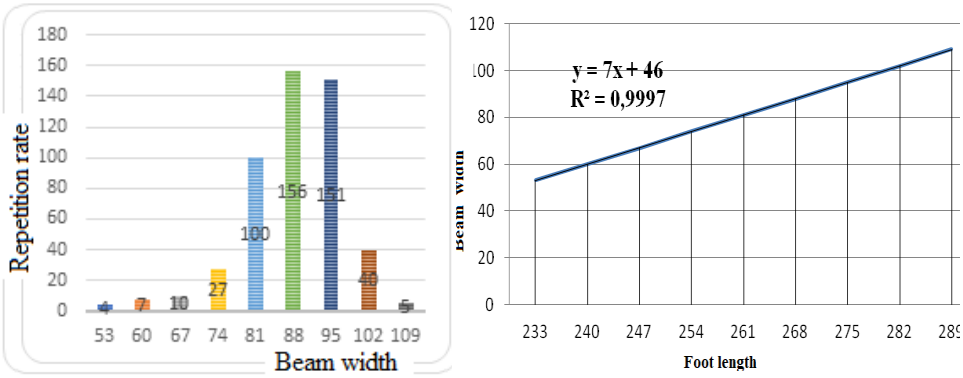
For foot length (Fig. 1a), the measurement interval was 7 and the measurement class was 9. Based on the average values, values between 260 and 292 were obtained. The most common size was 270. The regression equation graph is shown (Fig. 1b). Here the correlation coefficient is $R^2 = 0.9998$ and the regression equation is $y = 7x + 226$.



a) b)

Fig. 1. Normal distribution of foot measurements along length

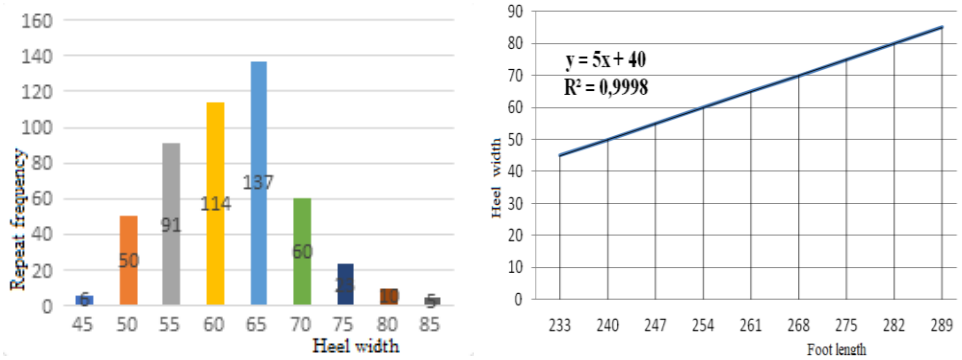
For ball of foot width measurements (Fig. 2a), the measurement interval was 7 and the measurement class was 9. The average values ranged from 53 to 109. The most common value was 88. The regression equation graph is shown (Fig. 2b). Here the correlation coefficient is $R^2 = 0.9997$ and the regression equation is $y = 7x + 46$.



a) b)

Fig. 2. Normal distribution of measurements across ball of foot widths

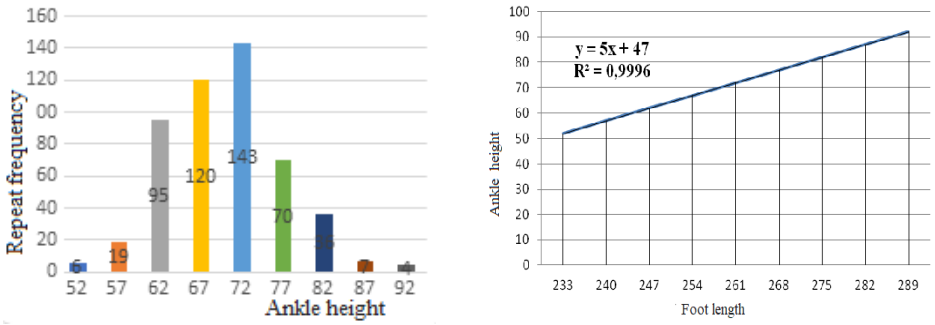
For the heel width values (Fig. 3a), the measurement interval was 5 and the measurement class was 9. Based on the average values, values between 45 and 85 were obtained. The most common value was 65. The regression equation graph is shown (Fig. 3b). Here the correlation coefficient is $R^2 = 0.9998$ and the regression equation is $y = 5x + 40$.



a) b)

Fig. 3. Normal size distribution by heel width

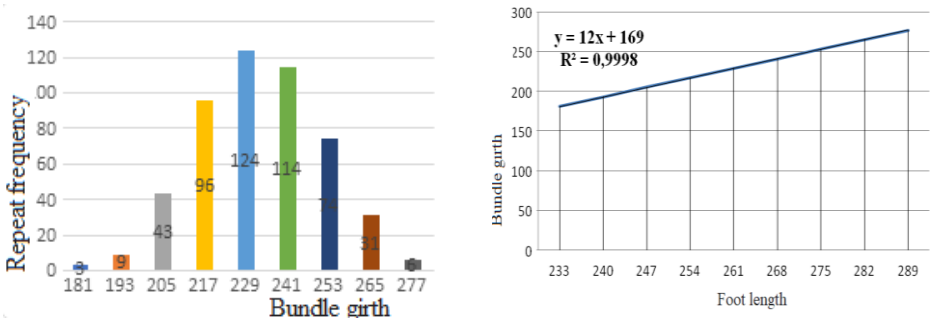
For ankle height (Fig. 4a), the measurement interval was 5 and the measurement class was 9. Based on the average values, measurements were obtained between 52 and 92. The most common value was 65. The regression equation plot is shown (Fig. 4b). Here the correlation coefficient is $R^2 = 0.9996$ and the regression equation is $y = 5x + 47$.



a) b)

Fig. 4. Normal distribution of values across ankle heights

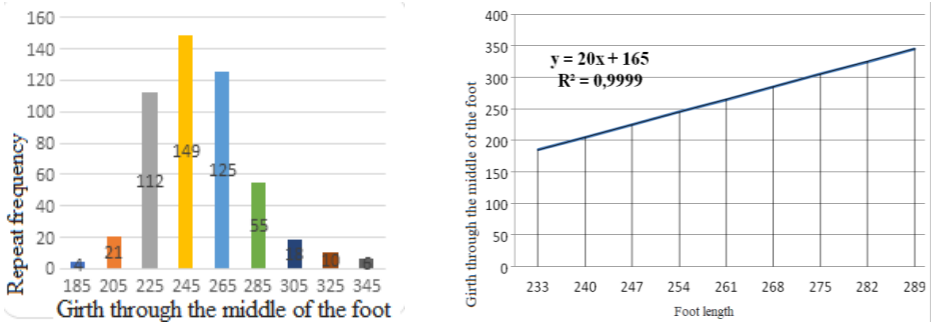
According to the ball of foot girth indicator (Fig. 5a), the measurement interval was 12, and the number of measurements was 9. In accordance with the average values, lengths between 181 and 277 mm were obtained. The most common value was 229mm. A graph of the regression equation is presented (Fig. 5b). Here the correlation coefficient is $R^2 = 0.9998$ and the regression equation is $y = 12x + 19$.



a) b)

Fig. 5. Normal distribution of values by ball of foot girth

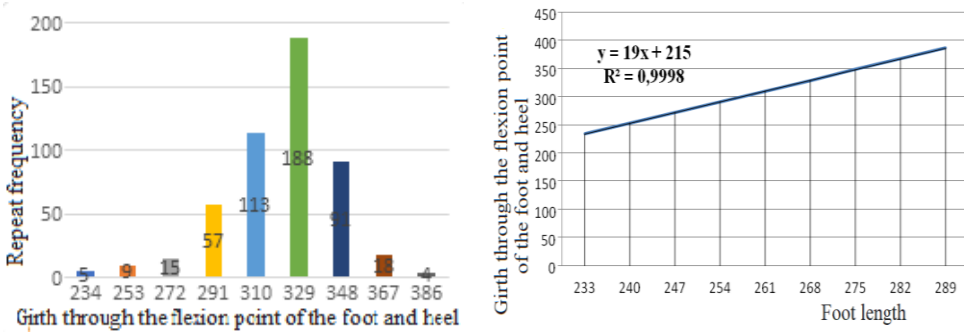
According to the indicator of size distribution by average foot girth (Fig. 6a), the measurement interval was 20, and the measurement class was 9. The average values ranged from 185 to 345. The most common size was 245. A graph of the regression equation is presented (Fig. 6b). Here the correlation coefficient is $R^2 = 0.9999$ and the regression equation is $y = 20x + 165$.



a) b)

Fig. 6. Normal distribution of sizes according to the average girth of the foot

In terms of girth through the flexion point of the foot and heel (Fig. 7a), the measurement interval was 19, and the measurement class was 9. The average values ranged from 234 to 386. The most common size was 329. The regression equation graph is shown (Fig. 7b). Here the correlation coefficient is $R^2 = 0.9998$ and the regression equation is $y = 19x + 215$.



a) b)

Fig. 7. Normal distribution of girth measurements through the flexion point of the foot and heel

Conclusion. This study employed an enhanced anthropometric methodology harnessing computer technology to assess foot dimensions among a cohort of 500 young men aged 15 to 19 years. Through the meticulous analysis of the collected data, was unveiled a pivotal finding: notably high correlation coefficients among all the investigated anthropometric characteristics. These robust correlations signify a strong and consistent relationship between various foot dimensions within the sample population. Importantly, this observation lays the groundwork for the development of regression equations, which, in turn, offer the prospect of establishing standardized foot sizes for the design and production of shoe lasts and footwear.

The robust correlation coefficients and resultant regression equations offer a pathway towards the provision of comfortable and well-fitting shoes for young men in the Zhambyl region, ultimately fostering positive socio-economic outcomes.

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Material received on 02.05.24.

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ЖАСӨСПІРІМ АЯҚТАРЫНЫҢ ӨЛШЕМДІК СИПАТТАМАЛАРЫНЫҢ ТАРАЛУ ЗАҢДЫЛЫҒЫН АНЫҚТАУ

Аңдатпа. Жамбыл облысында тұратын жас жігіттердің табандарының антропометриялық сипаттамаларын зерттеу жасөспірімдерге арналған аяқ киім дизайнын оңтайландыру жолындағы маңызды қадам болып табылады. Табан өлшемі туралы жан-жақты мәліметтерді жинау тек орташа тенденцияларды ашып қана қоймайды, сонымен қатар осы демографиялық топтың ерекшеліктерін анықтайды. Нақты нәтижелерге қол жеткізу үшін, деректердің сенімділігін қамтамасыз ету үшін қатаң антропометриялық өлшеу әдістері қолданылады. Зерттеу барысында алынған ақпаратты талдау белгілі бір өлшемдердің таралуы – табанның ұзындығы, ені және пішіні сияқты маңызды заңдылықтарды аша алады. Бұл, өз кезегінде, жасөспірім

табандарының бірегей анатомиялық ерекшеліктеріне сәйкес келетін инновациялық аяқ киімдерді әзірлеуге мүмкіндік береді.

Тірек сөздер: антропометрия, табан, жастар, қалыптар, өлшемдік сипаттамалары, ыңғайлы қасиеттер.

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ОПРЕДЕЛЕНИЕ ЗАКОНОМЕРНОСТИ РАСПРЕДЕЛЕНИЯ РАЗМЕРОВ СТОП ПОДРОСТКОВ

Аннотация. Исследование антропометрических характеристик стоп юношей, проживающих в Жамбылской области, представляет собой важный шаг к оптимизации дизайна обуви для подростков. Сбор комплексных данных о размерах стоп позволяет не только выявить среднемасштабные тенденции, но и установить специфику этой демографической группы.

Для достижения точных результатов используются строгие антропометрические методы измерения, что гарантирует достоверность данных. Анализ информации, полученной в ходе исследования, может выявить значимые закономерности, такие как распределение определенных размеров – длины, ширины и формы стоп. Это, в свою очередь, дает возможность разработать инновационные колодки для обуви, которые будут соответствовать уникальным анатомическим особенностям стоп подростков.

Ключевые слова: антропометрия, стопа, молодые люди, колодки, размерные характеристики, комфортная обувь.