Chapter 1

Bed Size, Quality Sleep and Occupational Safety: An Investigation of Students at Slovak Universities

Miloš Hitka, Pavol Joščák, Silvia Lorincová and Žaneta Balážová

Additional information is available at the end of the chapter

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Abstract

All devices and equipment helping humans to do everyday things are adapted to human body proportions. Projects would not meet the needs of customers regardless their proportions. Therefore, anthropometric measurements are a key factor in manufacturing any products. Sampling unit consisted of Slovak adult population. Empirical measurements of selected attributes of actual population were conducted in the years 1993–2015. Sampling unit consisted of 3358 students. Gained data were processed and described using descriptive statistics. Results are based on calculations of arithmetic and weighted mean. Standard deviation, asymmetry coefficient, percentiles, standard error, symmetry, and pointing were used for further processing. Following the outcomes associated with the body dimensions of Slovak population, we can propose the dimensions of bedroom furniture corresponding to the dimensions of actual adult population. Bed dimensions must be 102 × 222 cm (95th percentile) to satisfy the needs of people, their comfort, and health. Therefore, testing must be focused on strength and structural properties of bed as well. Increase in dimensions can result in the increase in product price. Staff of the finance department must deal with this issue to prevent economic damage of the company.

Keywords: healthy sleep, bedroom furniture, ergonomics, anthropometric measurements of adult population, occupational safety

1. Introduction

Changes in human population, especially in the anthropometric measurements, throughout history are and always will be the essential criteria for the conscious creation of projects and

architecture [1]. Anthropometry as the scientific study of measurements and proportions of human body is one of the most important tool in the process of designing devices and work aids [2]. It is defined as a set of physical properties and personality traits adapting to the environment. Not only technology development but also economic growth results in an increase in demand for development of machinery and equipment used industrially. Therefore, greater interaction between humans and machines can be observed. Subsequently, anthropometric data collection has to be updated [3]. Insufficient number of quality machines and devices can cause an increase in the number of workplace injuries as well as a decrease in productivity of work performance [4]. Sector of industry does not affect the rate of accidents in workplaces so much as the poor posture at work. Therefore, it is a major cause of back pain [5]. The appropriate use of anthropometry can affect human health, comfort and safety in workplaces in a positive way [6].

The modern man is exposed to various environmental risk factors at home as well as at work. Rise in demands for time is a typical feature of today's society. That is why people dedicate less time to relax and sleep more than ever before. At the same time, it is evident that costs associated with correcting the errors caused by lack of sleep are much higher than most people can admit. Sleep deprivation or long-term insomnia can lead to a number of different negative consequences. In the case of chronic insomnia, various effects on physical and mental health can be observed, for example, coordination impairment, concentration problems, decrease in employee performance on the one hand and on the other hand fatigue and stress, low mood, depression as well as migraine development. Lack of sleep as well as poor quality sleep can increase the risk of mistakes, or even accidents in the workplace with fatal injuries and high level of compensation. Lack of sleep and its poor quality have a negative impact on the bodily functions.

At present, there is little or no time to rest because of work or other activities. Sleep is the only chance to relax, to switch off the brain. Sleep is a normal, indeed essential part of our lives. Choosing the right bed and mattress make an important contribution in getting a good night's sleep.

Quality sleep is significantly affected by the comfort of a bed. Bed size is a factor that must be taken into account when the comfort bed is evaluated. Therefore, the use of bed size not reflecting the body dimensions can affect quality sleep in negative way.

Sleep is defined as a resting state in which body is not active; it means sleep is definitely the main thing in recovery affecting mental as well as physical well-being. Sleep has been characterized in many species from humans, birds and fish. The main aim of sleep is to have a rest that helps the body to recover. Adequate levels of sleep help to provide mental health, hormonal balance and muscular recovery. Pretty much most of our bodily functions slow down during sleep and our bodies begin to repair—breathing and heart rate slow down, sensitivity to external stimuli reduces, on the contrary, anabolism produces growth and differentiation of cells. From the point of view of health sciences, sleep is an altered state of consciousness when central nervous system relaxes and the organism is in a completely relaxed state.

The importance of sleep is the same as of food and fluid intake or breathing; it helps to restore the immune, nervous, skeletal, and muscular systems. Sleep disorders are very common

problems. As it is mentioned in research studies, one-third of adult population suffer from insomnia and 13% are severely sleep deprived, putting them more at risk of mental health and affecting their everyday life in negative way. The mentioned percentage depends upon the age. Therefore, almost one-half of the population who are 65+ suffer from mild sleep deprivation. In terms of health sciences, we can speak about a really big health problem. Moreover, lack of sleep affects not only personal health but people prone to insomnia are at higher risk of various types of depression and suicide. Sleep disorders belong to the most important reasons for lower labor productivity, higher sickness absence rate or a higher number of occupational injuries. There is not enough evidence for an assessment of the importance of sleep and its crucial role for organs other than the brain. Doctors suppose that higher level of growth hormone during sleep could be one of the impacts of sleep disorders. However, it can be only food intake compensation. One of the major functions of sleep is to allow the brain to recover and repair itself. The days with lack of sleep are followed by non-REM sleep, that is, non-rapid eye movement sleep. The role of non-REM sleep is seen in the recovery of brain energy. On the other hand, the role of REM sleep (rapid eye movement sleep with loss of muscle tone, also called paradoxical sleep) is not as clear. However, the brain is highly active and REM sleep is associated with dreaming. Higher brain activity during REM sleep is supported by increased blood flow and glucose metabolism. In particular, it is vital for memory formation. The fact that REM sleep prevails most after birth, and diminishes with age can be considered interesting. Scientists found out that a man waking up in each REM stage in the course of 5–7 days would die [7].

So why is getting enough quality sleep important? Sleep needs are high-priority physiological needs. Quality and regular sleep belong to essential human needs. Sleep disorders have occurred since time out of mind. The number of people not suffering from sleep disorders decreases as the civilization develops. Sleep plays an important role in physical as well as mental health, for example, sleep is involved in locomotive organs recovery, muscle tone decline, decrease in heart rate and cardiovascular system activity, impaired breathing, brain recovery and in some way regulating the psyche [8]. Lying and relaxing positions have been common for people for ages, especially because of the horizontal direction necessary for good sleep. However, there are different positions that people can adopt while still lying. From the point of view of medicine, relaxing positions are those to help relieve pain while sleeping [9]. While sleeping in relaxing positions, gravity causes your breasts to hang downward which can stretch the ligaments over time. It is very beneficial to our health as our body is compressed after sitting at work all day. Moreover, we can bend the knees and curl legs slightly toward upper body into a semi-fetal position and for keeping hips vertical we can place a firm pillow or two in between the knees so that legs are propped about hip-width apart [10]. Only a high-quality bed with dimensions suitable for the average population allows people to adopt mentioned sleep positions.

2. Development of selected anthropometric parameters

Anthropometry is one of the essential methods of anthropology. It is focused on human body proportions and it is used to identify proportion differences, whereby the measurements used

are easy and effective [11, 12]. Moreover, they are used to determine various aspects, such as muscle growth and reduction, body part dimensions as well as the nutritional assessment, that is, whether patients are overweight or malnourished (body fat percentage) considering several factors like height and age. Measurement is based on the assessment of items located on upper and lower limbs, head and trunk. The measured values are used to qualify the adequacy of body size—BMI index [13]. According to the BMI index the number of overweight or obese people has been increasing recently [14]. Following the measurements, we come to realize that female and male height is changing significantly over time. Adolescence as a transitional stage of physical and psychological development is getting faster. All these changes affect essentially the shape as well as common object sizes [15]. Factor of time is necessary to take into account. In case of manufacturing standardized products used by the largest group of population, knowledge of data statistically evaluated has to be taken into account [16]. On the other hand, when our manufacturing should be as effective as it is possible, we have to focus on specific groups of people. That is why the groups are created to identify with specific variety of human physique (standard DIN 33402).

Over time, changes in population height and weight occur. Therefore, data associated with proportions of selected sampling units have to be collected due to various reasons (e.g., lifestyle, eating and nutritional care, etc.) at a specific time [15–27]. Secular trend can be understood as the growth of body proportions of consecutive generations comparing to former generations. There are various reasons why it is interesting. It is a sign of public health, it determines the relation between economic growth and living standards [28, 29] and shows physiological aspects—getting taller and heavier over the generations. According to the authors Jirkovský [22], Vignerová [30] and Vignerová et al. [24], research studies aimed at determining anthropometric data of child and adult population show long-term changes in body sizes. In general, we can speak about so-called positive changes; it means measured parameters are growing. Height is the most commonly observed parameter describing the changes in the best way.

Keeping standards, recommendations and regulations can have a tremendous impact on the feeling associated with the use of the bedroom furniture. The fact that most of the regulations and standards are based on data collected round the year must be taken into account [31]. Anthropometric database of Slovak population used presently originates in the former Czechoslovak Socialistic Republic. It is published in the journal of the Ministry of Health of the Slovak Socialistic Republic entitled Vestník MZ SSR in the year 1987 where the average proportions of the population are mentioned [32]. Another important factor is that each new generation is getting bigger in size in terms of anthropometric proportions. The changes are significant from a long-term perspective. It is statistically proven that average height of young men has increased by 4.5 cm in comparison to their fathers and by 7.5 cm compared to their grandfathers. In the year 1950, the average male height was 170 cm and in 1991 it was 176 cm. Similar trends can be detected when we observe females. The height of young women has increased by 3 cm in comparison to their mothers and by 5 cm compared to their grandmothers [33]. Kotradyová [32] dealt with the issue of anthropometric measurements in the project entitled "Principles of Designing New Furniture." She carried out the research into body proportions of 202 respondents. Results of the research confirmed the fact that the

size of population increased by 5 cm in average in comparison to data published in Vestník in the year 1987 [34]. Extreme increase in female height (by 8 cm) as well as in weight was observed.

2.1. Methodology

Sampling unit consisted of Slovak adult population, that is, people at the adult age in terms of human growth—people who were 18+. Empirical measurements of selected attributes of population aged 18–25 were conducted in the years 1993–2015. Sampling unit consisted of 1538 males and 1820 females, students of the Technical University in Zvolen, University in Zilina, University of Economics in Bratislava and University of Presov. Altogether, 3358 students attending selected universities mirror the population of various parts of Slovakia, that makes the sample more representative. Gained data were processed and described using the tools and methods of descriptive statistics.

Results are based on calculations of arithmetic and weighted mean. Arithmetic mean can be defined as the average of a set of numerical values of specific attribute x_i calculated by adding them together and dividing by the number of terms n in the set. If the values are not divided into individual subgroups, the weight of all individual values is equal.

$$\overline{x} = \frac{x_1 + x_2 + \ldots x_n}{n} = \frac{\sum_{i=1}^{n} x_i}{n}$$

where x_1, x_2, … x_n are individual values of a given attribute; n is a number of terms in a given set.

Weighted mean can be calculated when we know individual arithmetic means of given sets $\overline{x}_j$, and we also know the weights of sets n_j. If all the weights are equal, then the weighted mean equals the arithmetic mean.

$$\overline{x} = \frac{n_1 * \overline{x_1} + n_2 * \overline{x_2} + n_m * \overline{x_m}}{n_1 + n_2 + \ldots n_m} = \frac{\sum_{j=1}^{m} n_j * \overline{x_j}}{n}$$

where $\overline{x_1}$, $\overline{x_2}$, … $\overline{x_m}$ are arithmetic means of individual sets; $\overline{x}$ is a weighted mean of the whole; n_1, n_2, … n_m are weights of individual sets; and n is a number of sets in a given set.

Further, calculated value is median that is the middle score for a set of data that has been arranged in order of magnitude. If we suppose that the values of a given attribute are rearranged into the order of magnitude (smallest first), median is calculated as follows:

$$\frac{n+1}{2}$$

where n is a number of sets in a given set.

Standard deviation is the square root of the variance where the variance is defined as the average of the squared differences from the mean. If we study a set, the most commonly used

deviation is with the degree of freedom N-1. The following formula can be used to calculate standard deviation:

$$s_x = \sqrt{\frac{\sum_{i=1}^{n} \left(x_i - \bar{x}\right)^2}{n-1}}$$

where x_i is a sum of values of given attribute; $\bar{x}$ is an arithmetic mean; and n is a number of sets in a given set.

The asymmetry coefficient is usually called the coefficient of skewness and it is the most frequently employed measure of the asymmetry of a distribution. Skewness is a measure of symmetry, or more precisely, the lack of symmetry. A distribution, or data set, is symmetric if it looks the same to the left and right of the center point. The skewness for a normal distribution is zero, and any symmetric data should have a skewness near zero. Negative values for the skewness indicate data that are skewed left and positive values for the skewness indicate data that are skewed right. By skewed left, we mean that the left tail is long relative to the right tail. Similarly, skewed right means that the right tail is long relative to the left tail. If the data are multi-modal, then this may affect the sign of the skewness.

$$A = \frac{\sum_{j=1}^{k} n_j \left(x_j - \bar{x}\right)^3}{n * s_x^3}$$

kde x_j are values of a set; $\bar{x}$ is an arithmetic mean; s_x^3 is a standard deviation powered to the third; and n is a number of sets in a given set.

2.2. Results

Following the empirical assessment, besides common descriptive characteristics, the most important percentile range (5th, 50th, 95th percentile), standard error, symmetry and pointing were determined (**Table 1**). Height growth of Slovak adult male population in dependence on time is illustrated in **Figure 1**. Dispersion in height of male population is shown in **Figure 2**. The increase in both height as well as weight of male population can be seen. The height increased by 0.15 cm per year and the body weight by 0.31 kg per year. Therefore, standard bed size prevent men with the height of 180 cm and more from sleeping comfortably. Dispersion in height of male population in a given year is illustrated in **Figure 3**. Dispersion in body weight of male population is shown in **Figure 4**.

Average	Median	5th percentile	50th percentile	95th percentile	Standard deviation	Standard error	Symmetry	Pointing
182.1	182.0	172.0	183.0	194.0	6.7	0.3	0.2	0.0

Source: [own data processing].
Values are in cm.

Table 1. Result analysis of the size of adult population—males (years 1992–2016).

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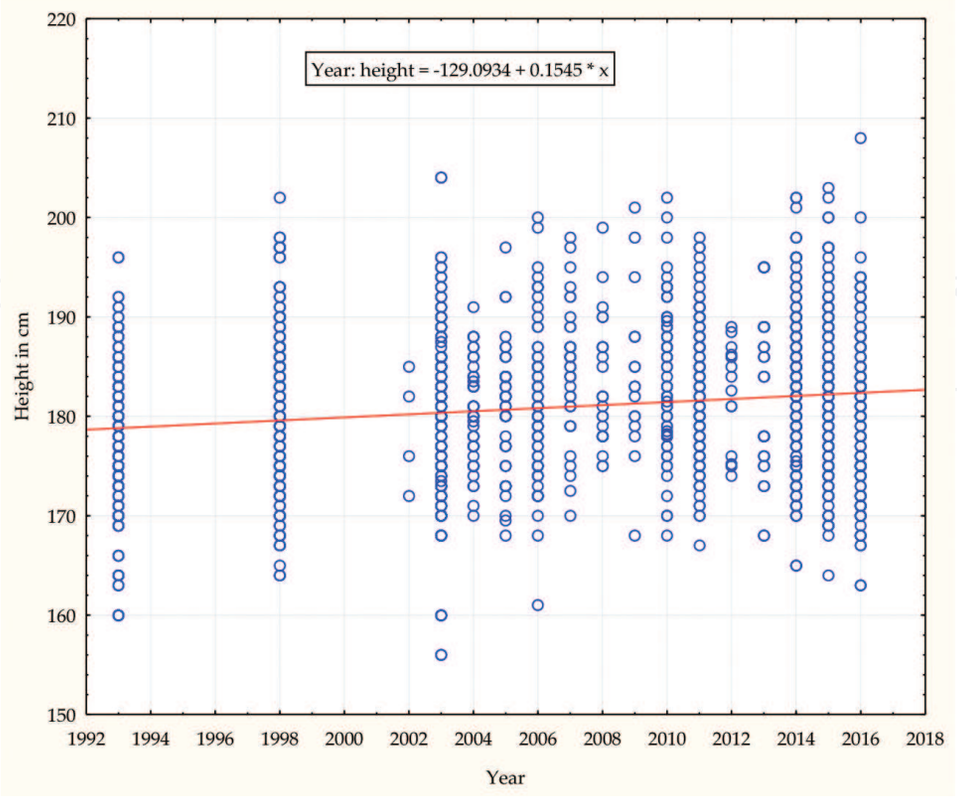

Figure 1. Height growth of Slovak adult population—male (Source: [own data processing]).

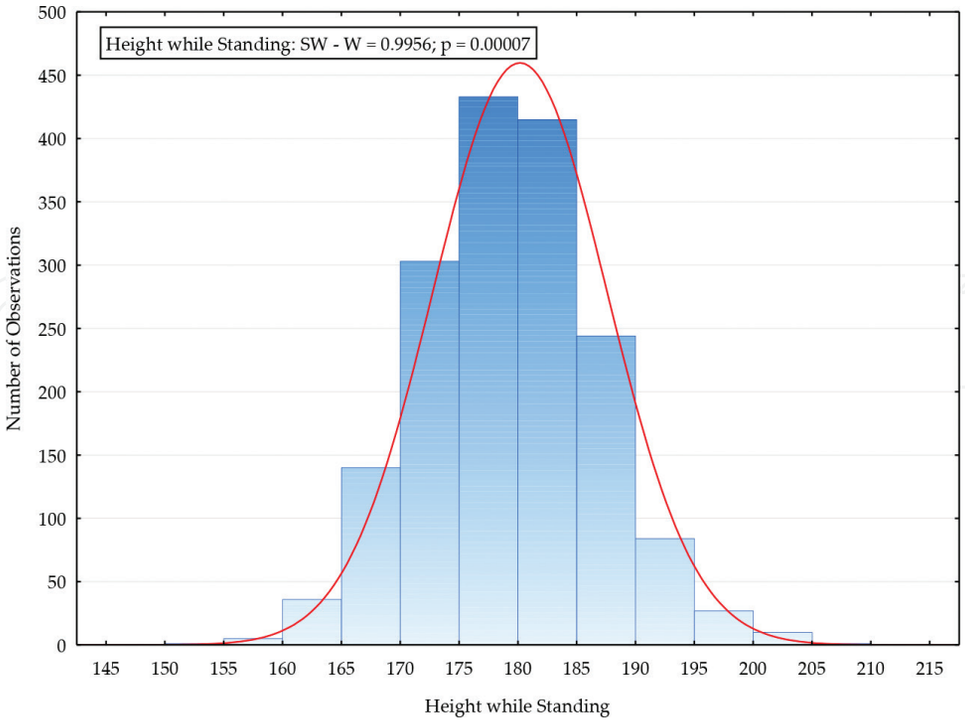

Figure 2. Histogram of male height (Source: [own data processing]).

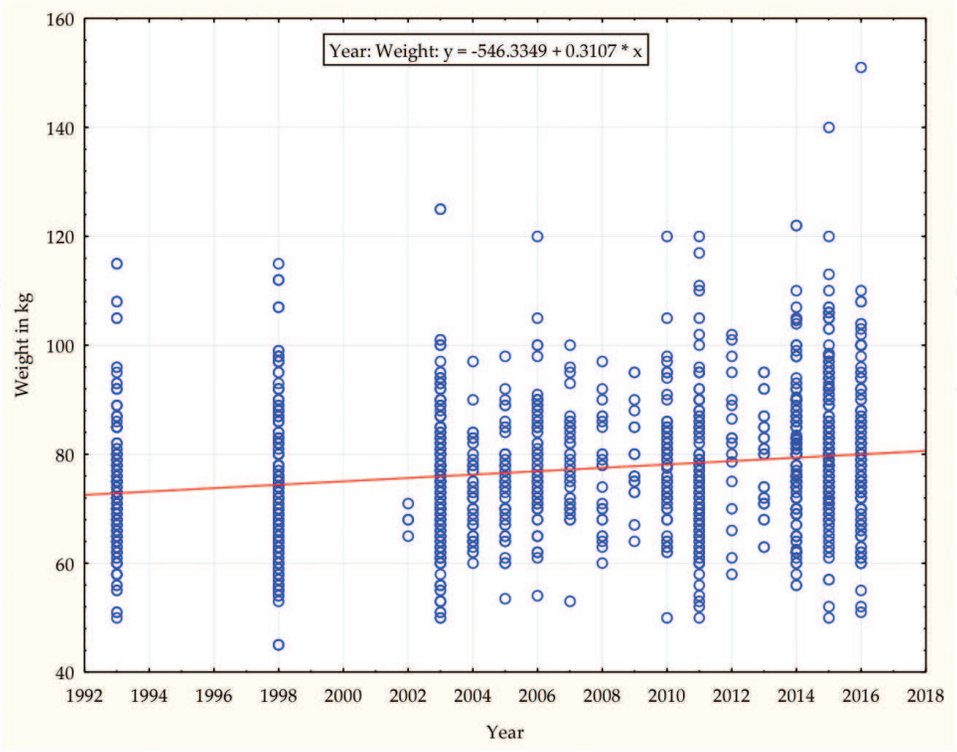

Figure 3. Body weight development of Slovak adult population—male (Source: [own data processing]).

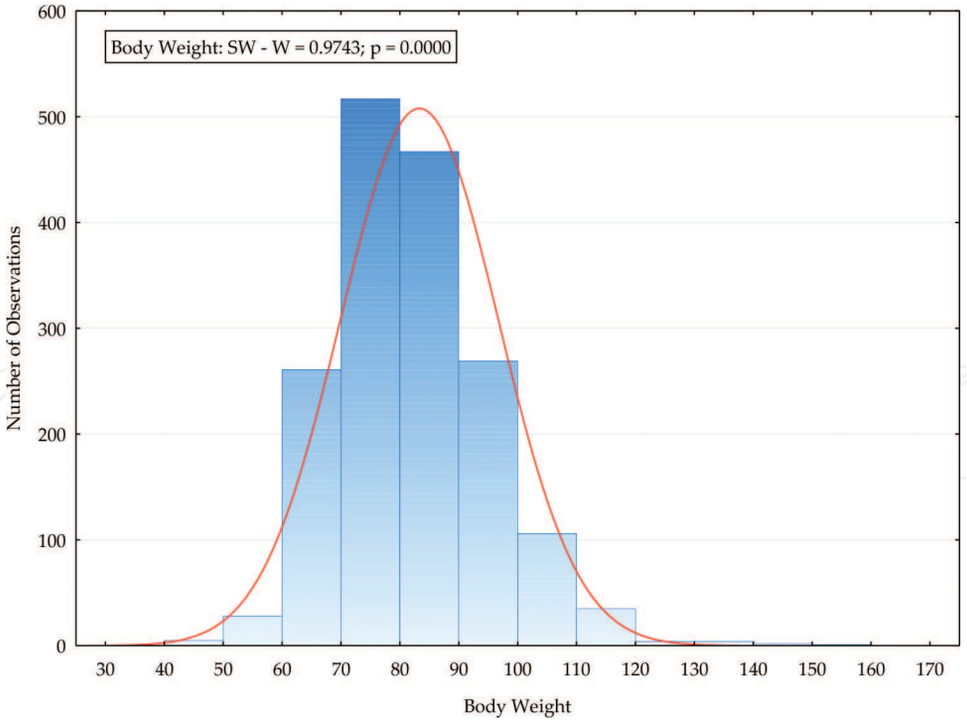

Figure 4. Histogram of body weight—male (Source: [own data processing]).

Our chapter deals with the analysis of proportions of adult female population. **Table 2** shows descriptive characteristics associated with females. Height growth of Slovak adult female population as well as weight in dependence on time is illustrated in **Figures 5** and **7**. In case

Average	Median	5th percentile	50th percentile	95th percentile	Standard deviation	Standard error	Symmetry	Pointing
168.2	167	159.7	169.5	179	5.9	0.2	0.2	0.0

Source: [own data processing].
Values are in cm.

Table 2. Result analysis of the size of adult population—Females (years 1992–2016).

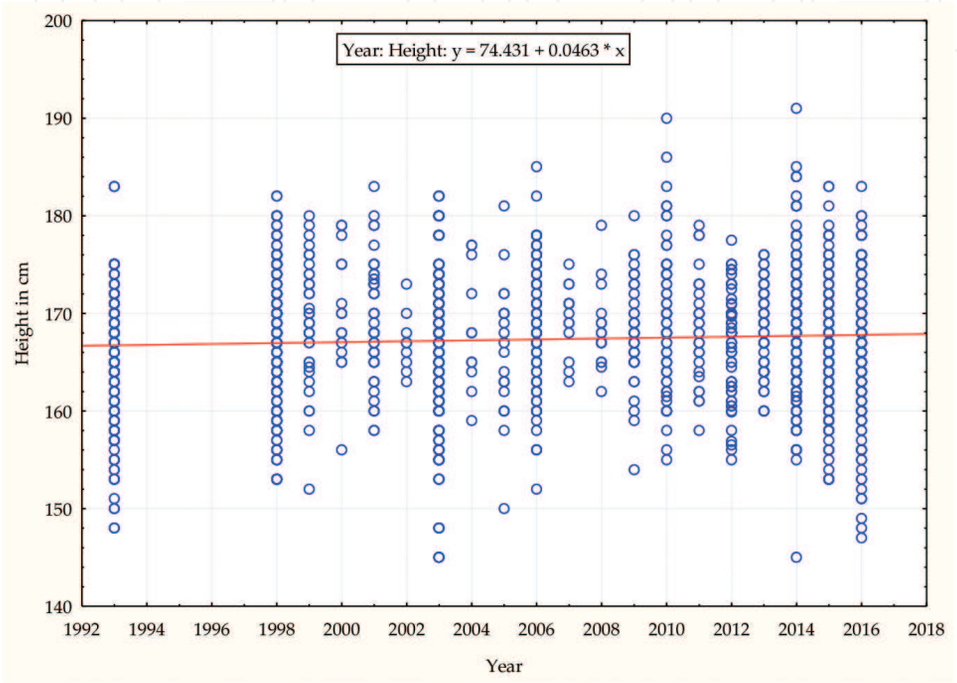

Figure 5. Height growth of Slovak adult population—female (Source: [own data processing]).

of females, the increase in both the height (0.05 cm per year) and body weight (0.03 kg per year) is slower. **Figure 6** shows dispersion in height of female population in a given year. Dispersion in body weight of female population is illustrated in **Figure 8**. Height growth of female population is not as distinctive as of female population. The slight increase in the weight of women compared to men can be affected by the effort to follow fashion trends and to have perfect female body.

Mentioned analyses are carried out in regard to future opportunities to manufacture furniture according to individual needs of population in terms of height and weight (e.g., made-to-measure furniture, or furniture in different sizes—S, M, L, XL, etc.). Moreover, furniture can be defined pursuant to the gender in the future. At present, people preferred living single (because of the career or after splitting up with a partner). Histograms of male as well as female height are shown in **Figures 2** and **6**. Histograms of male as well as female weight are illustrated in **Figures 4** and **8**.

Following the actual research studies [15, 16] secular trend of growing of body proportions of adult population in Slovakia can be stated. Secular trend can be considered a global phenomenon. Results of various international projects and research studies confirm the

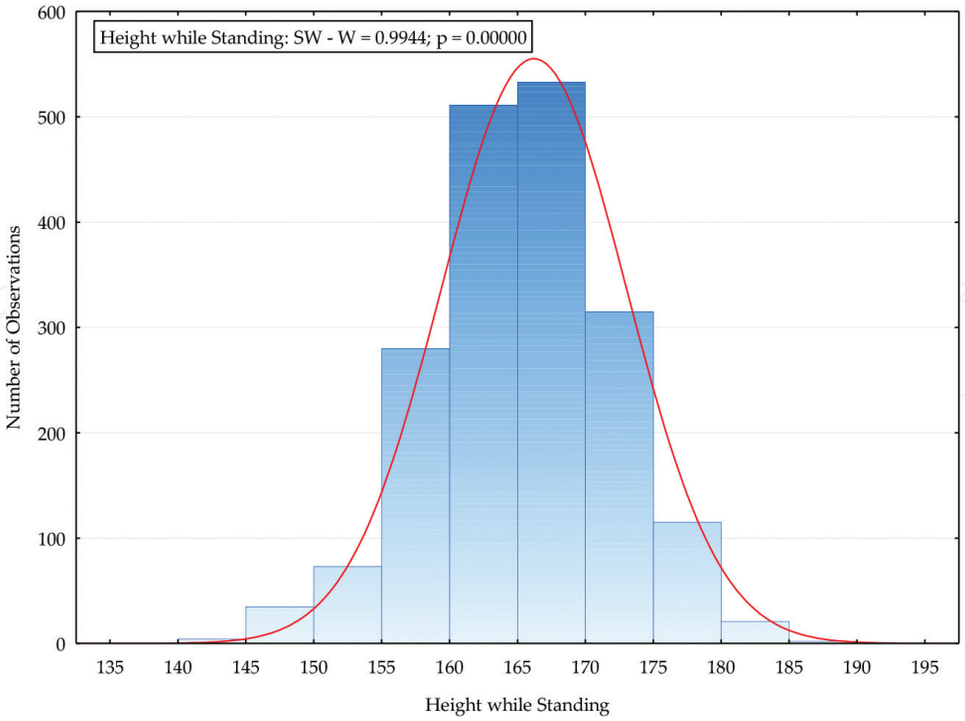

Figure 6. Histogram of female height (Source: [own data processing]).

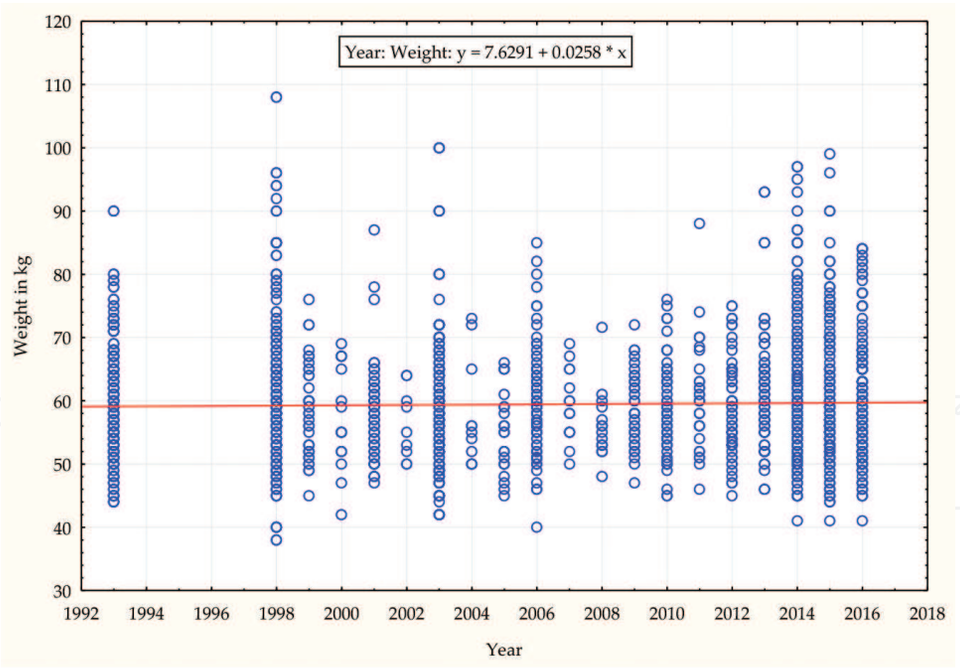

Figure 7. Body weight development of Slovak adult population—female (Source: [own data processing]).

trend as well [1, 19, 20, 23, 35–37]. At present, the size of men is much bigger than before, that is, men are much taller and heavier. It results in the increase in the value of BMI. Rapid increase in male weight can be explained by fashion trends preferring muscle men. Due to

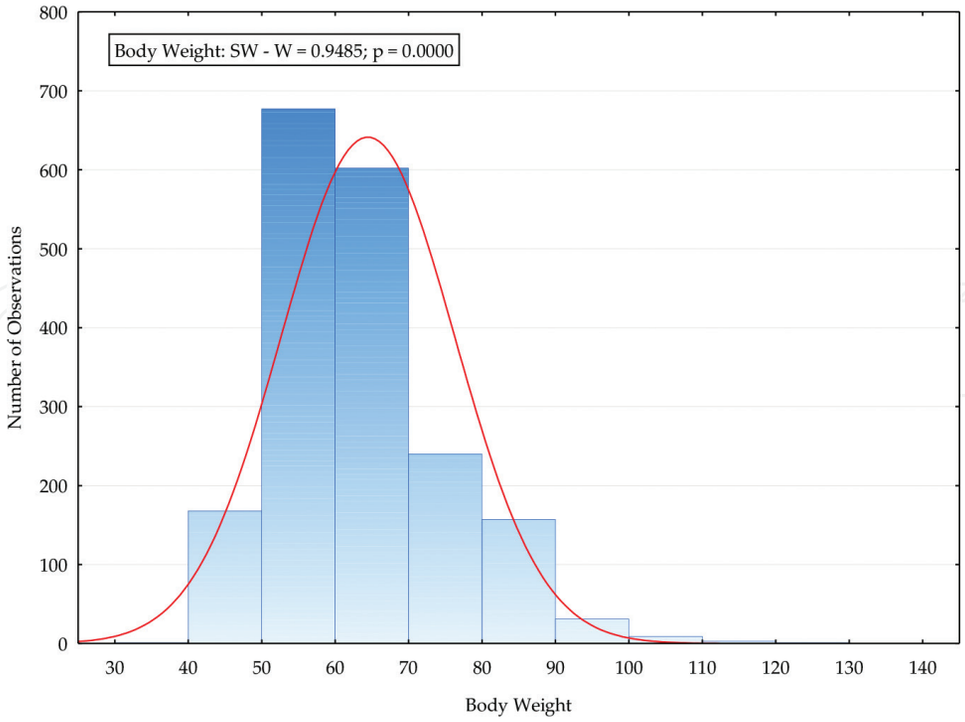

Figure 8. Histogram of body weight—female (Source: [own data processing]).

given reasons, research into secular trends of adult population in Slovakia is carried out. Sampling unit consists of Slovak adult population, that is, people at the adult age in terms of human growth—people who are 18+. Data are gained using the method of direct detection, which means through measurement of selected anthropometric data (height, weight, Bi-deltoid shoulder width, etc.). Anthropometer is used to measure height and pelvimeter is used to measure shoulder width. Gained data are processed and described using tools and methods of descriptive statistics. Scale and oscillation of measured values are characterized by averages, standard deviations and variation coefficient [38].

Modern furniture design ranges feature bedroom furniture, living room furniture, dining room furniture and home accessories and must follow the size and weight of present as well as of future generation. The minimum bed size and dimensions designated for present generation exceeds the European standard size. Following our outcomes, we can state that individual parameters of bedroom furniture at present, specifically length of bed, does not correspond with the need, that is, body proportions of present generation. Therefore, it is necessary to deal with the data upgrade. Standard size modification asks for cooperation between designers, furniture manufacturers, and health worker. Only a multidisciplinary approach can provide useful and meaningful results leading to manufacturing healthy furniture with positive impact on the population development.

Present Slovak generation is getting bigger. It is a generation affected by political changes in Slovakia over the last three decades (change in political regime, joining the EU). Impacts of the changes can be seen in changes in eating habits as well as in globalization of the Slovak society. Opening borders bring together people of differing ethnics and people of various backgrounds

mix together. Consequently, body proportions of present adult population in Slovakia change as well. Better nutrition, higher socio-economic status (following GDP), urbanization, lower incidence of specific diseases can be mentioned as further reasons affecting the proportions of population. Forasmuch as height is an essential parameter determining the size of bed, it must be taken into account in order to provide for the basic necessity of life—quality sleep.

Jirkovský [22] mentions that growth acceleration has slowed down and the body weight has been increasing gradually since the second half of the 1980s; thus, secular trend typical especially after the Second World War tends to slow down. Despite all these facts, slight increase in the average height of the Czech population can be observed. Results of the research into Norwegian population carried out by Bolstad et al. [19] support the fact about secular trend slowdown as well. During the years 1900–1994, height of Norwegian men increased from 170 to 179.8 cm; however, during the years 1994–2000, the change in height was not observed. The authors of an anthropometric research into Norwegian population suppose that further increase in height of Norwegian men will be very slight or none. Norwegians reached their full growth potential. Similar trend can be observed in female population as well. The female height increased from 162.8 to 166.1 cm in the course of 57 years. In the area of body weight of Norwegian men, an increase by 5.6 kg was observed in the years 1991–1995 comparing to the years 1963–1972. The body weight of Norwegian women increased only by 1.3 kg in the mentioned period of time. The slight increase in the weight of Norwegian women can be affected by the effort to follow fashion trends and to have a perfect female body. Cole [29], as well as the abovementioned authors, states in his research aimed at secular trends that an increase in body height slowed down in the second half of the twentieth century, whereas the weight continues to grow as part of global obesity epidemic. Secular trends associated with the proportions of Croatian population is observed in the anthropometric research carried out by Grbac et al. [39]. Authors state that young Croatian population grew up by 5 cm over the last 30 years. This trend continues and an increase by 2 cm over 10 years was observed. Besides the abovementioned countries, secular trend was observed in other European countries as well. It is confirmed by the research conducted by Lozovina and Lozovina [40]. Following the findings, it can be stated that results of the research studies into development of body proportions of Slovak adult population can be compared to the results of the research conducted home and abroad as well. Results show a tendency to increase the body proportions (especially height) of consecutive generations, that is, a secular trend that starts to slow down. Abovementioned research studies confirm the development of secular trends.

Ergonomics plays an important role, inter alia, in daily products, for example, furniture. Furniture is like a silent partner. It is a part of the environment. When designing or manufacturing new furniture, not only body proportions of present generations but of future ones as well must be in the center of our attention. Familiarity with actual anthropometric data of population is an essential factor necessary for furniture modification and subsequent quality sleep. Quality sleep provides employees with enough rest, therefore, it is a prerequisite for occupational safety as well as injury prevention.

The bed is one of the fundamental objects of furnishings. No other part of furniture must respect so strict quality standards as bedroom furniture. Human individuals spends more than one-third of life asleep. Lying area is adapted to the sleep and rest in a flat position [41].

In terms of anthropometry, physiology and hygiene, the bed size must fit the human measurements and changes in sleeping positions during sleep. A firm mattress is recommended in order to allow the spine to rest and regain its natural curve. Along these requirements, mattress must be fully breathable with a special hygienic treatment applied to the mattress material. Moreover, it must provide optimal thermal comfort as well as psychological well-being, that is, safety sense during the hypnagogic state [42].

The length, width, and the height of bed are the most important bed parameters (**Figure 9**). The length and width affect the size of lying area, whereas, the height of bed provides comfort when sitting on the edge or getting up. General requirements for bedroom furniture in terms of physiology and hygiene are as follows:

- the bed size must fit the human measurements and changes in sleeping positions during sleep;
- a firm mattress must allow the spine to rest and regain its natural curve (sleep on the back, side and stomach);
- thermal comfort and breathability (sweat absorption), that is, mattress must be breathable and must allow sweat absorption in order to provide thermal comfort as well as thermoregulation of organism;
- psychological well-being;
- hygiene (special hygienic treatment must be applied to the mattress); and
- comfort while using in general [43].

Bedroom furniture is designated for regular or occasional sleep routine. Beds can be designed as static, dynamic or fold-out beds for various groups of users, in terms of age—children, students, adults, seniors; in terms of the state of health—healthy, ill, temporary or permanently disabled; in terms of sensitivity—insensitive users or users sensitive to geopathic stress zones or electromagnetic smog [44].

Functional dimensions of bedroom furniture, its height, width and length are in accordance with standards [44]. Requirements for the height of bed are as follows: the height of bed including the mattress from the floor is 420–600 mm, the height of headboards and foot ends from the lying area is minimum 200 mm, the height of lower edge of the bed frame from the floor is minimum 200 mm, the height of bed should provide comfort when getting up effortlessly or sitting on the edge, the height of 420 up to 450 mm from the floor is considered a standard height of bed (zone of ground level air circulation is up to 300 mm). The height of bed must be increased by 20–25% in order to provide comfort in lying down and getting up for older or disabled people, that is, to the height of 500–600 mm. The height of bed plays an important role in making up the bed or tidying up the bedroom. The higher the bed is, the more difficult it is to put a sheet on it. The height of bed ranging from 450 to 500 mm provides comfortable making up in beds with the width of 850 mm. The lower edge of bed frame should be 250 mm above the floor level in order to provide comfort in tiding up under the bed. The standard length of lying area is 1,950, 2,000, 2,050 and 2,150 mm (**Figure 10**).

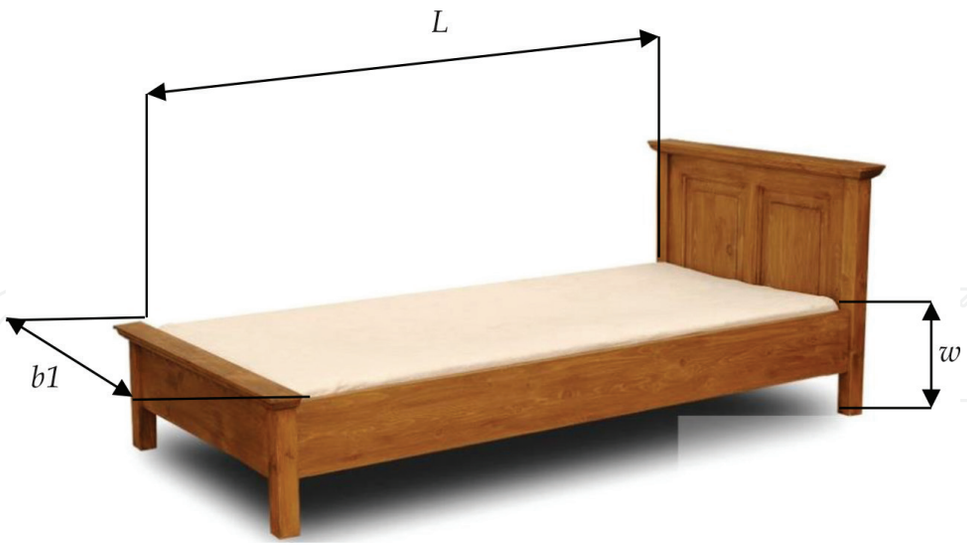

Figure 9. Basic parameters of a single bed (Source: [own data processing]).

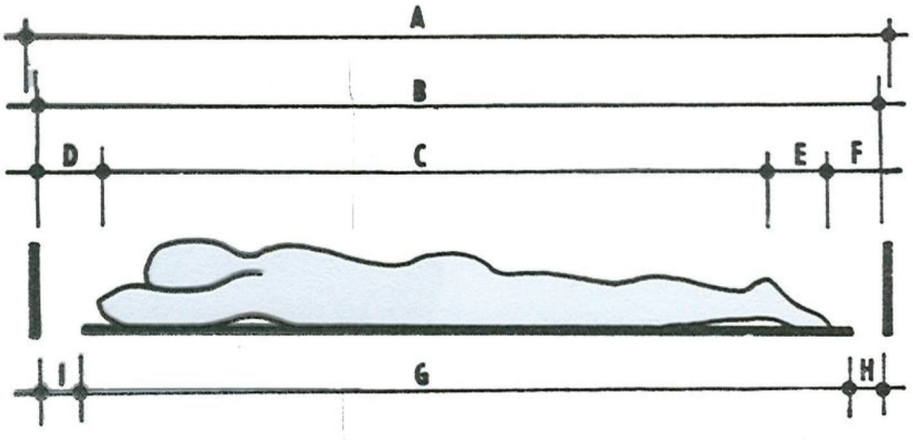

Figure 10. Factors affecting the length of lying area (Source: [59]). A—Length of bed; B—inside length of bed; C—length of a sleeper; D—space for hand supporting the head; E—spare space for feet; F—free space next to legs; G—length of mattress; and H, I—space for making up a bed.

Results of the survey mentioned in the **Figures 2** and **4** show the fact that not only height but also male and female weight is increasing. This fact should result in the changes of parameters of furniture mechanical testing aimed at improving furniture safety to ensure comfortable environment. Strength under static loading, mattress durability, impact of cycling loading on the durability, resistance to shock loading are performed in the process of bed testing. Lateral edges of bed frame should be tested as well, for example, the strength under static loading. Bunk beds and high sleeper beds for children and adults should be included in testing, too. Especially testing of stability of bedsteads and bunk beds, ladder strength test should be carried out. Moreover, upper bunks must have effective safety rails with the top of the upper rail at minimum of 200 mm above the upper surface of the mattress. We suppose the changes will cover also mattress performance and mattress cover fabrics (ticking)—physical tests are

carried out on the fabric to check for strength and durability. Changes in testing parameters will affect not only the bedroom furniture safety but also its quality and, subsequently, the quality of sleep.

Following the research, we submit a proposal to change the dimensions, especially length of bed, determined for the present population in Slovakia. We focus on determining the size and dimensions of single bed (bed intended for one adult person) due to body proportions of present generation, body dimensions of men. Therefore, the length of bed (lying area) results from the measurement of male height that becomes a determining factor. The upward trend in population growth is expected to continue over the next 10 years, so two standard deviations were added in order to ensure that bed size following the trend in population growth will fit next generation as well.

Following the outcomes of the actual statistical properties associated with the body dimensions of Slovak population, we can determine proposed dimensions of bedroom furniture. Bed size is based on the measurement of body dimensions of male population because of a general rule, men are taller in average than women. Male height (TV_m) was a determining dimension for the length of bed:

$$L = V_m + 2\,s_x + N_p \text{ [cm]} \tag{1}$$

Data summation result in three alternative lengths of bed due to the fact that Np changes according to the bed placement as follows [44]:

- 15 cm if there is not enough space (e.g., studio flat);
- 25 cm if there is enough space but no extra (e.g., flat); and
- 35 cm if there is a space big enough (e.g., detached house).

Single bed meeting the requirements for the new anthropometric data and the placement should be of the length mentioned in **Table 3**. At the present time, the standard size of single bed is 90 × 200 and 100 × 200 cm. This size does not correspond to the secular trend of the increase in body proportions of a human individual nowadays. Dimensions of bed satisfying the needs of present people, their comfort and health, must be 102 × 222 cm (95th percentile) (**Table 2**). At

Bed placement	Length of lying area (cm) when the percentile is			Proposed length of lying area (cm)
	5th	50th	95th	
Studio flat	200.2	211.7	222.2	213
Flat	210.2	221.7	233.2	223
Detached house	220.2	231.7	243.2	233

Source: [own data processing].

Table 3. Proposed length of bed following the proportions of present population.

the same time, we can state that weight gain trend of population is observed as well. Therefore, testing must be focused on strength and structural properties of bed in the future, too.

Width of bed must meet following requirements. The width of lying area of one person can be 780, 850, 900 and 1000 mm. The width of bed for two persons can be 1600, 1700, 1800 mm. When determining minimum lying area width (b1) Bi-deltoid (shoulder) width was an essential factor (see **Figure 1**). Firstly, it must be extended by 50% and subsequently two standard deviations must be added due to the trend in population growth. Each human individual changes the sleeping position many times during the night. Therefore, the minimum width of bed must be extended by next 25%. Final width of bed, that is, lying area is determined according to the formula [45]:

$$b_1 = 1.5\left(\check{S}_R + 2\,s_x\right) + 0.25\left(1.5\,\check{S}_R + 2\,s_x\right)[\text{cm}] \tag{2}$$

Lying area width b is determined by the width of human body and the area necessary for movement during night. Sleeping on back, on stomach or on side with relaxed arms are considered basic sleeping positions. Bed width refers to the size of the widest point of a human body extended by 10–15%. Each human individual changes the sleeping position many times during the night. Therefore, the standard lying area determined by the basic width must be extended by 20–25% to ensure comfort sleep. Minimum lying area width ranges from 800 up to 850 mm. Narrower dimensions can be used only in case the lying area is bounded by bed frame or side edges of lying area are reinforced.

Human individual must be assessed as a mechanism consisting of joints and bones in order to determine optimum bed width allowing users not only to sleep but also to make up a bed in a comfortable way. For the purpose of more comfortable making up of the bed, the bed width can be determined using the bed height (w = 5d) in dependence on a forward bend (angle α) and the easy access to the farthest side of the mattress (angle σ). Navrátil and Klein [46] dealt with this issue and following the solutions of trigonometric equations they found out that the angle of a forward bend starting from the waist α ranging from 101 to 120° and the arm inclination angle ranging from 30 to 45° ensure maximum comfort when making up the bed. Still comfortable lying area width can be determined in association with the values of angles using relations mentioned in **Table 4**. The value of a part d is defined as 1/20 of the human height (technique of the golden section).

The height of bed reflects the needs of people to put both their feet firmly on the ground and push off the bed with their knees bent. The height of 420 up to 450 mm from the floor is considered an optimum height of bed (zone of ground level air circulation is up to 300 mm). For lying down and getting up, elderly people ask for rising a bed by 20–25%, that is, to 500 or 600 mm. The bed height was determined according to the following formula [46]:

$$\text{w} = 5\text{d}\ [\text{cm}] \tag{3}$$

The bed height calculated using the formula fit 95% of population. Therefore, we propose the bed height of 42–60 cm.

Values of angles (°)			Width of bed b1 determined in multiples of parts
α	β	σ	
101	124	45	9.02 p
101	139	30	11.74 p
105	120	45	9.37 p
105	135	30	12.01 p
110	115	45	9.75 p
110	130	30	12.33 p
115	110	45	10.10 p
115	125	30	12.63 p
120	105	45	10.42 p
120	120	30	12.90 p

Source: [46].

Table 4. Width of bed.

3. Conclusion

Ergonomics plays an important role, inter alia, in daily products, for example, furniture. Furniture is like a silent partner. It is a part of the environment. When designing or manufacturing new furniture, not only body proportions of present generations but of future ones must be in the center of our attention as well. Ergonomics plays an important role in furniture design, in its shape and size; it means the quality of furniture and materials used. Familiarity with actual anthropometric data of population is an essential factor necessary for furniture modification. Quality sleep provides employees with enough rest, therefore, it is a prerequisite for occupational safety as well as injury prevention. Anthropometric characteristics of population can change over the period of time. Secular trend exists. Its increase can be expected in the future. The average height of Slovak men could reach the value of 184.27 cm in the year 2025.

The reasons why most body dimensions follow trends which involve rapid growth can be explained in many ways. The change in style of living, better health and nutrition care as well as sport activities can be one of them. Political changes in Slovakia over the last decades (change in political regime, joining the EU) could result in the changes of body proportions. Impacts of the changes can be seen in changes in eating habits as well as in globalization of the Slovak society. Moreover, opening borders bring together people of differing ethnicities and people of various backgrounds mix together.

Bed is one of the essential parts of furnishings. A human spends more than one-third of his/her life on it. Good quality sleep can affect the employee performance at work in positive as well as in negative ways. It can also help to prevent accidents in the workplace. Bed size in the context of body proportions of adult population in respect to occupational safety is defined in the chapter.

Bedroom furniture is designed to satisfy the need of users, especially to have a rest and sleep that helps the body to recover. Only bed following the anthropometric requirements of final users can meet mentioned needs. When implementing the actual anthropometric data of Slovak population in modification of bed sizes, the minimum lying area of 108 × 221 cm can be defined. The mentioned dimensions fit present human individual in terms of sleep comfort. Recommended bed height is 46 cm above the floor.

A total of 3358 students from Slovak universities were analyzed in the chapter. Gained data were processed and described using the tools and methods of descriptive statistics (standard deviation, asymmetry coefficient, percentiles, standard error, symmetry and pointing). Following the outcomes of the actual statistical properties associated with the body dimensions of Slovak population, we propose the dimensions of bedroom furniture which correspond to the actual adult population with minimum dimensions of 102 × 222 cm (95th percentile). After updating, it is necessary to start looking at adjustments of calculations when pricing the bed furniture in furniture companies, as the increase in dimensions will be reflected fundamentally in the product price. Economic damage may occur in the company, if the employees of the economic department do not deal with this problem [47–49].

Sleep is a complicated process, therefore, research studies of modern neurology focus more on it. Lack of sleep as well as poor quality sleep can increase the risk of mistakes or even accidents in the workplace with fatal injuries. Bad sleepers cause seven times more injuries than people with good sleep. Lack of sleep and its poor quality have a negative impact on the bodily functions, for example, reduced attention span, alertness and reaction time. Motivation, flexibility and logical thinking are affected by lack of sleep as well. Researchers claim missing sleep can make you stupid. During sleep, new learning and memory pathways become encoded in the brain, and adequate sleep is necessary for those pathways to work optimally. Another important impact of sleep is confirmed by researchers. They suggest that memory consolidation takes place during sleep through the strengthening of the neural connections that form our memories. Moreover, sleep likewise supports immunological memory formation. A full night's sleep post vaccination boosts the immunological memory. Research shows that sufficient sleep plays an important role in weight management and decreasing the risk of metabolic disorders such as insulin resistance and diabetes as well as other sleep-related problems. With too little sleep, the body is also more likely to produce the stress-response hormone cortisol [7]. Quality sleep is a significant factor affecting occupational safety. The size and condition of the bed as well as the mattress has a major effect on the quality of sleep.

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Conflict of interest

Authors declare no conflict of interest.

Author details

Miloš Hitka*, Pavol Joščák, Silvia Lorincová and Žaneta Balážová

*Address all correspondence to: milos.hitka@tuzvo.sk

Technical University in Zvolen, Zvolen, Slovakia

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