MILOŠ HITKA, MILOŠ GEJDOŠ

SECULAR TREND OF STATURE HEIGHT AND BODY WEIGHT AND BODY MASS INDEX OF THE SLOVAK POPULATION IN THE YEARS 1965–2022 – OBSERVATIONAL STUDY

ABSTRACT: The aim of the work is the quantification of changes in the stature height and body weight of the adult population over time, which represents key ergonomic information for many areas. Based on the previous research on the dimensions of the adult Slovak population, we conclude that there has been a secular growth of the adult population over 50 years, which has a fundamental impact on the proposals for the arrangement of optimal and safe working, as well as residential and non-residential space. The mentioned trend also affects the consumption and use of any aspects of human life. On a sample of 11,052 Slovakian respondents aged 18–25, we defined the values of the arithmetic mean of stature height, body weight, and BMI separately by gender. In addition, the basic descriptive statistics of these parameters were also calculated. As a result, during the monitored period, there is an annual increase in body height by 0.1392 cm for men and 0.1013 cm for women. Another finding is that there is an annual increase in body weight of 0.1881 kg for men and 0.0769 kg for women. In the near future, it is necessary to take into account the secular trend of the Slovak population and urgently deal with the standards that deal with height and weight limits.

KEY WORDS: Adult population – Stature height – Body weight – Body measurements – Secular trend – Anthropometry

INTRODUCTION

When designing and assessing the spatial arrangement of workplaces, but also when manufacturing ergonomically correct work tools, machines, and furniture, the human figure, especially its dimensions and strength capabilities, must be taken into account as a primary factor. The very design of optimal living space (furniture, work tools, aids, etc.) is therefore always based on measurements of the target interest group of

people, which are compared with the data of the entire population living in a certain area, usually divided into men and women (Čuta *et al.* 2019).

From the history of the settlement of the territory of Slovakia in the past centuries, based on the analysis of the burial ground from the period of the Avar Kaganate, we can define the stature height of the population of the ancestors of the current inhabitants. The average stature height of the population from the period of the Avar Kaganate buried at the Veľký Meder site (Čalovo) reached a medium value, namely 165.4 cm for males and 154.8 cm for females. While males reached the highest body height in the maturus II age category (above average – 168.7 cm), for females it was in the maturus I age category (above average – 156.9 cm) (Vondráková *et al.* 2022).

The average height of the figure of the Slavic population buried in the Nitra-Drážovce area from around the Church of St. Michael the Archangel in Nitra in the 11th to 17th centuries and their osteological analysis reached an above-average value of 168.47 cm for males and an average value of 155.98 cm for women, which, however, is already on the border with the above-average value for stature height (Kolena, Vondráková 2013).

Multi-year current epidemiological studies point to the relationship between the level of adaptation of the spatial conditions of the living space to the body dimensions of a person. The anthropometric characteristics of a certain population can change especially over longer periods of time due to the action of a number of factors, such as changes in the standard of living and lifestyle of the population, changes in nutrition, genetic factors, etc. Therefore, it is necessary to periodically update data on population anthropometric characteristics. The updated data reflect the real situation and make it possible to design an optimal layout of the workplace, or they will allow the creation of an optimal working environment necessary for achieving the maximum performance of workers while observing all principles of work safety and hygiene. Population data are mostly determined on selected samples at a certain point in time and for various reasons can change in trend over a longer period of time. This includes e.g. the way the population is fed, the variety of food, lifestyle, level of health care, etc. In addition to changes in time, important anthropometric features can also vary in space, which is related to the characteristics of the human population inhabiting a certain living space and population migration.

The aim of the work is to point out the development of the stature height and body weight of the adult Slovak population aged 18–25, namely stature height, body weight over time, and the derived value of Body Mass Index (BMI). Our research will provide updated information about the secular development trend in the years 1965–2022. Anthropometric and ergonomic parameters are in mutual influence, therefore, based on the secular trend, we see a subsequent need to update basic standards for practical areas of life.

EMPIRICAL MATERIAL AND WORK METHODOLOGY

Over time, population growth and weight changes occur. Therefore, it is necessary to determine population data on selected samples at a certain moment in time for various reasons (e.g. the way of nutrition the population, lifestyle, etc.) (Vignerová *et al.* 2006, Barroso *et al.* 2005, Jelačić *et al.* 2002, Mokdad 2002, Cole 2000, Loesch *et al.* 2000, Kayis, Ozok 1991).

We understand the secular trend as an increase in the final state of body dimensions of successive generations compared to previous generations (Jirkovský 2003). It is interesting for several reasons. It is a sign of the public health of the population, points to the relationship between economic growth and living standards (Cole 2003, Tanner 1992), and illustrates aspects of the physiology of intergenerational relationships in growth and size (Emanuel *et al.* 1992). According to the authors (Chuan *et al.* 2010, Vignerová *et al.* 2006, Vignerová 2005, Jirkovský 2003, Bolstad *et al.* 2001), research aimed at determining the anthropometric dimensions of the child and adult population clearly shows long-term changes in body dimensions. Mostly it is the so-called positive trends, i. e. there is an increase in the values of the measured parameters. The body dimension, that is monitored most often and also best characterizes given changes, is body height. The basic anthropometric method suitable for solving the mentioned problems is somatometry, which represents a system of techniques for measuring and observing a person and his body parts using the most accurate means and methods for scientific purposes. Somatometry systematizes and precisely defines a set of relevant anthropometric features of the human body, which significantly affect the performance, health, well-being, and safety of employees, and at the same time provides a series of measuring aids and procedures that enable the exact determination of the values of the monitored anthropometric features.

Anthropometry is one of the basic methods of physical anthropology. It is a field that deals with the measurement, description, and analysis of external body signs characterizing the growth and structure of the body. It is based on anthropometric points that are internationally approved (www.n-i-s.cz). These defined points are on the human body and skeleton, on the basis of which it is possible to measure a whole range of body dimensions that characterize the given person (Beneš 1990). In the anthropometric literature, a whole series of standardized dimensions and features are defined, which can be determined exactly on the human body (Hajn 2003). In the work, we focused only on two primary characteristics, stature height, and body weight. From the mentioned two features, we define a secondary feature, the Body Mass Index (BMI). BMI is one of the most widely used methods of measuring health. It is calculated as body weight in kilograms divided by the square of stature height in meters. In general, it can only be considered a statistical tool for comparison in the population. It ignores a large number of important factors for a specific individual (e. g. body structure, amount of muscles, etc.). The BMI value applies to an average adult human. It does not apply to children, youth under 18, pregnant women, and athletes. Waist circumference, blood pressure, cholesterol, and adherence to a healthy diet also play an important role. The higher the result, the heavier the person is for their stature height. Values from 20 to 25 are considered normal.

Data from 1965 to 1985 were obtained from the works of Bláha *et al.* (1982) and Bláha *et al.* (1986). These data were refined to measure data for the given age group of the population (18–25 years) exclusively for Slovakia. At the same time, the data of the population aged 35–55 were used to determine the stature height dimensions of the population in the years 1965–1975 since we were working with the hypothesis that the body height of these people did not change after reaching adulthood. However, these data could not be used for the analysis of the development of body weight and BMI, since weight can fluctuate considerably with age in adulthood. Empirical measurements of the current population aged 18–25 were periodically carried out in the years 1993–2022 on a sample of Slovak university students. The data were also obtained from the Office of Public Health. In total, data was obtained from the period 1965–2022 on a sample of 11,052 respondents aged 18–25. Of the total sample, the data of respondents from Universities and the Office of Public Health in the years 1993–2022 represented approximately 87% (9,667 respondents). The composition of the population sample is presented in *Table 1*.

TABLE 1: The size of the population sample.

Total population sample 1965–2022		
Category	Gender	Sample size
18–25 years	Male	5.353
18–25 years	Female	5.699
Population sample 1993–2022		
18–25 years	Male	4.672
18–25 years	Female	4.995

As part of the results, the values of the arithmetic mean of height, weight, and BMI were calculated separately by gender. In addition, the basic descriptive statistics of these three parameters (mode, median, standard deviation, variance) were also calculated. All calculations were made in the Statistica 10.0 software environment (Statsoft Inc. 2010).

RESULTS

Empirical measurements aimed at defining the development of secular changes in the anthropometric dimensions of the adult population of Slovakia were carried out between 1993 and 2022. They were carried out for both genders. The research sample consisted of a total of 9,667. This sample was supplemented with measurements from the Spartakiads in 1980 and 1985 with a total of 1,385 respondents aged 18–25. We present the development of secular changes in anthropometric dimensions over the last 57 years through linear regression equations. We are investigating the relationship between two variables. We assume that the variable x (years) depends on the variable y (stature height, body weight, and BMI) that affects it.

DEVELOPMENT OF STATURE HEIGHT OF THE MALE AND FEMALE POPULATION

Figure 1 presents the development of the stature height of the male and female population between 1965 and 2022. The results show that during the monitored period, there is an annual increase in stature height by 0.1392 cm for men and 0.1013 cm for women. The lowest average value for both the male and female population was measured in 1965 (172.5 cm for men; 159.8 cm for women). In 2019,
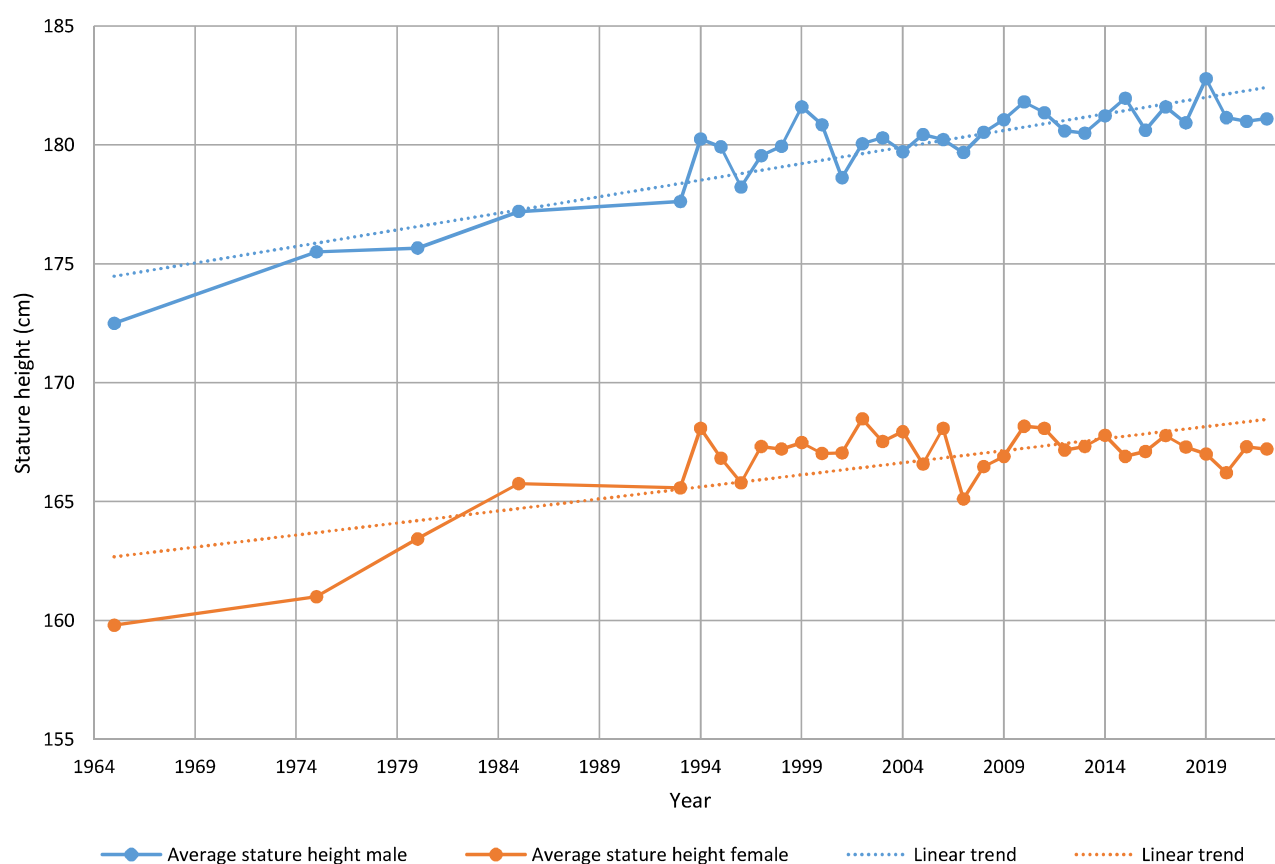
FIGURE 1: Development of the average stature height for the male and female population in the years 1965–2022.

the highest average stature height value for men was measured, namely 182.79 cm. For women, the highest average stature height was measured in 2002 (168.48 cm). The number of respondents in individual years as well as the basic descriptive statistics of body height parameters are shown in *Table 2*. These data are important for understanding the construction of the trend in *Figure 1*. The highest number of measured male respondents was in 2022 (436 males) and the highest number of female respondents was measured in 2014 (317 respondents). With data from 1965–1985, it was not possible to calculate basic statistical parameters, because absolutely individual values of the measured heights were not available, but only average values and the number of respondents were available.

DEVELOPMENT OF BODY WEIGHT OF THE MALE AND FEMALE POPULATION

Figure 2 presents the development of the body weight of the male and female population between 1980 and 2022. The results show that there is an annual increase in body weight of 0.1881 kg for men and 0.0769 kg for women. The growth of body weight in women is therefore fundamentally lower in intensity than in men. This fact is also related to the lifestyle and the change in the standard of living and lifestyle after 1989. In the last three years (2020–2022), on the contrary, we observe a slight decrease in the average weight for both men and women.

The lowest average body weight values were found in 1980 (71.22 kg for men; 57.22 kg for women). The highest average value of body weight for men was recorded in 2019, namely 81.3 kg. For women, the highest average value of body weight was recorded in 2017, namely 62.3 kg. In *Table 3*, we present the calculation of basic descriptive statistics for the body weight parameter of men and women, including the number of respondents in individual years. In some years, the number of respondents differs compared to the parameter of body height. The reason for this is the fact that both parameters were not measured for all respondents in the analysis.

TABLE 2: Basic descriptive statistics for stature height in male and female population in the years 1965–2022.

| Year	Male						Female					
	N–rate	Mean	Median	Modus	Variance	Sx	N–rate	Mean	Median	Modus	Variance	Sx
1965	26	172.5					30	159.8				
1975	36	175.5				5.1	24	161.0				6.0
1980	314	175.7				6.3	292	163.4				5.7
1985	305	177.2				6.8	358	165.8				6.0
1993	212	177.6	178.0	180.0	40.8	6.4	154	165.6	165.5	165.0	32.8	5.7
1995	24	179.9	180.0	Multiple	54.6	7.4	59	166.8	167.0	164.0	48.3	6.9
1996	39	178.2	178.0	182.0	68.2	8.3	96	165.8	166.0	Multiple	44.3	6.7
1997	61	179.5	180.0	180.0	46.9	6.8	164	167.3	168.0	172.0	38.6	6.2
1998	161	179.9	180.0	Multiple	52.1	7.2	245	167.2	167.0	170.0	36.4	6.0
1999	45	181.6	181.0	180.0	41.3	6.4	94	167.5	168.0	168.0	46.2	6.8
2000	58	180.9	181.0	180.0	31.1	5.6	99	167.0	167.0	172.0	38.2	6.2
2001	123	178.6	178.0	178.0	46.2	6.8	113	167.1	167.0	Multiple	39.1	6.3
2002	142	180.1	180.0	178.0	36.8	6.1	200	168.5	169.0	170.0	34.4	5.9
2003	246	180.3	181.0	182.0	56.7	7.5	312	167.5	168.0	164.0	39.7	6.3
2004	117	179.7	180.0	180.0	40.6	6.4	122	167.9	168.0	168.0	33.1	5.7
2005	134	180.4	180.0	180.0	49.5	7.0	105	166.6	166.0	165.0	42.5	6.5
2006	118	180.2	180.0	180.0	56.0	7.5	207	168.1	168.0	168.0	40.0	6.3
2007	111	179.7	181.0	Multiple	68.9	8.3	136	165.1	165.0	170.0	62.1	7.9
2008	101	180.5	180.0	180.0	49.1	7.0	142	166.5	167.0	168.0	49.5	7.0
2009	88	181.1	180.5	Multiple	62.3	7.9	175	166.9	167.0	168.0	43.8	6.6
2010	189	181.8	182.0	180.0	64.6	8.0	195	168.2	168.0	Multiple	41.8	6.5
2011	210	181.4	181.0	180.0	45.6	6.8	138	168.1	168.0	172.0	30.8	5.6
2012	102	180.6	181.0	176.0	101.1	10.1	182	167.2	168.0	168.0	25.6	5.1
2013	177	180.5	180.0	180.0	119.0	10.9	256	167.3	167.0	164.0	34.9	5.9
2014	272	181.2	181.8	180.0	86.2	9.3	317	167.8	168.0	170.0	38.0	6.2
2015	195	182.0	181.0	180.0	49.2	7.0	245	166.9	167.0	165.0	35.9	6.0
2016	354	180.6	181.0	175.0	53.5	7.3	279	167.1	168.0	168.0	39.8	6.3
2017	111	181.6	182.0	183.0	59.0	7.7	118	167.8	168.0	Multiple	41.0	6.4
2018	359	180.9	181.0	180.0	33.7	5.8	286	167.3	167.0	168.0	43.1	6.6
2019	96	182.8	183.0	Multiple	47.7	6.9	74	167.0	166.5	165.0	24.8	5.0
2020	122	181.1	181.0	Multiple	72.0	8.5	65	166.2	166.0	Multiple	47.2	6.9
2021	265	181.0	182.0	185.0	44.1	6.6	161	167.3	167.6	173.0	37.6	6.1
2022	436	181.1	181.0	Multiple	45.8	6.8	244	167.2	168.0	168.0	34.9	5.9
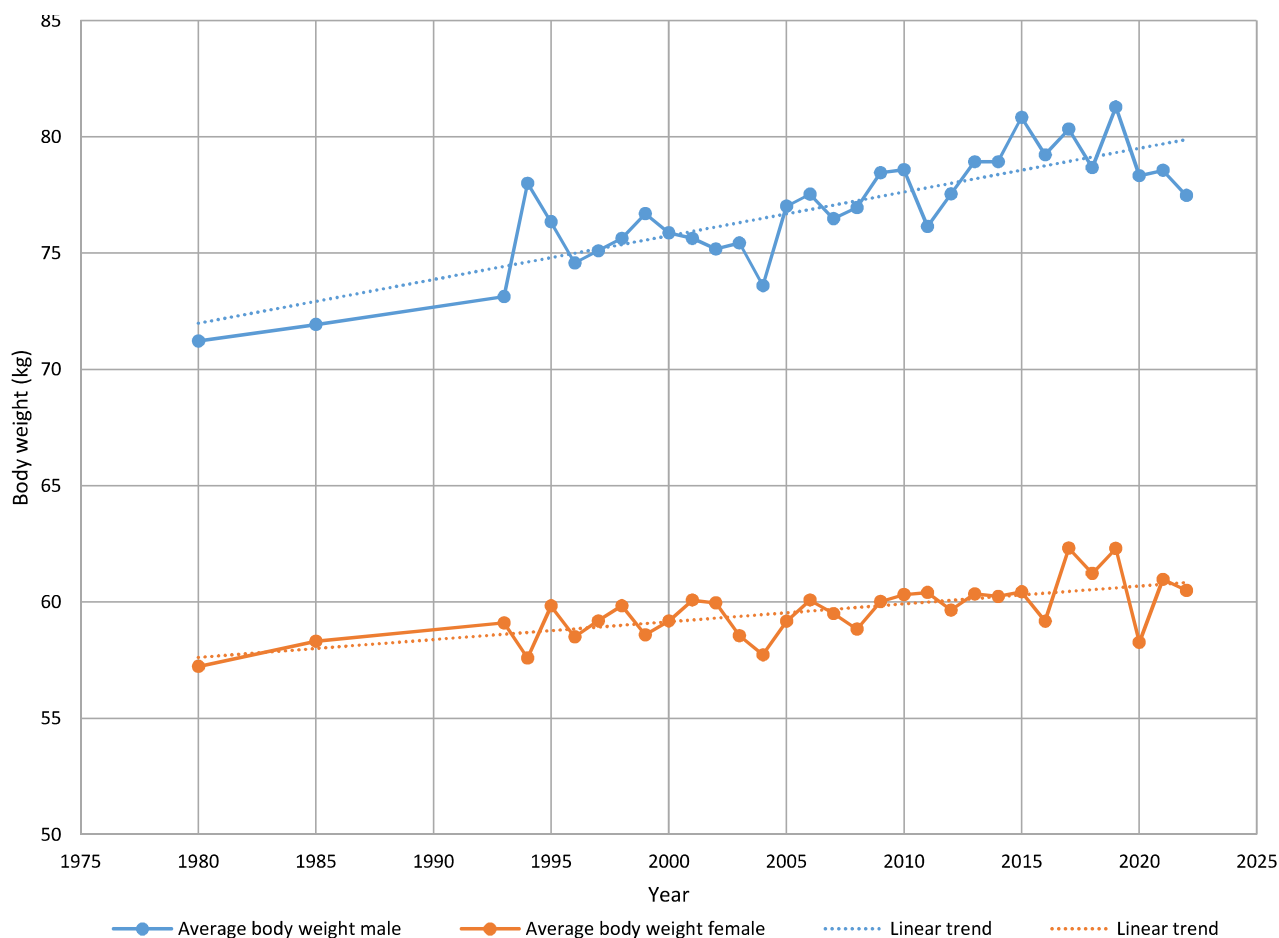
FIGURE 2: Development of the average body weight for the male and female population in the years 1980–2022.

DEVELOPMENT OF BODY MASS INDEX OF THE MALE AND FEMALE POPULATION

Figure 3 presents the development of the BMI index values of the male and female population in the age category 18–25 years for the period 1980–2022. This parameter also shows a linear increasing trend. Specifically, it is 0.0292 points per year for men and 0.0161 points per year for women. Since the main parameter entering into the BMI calculation is body weight, a slight decrease has been confirmed here as well in the last three years.

The highest average value of the BMI index for men was measured in 2013, namely 24.707. For women, the highest BMI value was measured in 2019 (22,339). *Table 4* again shows an overview of the calculation of the basic descriptive statistical parameters of the measured sample of the male and female population. The highest range of

the sample set of measured respondents was for men in 2022 (436 men) and for women in 1985 (358 women).

The results indicate that in the case of body weight and BMI growth, there is a reversal of the secular trend in recent years and these parameters are starting to decrease slightly. It can be concluded that the dispersion of the measured values of the adult population is also increasing, which also indicates an increase in the variability of the measured dimensions in the last 10 years.

The results of all three analyzed parameters were tested with a statistical t-test. The test showed that the populations of men and women are closest to the mean values for body height (more than 95%). In the case of body weight, approximately 77% of the analyzed sample falls within the mean in the given years. In the case of BMI, it was in the mean interval of only 33% of the analyzed population sample.

TABLE 3: Basic descriptive statistics for body weight in male and female population in the years 1980-2022.

Year	Male						Female					
	N-rate	Mean	Median	Modus	Variance	Sx	N-rate	Mean	Median	Modus	Variance	Sx
1980	314	71.2				8.0	292	57.2				7.7
1985	305	71.9				9.3	358	58.3				7.2
1993	212	73.1	72.0	75.0	113.5	10.7	154	59.1	58.0	55.0	65.6	8.1
1995	24	76.3	75.0	65.0	109.7	10.5	59	59.8	58.0	55.0	86.0	9.3
1996	39	74.6	72.0	Multiple	138.1	11.8	96	58.5	58.0	58.0	66.7	8.2
1997	61	75.1	74.0	74.0	139.4	11.8	164	59.2	57.5	56.0	83.0	9.1
1998	161	75.6	74.0	70.0	153.6	12.4	245	59.8	58.0	Multiple	106.6	10.3
1999	45	76.7	75.0	Multiple	157.4	12.5	94	58.6	57.5	Multiple	111.8	10.6
2000	58	75.9	75.0	75.0	108.2	10.4	99	59.2	57.0	Multiple	105.2	10.3
2001	123	75.6	75.0	70.0	127.2	11.3	113	60.1	58.0	Multiple	95.2	9.8
2002	142	75.2	74.5	80.0	110.1	10.5	200	60.0	59.0	55.0	76.4	8.7
2003	246	75.4	75.0	75.0	153.8	12.4	312	58.6	58.0	58.0	78.8	8.9
2004	117	73.6	72.0	70.0	84.5	9.2	122	57.7	56.0	50.0	77.4	8.8
2005	134	77.0	75.0	70.0	141.7	11.9	105	59.2	57.9	52.0	81.9	9.1
2006	118	77.5	76.0	70.0	129.1	11.4	207	60.1	60.0	60.0	69.7	8.3
2007	111	76.5	77.0	85.0	142.1	11.9	136	59.5	58.0	Multiple	117.2	10.8
2008	101	76.9	78.0	78.0	131.3	11.5	142	58.8	57.0	56.0	106.6	10.3
2009	88	78.4	76.3	90.0	183.3	13.5	175	60.0	58.0	54.0	114.3	10.7
2010	189	78.6	77.0	Multiple	148.5	12.2	195	60.3	58.0	56.0	104.2	10.2
2011	210	76.1	75.0	70.0	165.3	12.9	138	60.4	59.0	60.0	86.4	9.3
2012	102	77.5	76.8	70.0	141.5	11.9	182	59.6	57.0	55.0	97.0	9.8
2013	177	78.9	78.0	90.0	120.9	11.0	256	60.3	59.0	60.0	94.5	9.7
2014	272	78.9	78.0	Multiple	139.8	11.8	317	60.2	58.0	55.0	90.1	9.5
2015	195	80.8	79.0	Multiple	173.6	13.2	245	60.4	57.8	55.0	107.1	10.3
2016	354	79.2	76.0	75.0	172.6	13.1	279	59.2	58.0	50.0	86.4	9.3
2017	111	80.3	78.0	Multiple	210.5	14.5	118	62.3	59.0	58.0	150.2	12.3
2018	359	78.7	78.0	70.0	105.3	10.3	286	61.2	60.0	60.0	105.2	10.3
2019	96	81.3	80.0	90.0	153.6	12.4	74	62.3	58.0	Multiple	145.3	12.1
2020	122	78.3	75.8	70.0	222.4	14.9	65	58.3	59.0	Multiple.	50.1	7.1
2021	261	78.6	75.0	75.0	241.4	15.5	160	61.0	60.0	60.0	116.6	10.8
2022	430	77.5	76.0	70.0	183.9	13.6	243	60.5	59.7	55.0	104.1	10.2

DISCUSSION

Secular trends have been documented in many countries of the world since the 19th century (Fudvoye, Parent 2017, Leitao *et al.* 2013, Komlos, Lauderdale 2007). An increase in height has been noted in southern Europe (Schmidt, Jorgensen 1995). The existence of secular trends can be considered a global phenomenon (Cole 2003, Bolstad *et al.* 2001). Our research complements a number of other studies carried out in the recent past in Slovakia and in various countries of Europe and the world. Comparing the results of our
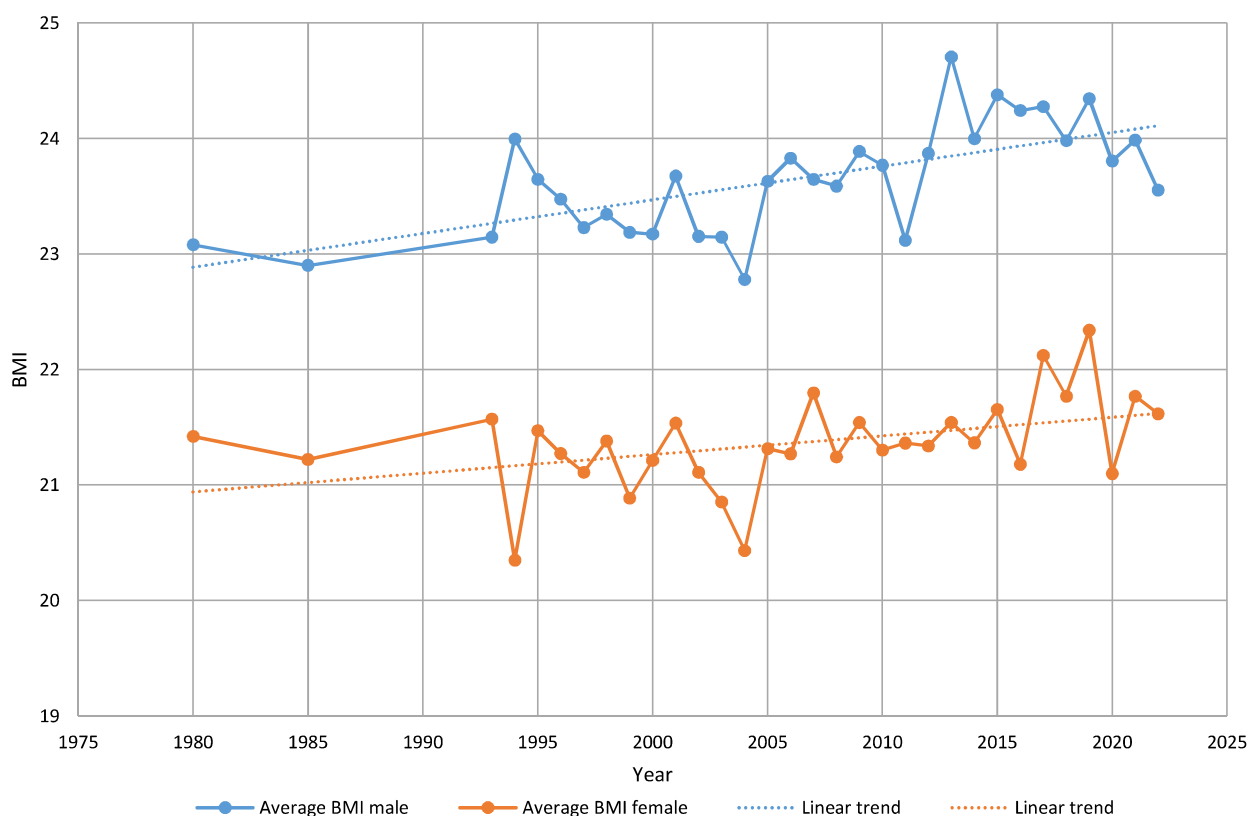
FIGURE 3: Development of the average BMI for the male and female population in the years 1980–2022.

research with the results of other research is difficult for various reasons, such as different population sample sizes, specific measurement methods, demographic coverage, ethnic mix, or health status of the participants.

Very interesting results regarding secular trends in heights, weights, and BMI in young Romanian students aged 18–24 years were reported by Ioana *et al.* (2014). The authors noted the stagnation of secular growth in men and women in stature height, accompanied by a significant increase in BMI values in accordance with overall European trends. The mentioned increase in BMI is also confirmed by our research.

The authors Lhotská *et al.* (1991) state a continuing secular trend in the Czech child population. The authors Podstawski and Żurek (2021) observed a confirmed secular trend at the beginning of the 21st century among Polish university students. The stated secular trend was also confirmed by the study by the authors Kalka *et al.* (2019). Other results were published by the authors Kopecký *et al.* (2016), who

assumes the stagnation of the secular trend within the Czech Republic. Authors Kasović *et al.* (2021) confirmed the secular trend in the Croatian population. The authors Regecová *et al.* compared the anthropometric measurements of the Slovak population with the rest of the world (2018).

There are several possible explanations for the positive secular trend in Slovakia. The current generation is still influenced by the events that have taken place in Slovakia over the past three decades (fundamental change in the political regime, Slovakia's entry into the European Union etc.). The economic prosperity of the population resulting from economic and political changes (purchasing power has more than doubled compared to 1989), the availability and quality of food, adherence to a healthy lifestyle or the availability of vitamins and medicines could also have had an impact. A positive change in the healthcare sector also significantly affects such trends (http://statdat.statistics. sk). Grashuber *et al.* (2016) found in their global reviews that the most important factors influencing the stature height of the human population are the consumption

TABLE 4: Basic descriptive statistics for BMI in male and female population in the years 1980–2022.

Year	Male						Female					
	N–rate	Mean	Median	Modus	Variance	Sx	N–rate	Mean	Median	Modus	Variance	Sx
1980	314	23.1					292	21.4				
1985	305	22.9					358	21.2				
1993	212	23.1	22.9	22.9	8.3	2.9	154	21.6	21.0	Multiple	8.5	2.9
1995	24	23.6	22.9	Multiple	12.7	3.6	59	21.5	21.0	22.7	8.2	2.9
1996	39	23.5	23.0	Multiple	12.1	3.5	96	21.3	21.1	Multiple	6.9	2.6
1997	61	23.2	22.5	Multiple	8.4	2.9	164	21.1	20.7	Multiple	8.0	2.8
1998	161	23.3	22.8	Multiple	12.6	3.5	245	21.4	20.6	19.5	11.5	3.4
1999	45	23.2	23.5	Multiple	8.6	2.9	94	20.9	19.9	18.7	13.1	3.6
2000	58	23.2	22.9	Multiple	8.1	2.8	99	21.2	20.3	Multiple	12.5	3.5
2001	123	23.7	23.2	22.1	9.3	3.1	113	21.5	21.0	17.9	11.8	3.4
2002	142	23.2	22.9	23.7	7.6	2.7	200	21.1	20.8	21.5	7.8	2.8
2003	246	23.1	22.8	24.1	9.8	3.1	312	20.9	20.1	Multiple	8.6	2.9
2004	117	22.8	22.5	Multiple	6.2	2.5	122	20.4	20.0	Multiple	7.5	2.7
2005	134	23.6	23.1	23.1	10.6	3.3	105	21.3	20.6	Multiple	8.5	2.9
2006	118	23.8	23.7	23.9	8.4	2.9	207	21.3	20.8	Multiple	7.9	2.8
2007	111	23.6	23.7	Multiple	9.5	3.1	136	21.8	21.0	Multiple	12.3	3.5
2008	101	23.6	23.4	Multiple	9.7	3.1	142	21.2	20.4	19.6	12.5	3.5
2009	88	23.9	23.3	Multiple	13.3	3.6	175	21.5	20.8	Multiple	13.1	3.6
2010	189	23.8	23.4	Multiple	11.2	3.3	195	21.3	20.6	Multiple	10.4	3.2
2011	210	23.1	22.6	Multiple	12.1	3.5	138	21.4	20.8	19.3	8.9	3.0
2012	102	23.9	23.3	23.7	15.6	4.0	182	21.3	20.4	22.8	11.1	3.3
2013	177	24.7	23.5	29.7	78.5	8.9	256	21.5	21.1	Multiple	10.0	3.2
2014	272	24.0	23.8	22.1	9.6	3.1	317	21.4	20.8	Multiple	8.6	2.9
2015	195	24.4	24.1	24.7	12.6	3.5	245	21.7	21.0	21.3	10.5	3.2
2016	354	24.2	23.9	23.1	11.3	3.4	279	21.2	20.5	Multiple	9.3	3.1
2017	111	24.3	24.0	22.4	12.7	3.6	118	22.1	20.8	20.3	16.9	4.1
2018	359	24.0	23.8	22.3	6.3	2.5	286	21.8	21.2	21.3	6.7	2.6
2019	96	24.3	23.9	Multiple	12.9	3.6	74	22.3	20.9	31.2	18.5	4.3
2020	122	23.8	23.3	Multiple	15.5	3.9	65	21.1	21.1	Multiple	5.5	2.4
2021	266	24.0	23.6	23.7	22.6	4.7	161	21.8	21.0	20.0	12.7	3.6
2022	436	23.6	23.0	22.9	13.8	3.7	244	21.6	21.1	Multiple	10.4	3.2

of protein-rich foods and the Human Development Index (as a measure of society's wealth), which are most strongly associated with tall stature. Both factors increased or improved in Slovakia, especially after the country joined the EU thanks to favourable economic development.

CONCLUSION

When analyzing the dimensional characteristics of the current adult Slovak population, it can be clearly stated that there has been a positive secular trend in recent decades. We assume that this state occurs as

a result of better nutrition, better psycho-social factors, and socio-economic conditions in which today's population grew up. This trend will continue to a lesser extent. Since the values of the quantile characteristics of anthropometric features are used to create ergonomic, hygienic, and design standards and standards in the field of consumer products, it is necessary to re-evaluate the suitability of their current standard dimensions and capacity standards. The secular trend is visible not only in our country but also in the world, it is necessary to revise outdated standards globally. Anthropological and ergonomic requirements are decisive in many ways, especially in connection with things of daily consumption and needs, which mainly include dimensions in the movement industry (cars, trains, planes, elevators), then the clothing and footwear industry, but also the construction industry within the dimensions of entrance openings and height of windows and railings. Another basic human need is housing, as a dynamic process that takes place in the limited space of an apartment. Its most important material component is furniture, which is an integral part of everyday life. Furniture has always belonged and still belongs to a set of things that immediately create favorable conditions for human existence, to facilitate some of his physiological needs, work, and social activities. That is why it is very important for furniture to have the right dimensions, which are based primarily on the relationship with the person and the activities taking place in the apartment and on the dimensions of the objects used in their performance. During production, it is, therefore, necessary for the manufacturer to be informed about problems, interests, and needs to the extent that he knows the connections and interdependence of the action of individual factors (anthropometric, ergonomic, physiological, etc.), which are important and paramount for the production of furniture. Last but not least, it is necessary to pay attention to hand tools, because, at the same time as height increases, other dimensions of the human body also grow proportionally.

In all the mentioned areas, it is, therefore, necessary to take into account the secular trend and deal with the standards that deal with stature height, and body weight limits in the near future.

ACKNOWLEDGEMENTS

REFERENCES

BARROSO M. P., AREZES P. M., COSTA L. G., MIGUEL A. S., 2005: Anthropometric study of Portuguese workers. *International Journal of Industrial Ergonomics* 35: 401–410.

BLÁHA P., a kol., 1980: *Antropometrie Československé populace od 6 do 35 let*. Československá spartakiáda 1980. Praha.

BLÁHA P., a kol., 1986: *Antropometrie Československé populace od 6 do 55 let*. Československá spartakiáda 1985. Praha.

BOLSTAD G., BENUM B., ROKNE A., 2001: Anthropometry of Norwegian light industry and office workers. *Applied Ergonomics* 32: 239–246.

CHUAN T. K., HARTONO M., KUMAR, N., 2010: Anthropometry of the Singaporean and Indonesian populations. *International Journal of Industrial Ergonomics* 40: 757–766.

COLE T. J., 2003: The secular trend in human physical growth: a biological view. *Economics and Human Biology* 161–168.

COLE T. J., 2000: Secular trends in growth. *Proceedings of the Nutrition Society* 59: 317–324.

ČUTA M., URBANOVÁ P., BRUNECKÝ P., DVOULETÁ K., KRÁLÍK M., MOŘKOVSKÝ T. 2019: Body measurements of Czech adult population: A background for seating furniture functional dimension updates. *Anthropologie* 57, 3: 349–361. https://doi.org/10.26720/anthro.19.10.02.1

FUDVOYE J., PARENT A. S., 2017: Secular trends in growth. Klotz Communications 2017: From the shortest to the tallest. *Annales d'Endocrinologie* 78: 88–91.

GRASGRUBER P., SEBERA M., HRAZDÍRA E., CACEK J., KALINA T. 2016: Major correlates of male height: A study of 105 countries. *Econ. Hum. Biol.* 21: 172–195. https://doi.org/10.1016/j.ehb.2016.01.005

IOANA O., LILIANA G. C., COZETA, M., 2014: Secular trend of growth in height, weight and body mass index in young Romanians aged 18–24 years. *Procedia Soc. Behav. Sci.* 117: 622–626. doi: 10.1016/j.sbspro.2014.02.272

JELAČIĆ D., GREGER K., GRLADINOVIĆ T., 2002: Research on anthropometric characteristics of high school students and ergonomic characteristics of high school furniture. *Drvna Industrija* 2, 2: 99–106.

JIRKOVSKÝ D., 2003: Tělesná výška a hmotnost mladých mužů vo věku 18–25 let v druhé polovině 20. století. *Vojenské zdravotnícke listy* 72, 5.

KALKA E., PASTUSZAK A., BUŚKO K., 2019: Secular trends in body height, body weight, BMI and fat percentage in Polish university students in a period of 50 years. *PLoS One.* 14(8):e0220514. doi: 10.1371/journal.pone.0220514

KASOVIĆ M., ŠTEFAN L., PETRIĆ V., 2021: Secular trends in health-related physical fitness among 11-14-year-old

Croatian children and adolescents from 1999 to 2014. *Sci Rep.* 11(1):11039. doi: 10.1038/s41598-021-90745-y

KAYIS B., OZOK A. F., 1991: The anthropometry of Turkish army men. *Appl. Ergon.* 22: 49–54.

KOLENA B., VONDRÁKOVÁ M., 2013: *Nitra-Dražovce. Osteologická analýza jedincov zo stredovekého pohrebiska z okolia kostola sv. Michala Archanjela v Nitre-Dražovciach.* Fakulta prírodných vied UKF v Nitre, Nitra.

KOMLOS J., LAUDERDALE B. E., 2007: The mysterious trend in American heights in the 20th century. *Ann. Hum. Biol.* 34: 206–215.

KOPECKÝ M., KIKALOVÁ K., CHARAMZA J., 2016: The secular trend in body height and weight in the adult population in the Czech Republic. *Cas Lek Cesk.* 155, 7: 357–364. Czech. PMID: 27990830

LEITAO R. B., RODRIGUES L. P., NEVES L., CARVALHO G. S., 2013: Development of adiposity, obesity and age at menarche: An 8-year follow-up study in Portuguese schoolgirls. *Int. J. Adolesc. Med. Health* 25: 55–63.
DOI: 10.1515/ijamh-2013-0007

LHOTSKÁ L., BLÁHA P., VIGNEROVÁ J., ROTH Z., PROKOPEC M., 1994: Vth nation-wide anthropological survey 1991 in the Czech Republic comparison with 1981 data. *Cent Eur J Public Health.* 2, 2: 95–9. PMID: 7697030.

LOESCH D. Z., STOKES K., HUGGINS P. M., 2000: Secular trend in height and weight of Australian children and adolescents. *Am. J. Phys. Antropol.* 111: 545–556.

ŁOPUSZAŃSKA-DAWID M., SZKLARSKA A., 2020: Growth change in Polish women: Reduction of the secular trends? *PLoS One.* 15(11): e0242074.
doi: 10.1371/journal.pone.0242074

MOKDAD M., 2002: Anthropometric study of Algerian farmers. *International Journal of Industrial Ergonomics* 29: 331–341.

PODSTAWSKI R., ŻUREK P., 2021: Secular changes in the anthropometric and motor characteristics of Polish male university students between 2000 and 2018. *Am J Hum Biol.* 33(4): e23520. doi: 10.1002/ajhb.23520

REGECOVÁ V., HAMADE J., JANECHOVÁ H., ŠEVČÍKOVÁ Ľ., 2018: Comparison of Slovak reference values for anthropometric parameters in children and adolescents with international growth standards: implications for the assessment of overweight and obesity. *Croat Med J.* 59(6): 313–326. doi: 10.3325/cmj.2018.59.313

SCHMIDT I. M., JORGENSEN M. H., MICHAELSEN K. F., 1995: Height of concscripts in europe: Is postneonatal mortality a predictor? *Ann. Hum. Biol.* 22: 57–67.

Statistical Office of the Slovak Republic. Average monthly wages in economy of the SR. Available online: http://statdat.statistics.sk.

StatSoft Inc (2010). Electronic statistics textbook. Tulsa, OK, USA. [online] URL: http://www.statsoft.com/textbook/

TANNER J. M., 1992: Growth as a measure of the nutritional and hygienic status of a population. *Hormone Research* 38, Suppl. 1: 106–115.

VIGNEROVÁ J., BRABEC M., BLÁHA P., 2006: Two centuries of growth among Czech children and youth. *Economics and Human Biology* 4: 237–252.

VONDRÁKOVÁ M., MATEJOVIČOVÁ B., KOLENA B., 2022: *Veľký Meder (Čalovo): Antropologický rozbor pohrebiska z obdobia avarského kaganátu.* UKF, Nitra.

Miloš Hitka
Department of Economics
Management and Business
Faculty of Wood Sciences and Technology
Technical University in Zvolen
T. G. Masaryka 24, 96001 Zvolen, Slovakia
E-mail: hitka@tuzvo.sk

Miloš Gejdoš*
Department of Forest Harvesting Logistics and Ameliorations
Faculty of Forestry
Technical University in Zvolen
T.G. Masaryka 24, 960 01 Zvolen, Slovakia
E-mail: gejdos@tuzvo.sk

*Corresponding author.