

RESEARCH ARTICLE

# The effect of different socio-economic and working conditions on body size and proportions: A case study on adults from Samsun, Turkey

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## Abstract

Conditions in the early stages of life shape body size and proportions. This study includes individuals who came from different socio-economic conditions and worked in physically demanding jobs in childhood. By determining the body sizes of these individuals and evaluating the proportional relationships between several groups, the goal was to understand the effect levels of socio-economic levels and working conditions on the body. For this purpose, an anthropometric study was conducted on 623 males and females between the ages of 20 and 45 living in Samsun, Turkey. The study sample consisted of four different groups. It was divided into two main groups of high and low socio-economic level, and the low socio-economic group was divided into two sub-groups of heavy-worker and nonheavy-worker. The results demonstrated that socio-economic differences in the size and proportions of the individuals were statistically significant ( $p < 0.05$ ). The high socio-economic group had the highest values in all measures. External factors affected the lower limbs more than the upper limbs. The measurement most affected by these factors was leg length. Longer legs characterized the high socio-economic group, while longer arms characterized both low socio-economic groups. The relative differences observed can be said to derive from the distal limbs. This finding was valid for both sexes. The average values were close to each other in the low socio-economic group, for which the aim was to comprehend the effects of heavy working conditions. However, differences in proportional relationships were more significant. In this context, it was seen that heavy labour also affected growth, in addition to the well-known factors encountered during the growth period, such as nutrition, health, and illness. The observed changes were more significant in males than in females. Thus, it can be said that males were more affected by physiological and physical conditions.

**Keywords:** Socio-economic differences; heavy working conditions; body sizes; body proportions; sex differences

## Introduction

Conditions of life during the growth period shape body dimensions, especially height (Lasker and Mascie Taylor, 1989; Mascie-Taylor, 1991; Peck and Lundberg, 1995; Steckel, 1995; Cole, 2003; Eiben and Mascie-Taylor, 2004). Studies on modern societies have demonstrated that many factors such as parental education level, welfare level, industrialization, heavy work, hygiene conditions, nutrition, and diseases during growth affect the formation of body dimensions (Hauspie et al., 1997; Lindgren, 1998; Eveleth, 2001; Cole, 2003; Koca Özer, 2008; Steckel, 1995, 2012). Research has shown that members of high socio-

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economic groups (i.e., advantaged groups) have larger body dimensions, while those from disadvantaged groups have smaller ones (Susanne, 1979; Duyar, 1990; Howe et al., 2012; Towne et al., 2012; Mumm et al., 2016; Hancock et al., 2016; Mumm et al., 2017; McCrory et al., 2017).

A change in the socio-economic conditions of a population significantly affects body proportions and height (Kryst et al., 2019). In addition, alterations can be observed in the relations of dimensions such as the forearm, leg, thigh length, and body height to each other (Dempster et al., 1964). Recent studies have shown that leg length, one of the components of height, is sensitive to growth conditions and reflects the stresses experienced in childhood (Gunnell et al., 1998; Li et al., 2007; Frisncho, 2007; Webb et al., 2008; Stinson, 2009; Patel et al., 2011; Godina et al., 2016). The upper and lower parts of the body exhibit different growth patterns depending on variation in growth rate in humans (Dangour et al., 2002). The growth rates of sitting height and total lower leg length do not change in the same way over time; instead, while the speed of the growth of the total lower leg length increases, that of the sitting height slows down (Duyar, 1997a). Many studies have stated that the lower part of the body (total lower leg length) has more significant plasticity during growth than the upper part (sitting height) (Johnston, 1998; Dangour et al., 2002; Živičnjak et al., 2003; Webb et al., 2008; Pomeroy et al., 2012). Besides the trunk-leg parts, distal limbs segments seem to show more variability than proximal limbs (Holliday and Ruff, 2001; Auerbach and Sylvester, 2011; Koziel et al., 2016; Koziel et al., 2019; Kryst et al., 2019).

The plasticity observed in body size and proportions is thought to be related to socio-economic level, nutrition, and diseases, as well as to different physical stresses encountered during the growth period. In this regard, studies on child workers in underdeveloped or developing countries, including Turkey, have provided important information on how the morphological structure of the human body is affected by physical stress (Raina et al., 1990; Ambadekar et al., 1999; Hawamdeh et al., 2001; Duyar and Özener, 2003; 2005; Omokhodion and Omokhodion, 2004; Pasdard et al., 2014; Rahman et al., 2014; Demir, 2018).

The most important results were obtained by Duyar and Özener (2003) from studies on child workers. According to them, children doing heavy work fell behind non-working children in growth in height but were ahead in growth in width. They had relatively long bodies and arms, but their legs were short. It is not clear whether this pattern carried over into adulthood because the adaptive biological system of 'catch-up growth' can partially or completely remove the effects of deficiencies in growth at other periods (Steckel, 2016). For this reason, it is important to determine how physical stress shapes the final size and proportions in human growth, which is affected by so many factors.

Studies dealing with how the human body is affected by environmental stresses are generally carried out on individuals in childhood. There have been relatively few studies carried out on adults concerning how physical and physiological stresses are reflected in final dimensions and body proportions (Cortez et al., 2007; Dantas and Santana, 2010), and this issue has not yet been discussed enough.

The aim of this study was to analyse the dimensions and proportions reached in adulthood by individuals who are exposed to different levels of environmental stress (nutrition, labour, health, etc.) from early life and ones living under optimal conditions. In addition, the aim was to investigate how individuals from different socio-economic structures, their sizes, and the proportions of related parts of the body are affected by this structure, and how excessive physical stress in childhood is reflected in the final dimensions in groups having similar socio-economic statuses.

## Methods

### *Why was Samsun chosen for the study?*

According to World Bank data, Turkey is a country that has risen to the level of upper middle income. However, the economic disruptions after the 2000s pose a risk to this rise (World Bank, 2021). As a matter of fact, despite the advancement of regional development over the years,

economic and social development is still not evenly distributed throughout the country, and this has led to inequalities and distinctions between regions and income groups (Turkey State Planning Organization (DPT), 2003; Selim et al., 2014). The data of the last ten years indicates that Turkey has greater inequality than many Organisations for Economic Cooperation and Development (OECD) countries with its Gini coefficient (OECD, 2015).

According to 2020 data, the gross national product (GNP) per capita in Turkey is 8.636 United States dollar (USD) from a total GNP of 720.1 billion USD (World Bank, 2021). The poverty threshold in the country is ~842 USD (Türkiye İşçi Sendikaları Konfederasyonu (TÜRK-İŞ), 2021), and 14.4% of the population of 83,154,997 people live in relative poverty in 2019 (Turkish Statistical Institute (TURKSTAT), 2020). This income-based inequality also deepens social inequality (Candaş et al., 2010). Such inequality has significantly triggered growth in child labour in the country. The biggest factor forcing children to work is the lack of income in the household, or in other words, poverty (TURKSTAT and International Labour Organization, (ILO), 1999; Candaş et al., 2010; TURKSTAT, 2012). Moreover, although Turkey is among the developing countries, it is a country where physical work begins in childhood (ILO, 2020). Reports on children working in different periods have been published, showing the rate of child labour to be 4.4% of 12 million children aged 6-14 in 1999, and 5.9% of 15 million children aged 6-17 in 2012 (TURKSTAT and ILO, 1999; TURKSTAT, 2012). These percentages show that society consists of different groups throughout the country and that these groups can still be determined in terms of similar characteristics. For this reason, it was thought that this economic and social structure of Turkey would help to find answers to the main objectives of the study.

Samsun is located in the Black Sea Region and has a population of 1,335,700. It ranks 16<sup>th</sup> among the provinces of Turkey in terms of population (Middle Black Sea Development Agency (OKA), 2019). In terms of socio-economic development, it is ranked in the third of six levels, and 31<sup>st</sup> among the 81 provinces in Turkey (Acar et al., 2019). Samsun has these characteristics, with agricultural potential and seven organized industrial zones. According to 2017 data, 12.45% of its economic activities consist of agriculture, 24.22% of industry, and 63.33% of the service sector. While agricultural activities have been declining recently, the industrial area, which is developing, is at the forefront in the region with medical device production, food, metal industry, and furniture sectors (OKA, 2019). Also, 2015 data showed that Samsun is among the first 30 of the 81 provinces in terms of health, education, civic participation, and social life, and is prominent in the region with its specialization and quality in health services (OKA, 2019).

The demographic transformation process that Turkey is undergoing is heterogeneous in all settlements and regions (Koç et al., 2008). Undoubtedly, one of the biggest reasons for this is immigration. There has been intense internal migration from rural to urban areas in Turkey since the 1950s, and external migration to western countries to meet the need for a foreign workforce since the 1960s (Hacettepe University Institute of Population Studies 2014). The main reason for this observed internal migration is economic. The economic transformation observed in the country has changed the structure of urban settlements, and the population has increased to meet the need for labour in these areas (Koç et al., 2008). Especially in the 2000s, the rate of urbanization gained momentum (Hacettepe University Institute of Population Studies, 2014). This study could have been carried out in cities such as Istanbul, Kocaeli, Ankara, or Bursa, where there is a lot of heavy industry, and child labour is commoner. However, these cities receive intense immigration from regions of Anatolia that vary in terms of different ecological and ethnic groups (TURKSTAT, 2020).

Cities like Samsun, on the other hand, contain more homogeneous populations in terms of demographic pattern compared to megacities such as İstanbul, Ankara, and İzmir. The population in Samsun has been spatially clustered in provincial and district centres since the 2000s. Although migration is lower for Samsun than for other provinces in the region, people have migrated towards provinces with more opportunities for business, education, and social life. Thus, Samsun is a province that sends out migrants rather than receiving them, and overall migration has been outward (OKA, 2015). On the other hand, the general population structure consists

mostly of individuals registered in Samsun and surrounding provinces (mostly Ordu, Trabzon, Amasya, Rize, and Giresun) (TURKSTAT, 2017). The sample of this study also supports demographic records. The birthplace of the sample group was mostly Samsun.

Considering that genetic structure has as much effect as environmental factors on growth and height, the structure of the sample suggested that the social, economic, and labour effects on the human body could be revealed more clearly by relatively avoiding genetic and ecological factors. For this reason, Samsun seemed suitable for the groups that were the target of this study, because of both its socio-economic structure and its population structure.

The sample group consisted of female and male individuals between the ages of 20 and 45 who lived in Samsun, belonged to various socio-economic structures, and grew up under heavy-working conditions. The field survey was carried out cross-sectionally on 623 individuals, comprising 304 females and 319 males, between September 2018 and July 2019.

### ***Information on Socio-economic Level and Business Line***

However clear social level divisions may be in a country, there are gaps in knowledge concerning the main dynamics of this division. The shortage of comprehensive studies on understanding Turkey's socio-economic structure and its change causes restrictions in performing studies (Kalaycıoğlu et al., 2008). This makes a retrospective determination of socio-economic level difficult. A retrospective socio-economic condition questionnaire was applied to the individuals to obtain information about their growth conditions in the adulthood stage. This questionnaire was prepared from the Socio-economic Status Index developed by Veri A.Ş. and mentioned in a study published by Kalaycıoğlu et al. (1998) and was adapted for this research. The reliability of this questionnaire has been tested by in-depth interview, and it has been found that it can be used with the Turkish population. The questionnaire covers the variables of mean parental profession, mean parental education level, appliances in the house, and home ownership. Each variable has one point, and the points of the variables form the total score. The higher and lower strata are determined by the calculated total score. Individuals in the socio-economic strata so determined were at the same time asked about their current occupation and their educational and income levels. In this way, information was obtained on their socio-economic status both during the growth period and in adulthood. Another variable researched in this study was heavy working conditions in childhood. Duyar (2013), in studies on child workers, called attention to various methodological deficiencies in 'workforce' studies, and said that the type of work and working conditions of individuals should be determined as being 'heavy' or 'light'. In these studies, individuals are determined as 'working' or 'not working' according to their current situation. However, this evaluation is wrong, because individuals' working situation and length of time working do not allow a complete evaluation in current situations. In addition, studies conducted on this problem in the local and international literature are limited, which restricts evaluation of the results of data analysis. This makes the formation of a control group more important (Duyar, 2013). The sample was first divided into two different groups for the questionnaire: a high socio-economic group (n:202) (HSG) and a low socio-economic group (LSG). To understand the effects of physical stresses, the low socio-economic group was then divided into two subgroups: nonheavy workers (NHWG) (n:210) and heavy workers (HWG) (n:211) during the growth period. With this grouping, the high socio-economic group formed the control group.

In Turkey, a developing country, socio-economic levels vary in terms of gross domestic product (GDP) and GDP per capita. According to World Bank data, per capita national income in Turkey for the age range of the sample (year of birth 1973-1999) was largely stable at 1952 USD. There was a large increase in national income in 2004 and afterwards (World Bank, 2021). Despite this stability and change, income inequality in the country has always been widespread. The income imbalance causes those who are well off to become richer, and the poor to become poorer (Erdoğan, 2004).

Table 1 summarizes the data on the families in the sample and their socio-economic structure. Table 1 shows that for both sexes, the socioeconomic conditions of the families are distinguished in both socio-economic sub-groups - from HSG ( $p < 0.05$ ). There is no difference between the NHWG and the HWG in terms of socio-economic characteristics ( $p > 0.05$ ). On the other hand, when socio-economic characteristics are compared between generations, it is seen that individuals' occupation distributions are similar to those of their parents, particularly the father ( $p > 0.05$ ). Education level is slightly higher in the HWG ( $p < 0.05$ ), but it is still at a low level. This observed increase is a reflection of the 'continuous education' policies in the country.

At the time when the study was conducted, the minimum wage in Turkey was less than 400 USD. The income levels of individuals in both LSGs was low (Table 1). Moreover, there is a strong correlation in Turkey between education level and poverty. According to data for 2006, 84% of poor people were either illiterate or had not completed basic education (Aran et al., 2010). This shows that there is always a socio-economic separation between HSGs and LSGs. At the same time, this data shows that in both LSGs, socio-economic characteristics and the factors pushing individuals into working at an early age have hardly changed, and that they continue in to be poor. All groups were asked about their work status as children. There was no one in the high socio-economic group who had worked in childhood, but in the low socio-economic group manual work such as furniture business, automobile industry etc. was accepted as hard physical work (Kalaycıoğlu et al., 2008), and so the heavy working group was included in the low socio-economic group. The occupation distribution of the HWG is shown in Table 2. Furniture making (42.3%) and the auto industry (29.7%) were the highest in males, while agriculture-livestock raising and fishing (90%) were the highest in females. The high frequency of the agricultural sector in females is because agricultural employment is a determining sector for females from childhood to old age in this country (TURKSTAT, 2012; T.C. Aile ve Sosyal Politikalar Bakanlığı, 2014). In the HWG, agriculture was predominant for women and the industrial sector for men. These two sectors play an important role in child employment, and the working conditions are very harsh. In agriculture, children are employed for very low or no pay as family workers. Girls are more often employed without pay than boys (TURKSAT and ILO, 1999). Children working in this sector are exposed to climatic events and biological and chemical substances and have to lift and carry heavy loads. In the industrial sector, children mostly work in small businesses and workshops, and are exposed to ergonomic risks, chemicals, and poor physical and hygienic conditions (Duyar, 2017). In addition to this, the time spent working and the starting age also affect growth.

Individuals in the HWG were asked about the age at which they started working and their daily working hours (Table 3). In Turkey, the age range of child workers is from 6 to 17 (TURKSTAT and ILO, 1999; TURKSTAT, 2012). In the HWG, the age of starting work was 12.08 in women and 13.14 in men. With regard to working hours, the number of working hours per week is 47.7 hours. For child workers, working hours in the countryside were longer than in the cities, and shorter for girls than for boys (TURKSTAT and ILO, 1999). In the HWG, daily working hours were 9.38 for women and 10.57 for men. This means an average of 59.85 hours in a six-day working week.

### **Anthropometric Measurements**

A total of eight measurements of height, total lower leg length (iliospinal height), sitting height, total arm length, upper arm length, forearm length, upper leg length, tibia length were made in millimetres with a Martin-Type Anthropometer following the techniques prescribed by the Anthropometric Standardization Reference Manual (Lohman et al., 1988) and the International Biological Program (Weiner and Lourie, 1981). As suggested, measurements were taken from the left side, and it was ensured that individuals had minimum clothing. Repeated measurements were taken in a total of 20 individuals to test the reliability of the measurements and no statistically significant difference was found ( $p > 0.05$ ).

**Table 1.** The Distribution of the Sample's Own and Their Families' Socio-economic Characteristics in Different Socio-economic Groups

	Female			Male		
	HSG	NWHG	HWG	HSG	NWHG	HWG
	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
<b>Mother's Education Level</b>						
Basic literacy	-	49(47.6)	42(42.0)	-	34(31.8)	44(39.6)
Primary/Secondary S.	25(24.8)	52(50.5)	58(58.0)	17(16.8)	71(66.4)	67(60.4)
High School	34(33.7)	2(1.9)	-	41(40.6)	2(1.9)	-
University	42(41.6)	-	-	43(42.6)	-	-
<b>Father's Education Level</b>						
Basic literacy	-	24(23.3)	23(23.0)	-	13(12.1)	25(22.5)
Primary/Secondary S.	19(18.8)	77(74.7)	76(76.0)	10(9.9)	86(80.3)	83(74.8)
High School	26(25.7)	2(1.9)	1(1.0)	31(30.7)	7(6.5)	3(2.7)
University	56(55.4)	-	-	60(59.4)	1(0.9)	-
<b>Mother's Occupation</b>						
Manual Worker	-	5(4.9)	15(15.0)	5(5.0)	9(8.4)	13(11.7)
Non-manual Worker	64(63.4)	-	-	62(61.4)	1(0.9)	1(0.9)
Unemployed/Housewife/ Unpaid Family Worker	37(36.6)	98(95.1)	85(85.0)	34(33.7)	97(90.7)	97(87.4)
<b>Father's Occupation</b>						
Manual Worker	2(2.0)	87(84.5)	98(98.0)	3(3.0)	89(83.2)	97(87.4)
Non-manual Worker	99(98.0)	8(7.8)	2(2.0)	98(97.0)	15(14.0)	12(10.8)
Unemployed/ Housewife/ Unpaid Family Workers	-	8(7.8)	-	-	3(2.8)	2(1.8)
<b>Education Level</b>						
Basic literacy	-	2(1.9)	3(3.0)	-	-	1(0.9)
Primary/Secondary S.	-	62(60.2)	83(83.0)	-	60(56.1)	96(86.5)
High School	5(5.0)	21(20.4)	12(12.0)	19(1.8)	31(29.0)	13(11.7)
University	96(94.2)	18(17.5)	2(2.0)	82(81.2)	16(15.0)	-
<b>Occupation</b>						
Manual Worker	5 (5.0)	62(60.2)	27(27.0)	4(4.0)	84(78.9)	103(92.8)
Non-manual Worker	77 (76.2)	15(14.6)	3(3.0)	91(91.1)	22(20.6)	8(7.2)
Unemployed/ Housewife/ Unpaid Family Workers	19(18.8)	26(25.2)	70(70.0)	5(5.0)	1(0.9)	-
<b>Income</b>						
0-400 USD	22 (21.8)	84(35.6)	97(97.0)	18(17.8)	45(42.0)	66(60.5)
400 USD <	79(78.2)	19(18.4)	3(3.0)	83(82.2)	62(57.9)	45(40.5)

**1-**Mother's and father's educational and professional groups were compared pairwise between groups with the Kruskal-Wallis test HSG-NHWG= $p < 0.05$ ; HSG-HWG= $p < 0.05$ ; NHWG-HWG= $p > 0.05$ . **2-**Individuals' own education levels, professions and income levels were compared pairwise between groups with the Kruskal-Wallis test HSG-NHWG= $p < 0.05$ ; HSG-HWG= $p < 0.05$ ; NHWG-HWG= $p < 0.05$ . **3-**The groups' parents' and their own education and professions were compared with the chi-square test HSG-NHWG= $p > 0.05$ ; HSG-HWG= $p > 0.05$ ; NHWG-HWG= $p > 0.05$ .

**Table 2.** Occupation Distribution of Females and Males in the Low Socio-Economic Heavy-Worker Group

Sector	Female	Male
	n (%)	n (%)
<b>Furniture business</b>	–	47(42.3)
<b>Automobile Industry</b>	–	33(29.7)
<b>Transportation</b>	–	10(9.1)
<b>Service Industry</b>	4(4)	8(7.2)
<b>Building and Construction</b>	–	8(7.2)
<b>Metal Work</b>	–	2(1.8)
<b>Agriculture, Stock-Raising, and Fishing</b>	90(90)	2(1.8)
<b>Textile Industry</b>	6(6)	1(0.9)
<b>Total</b>	100(100)	111(100)

**Table 3.** Mean and Standard Deviation Values of Age at First Work, Working Hours per Day, and Worked Years

	Female			Male		
	Min-Max.	Mean	SD	Min-Max.	Mean	SD
<b>Age at First Work</b>	9-16	12.08	1.50	9-17	13.14	1.68
<b>Working Hours per Day</b>	8-12	9.83	0.60	6-14	10.57	1.35
<b>Worked Years</b>	8-35	23.69	7.84	6-35	22.24	6.99

### Statistical Analysis

The collected data was transferred to the computer and analysed with the SPSS (21.00) package program. Socioeconomic variables were analysed pairwise with the Kruskal-Wallis test and the Chi-square test. The data from three different socio-economic groups was tested with the Kolmogorov-Smirnov Test regardless of sex and it was found that the sample showed a normal distribution ( $p > 0.05$ ). Homogeneity of Variance was tested for all measures in males and females, and it was determined that variances were homogeneous (Levene's Test  $p > 0.05$ ). Therefore, in the analysis of data, descriptive statistics, One Way Variance Analysis (ANOVA) and the Tukey test were used to determine inter-group differences. The error level was taken as 0.05.

Sitting height ratio (SHR) (Bogin, 2021), intermembral index, relative tibia length, relative thigh length, relative arm length, relative forearm length, brachial index, and crural index were calculated in order to determine body proportions (Oliver, 1969) (Table 4).

## Results

### Socio-economic Differences in Anthropometric Measurements

In anthropometric measurement means, except for sitting height in males, the HSG had the highest values. Table 5 shows anthropometric measurement means in all socio-economic groups. In body height, HSG was 40 mm taller in females and 52 mm in males than both LSG (NHWG-HWG). This result was statistically significant ( $p < 0.001$ ). In females, the differences were clear in both parts of the body, and values fell in both LSG. In total lower leg length, the difference between HSG and both LSG was significant (HSG-NHWG:  $p < 0.001$ , HSG-HWG:

**Table 4.** Formulas Used in the Research

Formulas	
<b>The Proportions of the Body Parts</b>	Sitting Height Ratio = $[\text{Sitting Height}/\text{Height}] \times 100^{\text{§}}$
	Intermembral Index = $[\text{Total Arm Length}/\text{Total Lower Leg Length}] \times 100$
<b>Body Limb Ratios</b>	Relative Tibia Length = $[\text{Tibia Length}/\text{Height}] \times 100$
	Relative Thigh Length = $[\text{Thigh Length}/\text{Height}] \times 100$
	Relative Arm Length = $[\text{Arm Length}/\text{Height}] \times 100$
	Relative Forearm Length = $[\text{Forearm Length}/\text{Height}] \times 100$
	Brachial Index= $[\text{Forearm Length}/\text{Arm Length}] \times 100$
	Crural Index = $[\text{Tibia Length}/\text{Thigh Length}] \times 100$

<sup>§</sup>Bogin, 2021; Oliver, 1969

**Table 5.** Mean and Standard Deviation Values of Anthropometric Measurements of Female and Male Individuals from Different Socio-Economic Groups

Measurements	Female						Male					
	HSG (n:101)		NHWG (n:103)		HWG (n:100)		HSG (n:101)		NHWG (n:103)		HWG (n:100)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
<b>Height</b>	1591.50	61.01	1561.60	55.20	1542.90	62.52	1739.80	77.23	1700.00	69.96	1675.10	77.83
<b>Sitting Height</b>	836.90	41.77	832.60	33.87	824.60	41.97	900.10	49.72	900.30	41.58	879.80	64.34
<b>Total Lower Leg L.</b>	886.70	54.31	845.40	40.56	828.80	50.70	942.30	62.78	896.10	61.00	882.25	66.26
<b>Thigh L.</b>	483.00	38.27	474.30	40.09	475.40	33.03	523.90	42.50	499.30	45.52	490.00	45.17
<b>Tibia L.</b>	309.00	21.07	297.60	17.83	298.30	20.38	350.80	25.46	327.70	25.14	326.50	27.15
<b>Total Arm L.</b>	686.40	35.51	668.90	36.14	667.73	38.39	768.10	40.18	726.50	37.96	720.60	43.13
<b>Upper Arm L.</b>	284.09	24.54	273.78	23.49	278.87	25.33	324.40	24.16	297.37	24.67	293.45	25.37
<b>Forearm L.</b>	204.46	17.53	200.56	18.13	203.82	19.48	232.90	17.06	217.80	16.32	218.69	20.79

L.: Length **HSG:** High Socio-Economic Group **NHWG:** Low Socio-Economic Nonheavy-Worker Group **HWG:** Low Socio-Economic Heavy-Worker Group

$p < 0.001$ ) (Table 6). In males, the difference between HSG and LSG in both sitting height (HSG-NHWG:  $p < 0.001$ , HSG-HWG:  $p < 0.001$ ) and total lower leg length (HSG-NHWG:  $p < 0.001$ , HSG-HWG:  $p < 0.001$ ) was statistically significant (Table 6). In body limbs, differences between HSG and the LSG were statistically significant in tibia length (HSG-NHWG:  $p < 0.001$ , HSG-HWG:  $p < 0.001$ ), total arm length (HSG-NHWG:  $p < 0.001$ , HSG-HWG:  $p < 0.001$ ) and upper arm length (HSG-NHWG:  $p < 0.01$ , HSG-HWG:  $p < 0.01$ ) in females, and in all body limbs in males (HSG-NHWG:  $p < 0.001$ , HSG-HWG:  $p < 0.001$ ).

**Socio-economic Differences in Proportional Values**

The differences observed between HSG and both LSG were not at the same level for the different body parts. Table 7 gives the estimated proportional values of anthropometric measurements. According to this table, the SHR value was one percentage point higher in both sexes in the LSG. This result was statistically significant both in females (HSG-NHWG:  $p < 0.05$ , HSG-HWG:

**Table 6.** ANOVA and Tukey Test Results of Anthropometric Measures of Female and Male Individuals from Different Socio-Economic Groups

Measurements	Female					Male				
	F	p-value	P <sub>a-b</sub>	P <sub>a-c</sub>	P <sub>b-c</sub>	F	p-value	P <sub>a-b</sub>	P <sub>a-c</sub>	P <sub>b-c</sub>
<b>Height</b>	16.99	<0.001	<0.01	<0.001	NS	19.82	<0.001	<0.001	<0.001	<0.05
<b>Sitting Height</b>	2.53	NS	NS	NS	NS	8.47	<0.001	NS	<0.001	<0.01
<b>Total Lower Leg L.</b>	37.60	<0.001	<0.001	<0.001	<0.05	27.31	<0.001	<0.001	<0.001	NS
<b>Thigh L.</b>	1.62	NS	NS	NS	NS	16.21	<0.001	<0.001	<0.001	NS
<b>Tibia L.</b>	10.53	<0.001	<0.001	<0.001	NS	28.78	<0.001	<0.001	<0.001	NS
<b>Total Arm L.</b>	8.22	<0.001	<0.01	<0.01	NS	42.14	<0.001	<0.001	<0.001	NS
<b>Upper Arm L.</b>	5.13	<0.05	<0.05	NS	NS	40.75	<0.001	<0.001	<0.001	NS
<b>Forearm L.</b>	1.10	NS	NS	NS	NS	21.35	<0.001	<0.001	<0.001	NS

**NS:** Not Significant **L.:** Length **a:** High Socio-Economic Group **b:** Low Socio-Economic Nonheavy-Worker Group **c:** Low Socio-Economic Heavy-Worker Group

**Table 7.** Mean and Standard Deviation Values of Calculated Body Ratios of Female and Male Individuals from Different Socio-Economic Groups

Ratios	Female						Male					
	HSG (n:101)		NHWG (n:103)		HWG (n:100)		HSG (n:101)		NHWG (n:103)		HWG (n:100)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
<b>SHR</b>	52.6	.021	53.3	.018	53.4	.022	51.7	.023	52.9	.019	52.6	.019
<b>Intermembral Index</b>	77.5	.047	79.1	.037	80.6	.043	81.7	.049	81.3	.059	82.2	.061
<b>Relative Tibia L.</b>	19.4	.009	19.0	.010	19.3	.011	20.1	.009	19.2	.011	19.4	.011
<b>Relative Thigh L.</b>	30.3	.021	30.3	.018	30.8	.018	30.1	.022	29.3	.022	29.2	.024
<b>Relative Forearm L.</b>	12.8	.007	12.8	.008	13.2	.010	13.3	.008	12.8	.009	13.0	.008
<b>Relative Arm L.</b>	17.8	.013	17.5	.013	18.0	.016	18.6	.012	17.5	.011	17.5	.012
<b>Brachial Index</b>	72.1	.004	73.5	.056	73.3	.056	71.9	.041	73.2	.050	74.7	.050
<b>Crural Index</b>	64.1	.052	63.0	.049	62.9	.051	67.2	.062	65.9	.049	66.9	.063

**SHR:** Sitting Height Ratio **L.:** Length **a:** High Socio-Economic Group, **b:** Low Socio-Economic Nonheavy-Worker Group **c:** Low Socio-Economic Heavy-Worker Group

Sitting Height Ratio = [Sitting Height /Height]x100, Intermembral Index=[Total Arm Length/Total Lower Leg Length]x100, Relative Tibia Length = [Tibia Length /Height] x 100, Relative Thigh Length=[Thigh Length/Height]x100, Relative Forearm Length = [Forearm Length/Height] x 100, Relative Arm Length = [Arm Length/Height] x 100, Brachial Index= [Forearm Length/Arm Length] x 100, Crural Index = [Tibia Length/ Thigh Length] x 100.

p<0.05) and in males (HSG-NHWG:p<0.001, HSG-HWG:p<0.05). Intermembral index HSG was two percentage points longer than both LSG in females, and the differences were statistically significant (HSG-NHWG:p<0.05, HSG-HWG:p<0.001) (Table 8). According to this, upper body and limbs were longer in LSG. In addition, relative arm length values in males were statistically significant (HSG-NHWG:p<0.001, HSG-HWG:p<0.001). Regarding the lower limbs in males, relative tibia and thigh length was one percentage point lower in the LSG, and the difference between these groups was statistically significant (HSG-NHWG:p<0.001, HSG-HWG:p<0.001 and HSG-NHWG:p<0.05, HSG-HWG: p<0.05) (Table 8).

**Table 8.** ANOVA and Tukey Test Results of Body Ratios of Female and Male Individuals from Different Socio-Economic Groups

Ratios	Female					Male				
	F	p-value	P <sub>a-b</sub>	P <sub>a-c</sub>	P <sub>b-c</sub>	F	p-value	P <sub>a-b</sub>	P <sub>a-c</sub>	P <sub>b-c</sub>
<b>SHR</b>	5.06	<0.01	<0.05	<0.05	NS	8.99	<0.001	<0.001	<0.05	NS
<b>Intermembral Index</b>	13.14	<0.001	<0.05	<0.001	<0.05	0.64	NS	NS	NS	NS
<b>Relative Tibia L.</b>	3.28	<0.05	<0.05	NS	NS	17.99	<0.001	<0.001	<0.001	NS
<b>Relative Thigh L.</b>	1.52	NS	NS	NS	NS	4.34	<0.05	<0.05	<0.05	NS
<b>Relative Forearm L.</b>	5.59	<0.05	NS	<0.05	<0.05	29.91	<0.001	<0.001	NS	NS
<b>Relative Arm L.</b>	3.80	<0.05	NS	NS	<0.05	11.35	<0.001	<0.001	<0.001	NS
<b>Brachial Index</b>	1.84	NS	NS	NS	NS	9.13	<0.001	NS	<0.05	NS
<b>Crural Index</b>	1.64	NS	NS	NS	NS	1.60	NS	NS	NS	NS

**NS:** Not Significant **L.:** Length **a:** High Socio-Economic Group **b:** Low Socio-Economic Nonheavy-Worker Group **c:** Low Socio-Economic Heavy-Worker Group

Table 7 also gives the values of limbs relative to each other. In the upper limbs, according to the brachial index, HSG was one percentage point lower in females, and in males it was two percentage points lower than LSG. In the lower limbs, in the crural index, HSG was one percentage point higher than LSG in females, and two percentage points higher in males'. However, no significant differences were found in this value between the groups in either sex (Table 8).

### **The Effect of Heavy Working Conditions on the Body in Both Sexes**

Table 5 shows that the HSG individuals had greater values for measures of body parts and limbs. Differences between HSG and HWG were highest between the three groups. In both subgroups, nonheavy-working individuals of both sexes had greater height, total lower leg length, sitting height, and total arm length compared to heavy-working individuals (Table 5). In the LSG, the difference between heavy-working and nonheavy-working individuals was statistically significant in total lower leg length ( $p < 0.001$ ) in females, and in height ( $p < 0.001$ ) and sitting height ( $p < 0.01$ ) in males ( $p < 0.05$ ) (Table 6). Heavy working conditions affected height by -19 mm in females and by -25 mm in males. Also, it caused total lower leg length to be 16.6 mm less females and sitting height to be 20.5 mm less in males (Table 5). For body limbs, the difference in the lengths of the upper leg, tibia, upper arm, and forearm in females and the length of the forearm in males was lower, but this was not statistically significant ( $p > 0.05$ ) (Table 6).

Table 7 shows that the intermembral index was 1.5 percentage points greater in heavy-working females and 0.9 percentage points greater in heavy-working males (Table 7). According to Table 6, it was statistically significant in females ( $p < 0.05$ ) (Table 8). In females, relative forearm length and relative arm length were approximately one percentage point greater, and this was statistically significant ( $p < 0.05$ ;  $p < 0.05$ ) (Table 8).

## **Discussion**

### **Socio-economic Differences**

Children from different socio-economic strata have different body sizes at all ages, and the high socio-economic group shows greater values (Tanner, 1988; Lasker and Mascie-Taylor, 1989; Stinson, 2012). In support of other studies, it was found in this study that anthropometric dimensions differed from each other in females and males growing up in different socio-economic

conditions, and that the HSG had greater values in all measures. Studies conducted on childhood growth have confirmed that the children of families from high social classes are taller (Tanner, 1981; Peck and Lundberg, 1995; Mascie-Taylor, 1991; Koziel et al., 2019). According to Kuh et al. (1991), of those whose father was a qualified worker, unqualified female adults were 1.61cm taller and adult males were 1.97cm taller. Similarly in Switzerland, adults with unqualified worker children were shorter, and adults with children with a seniority salary were taller (Peck and Vågerö, 1987). There was also a height difference in this sample of adults who grew up under different socio-economic conditions. In both LSGs (NHWG and HWG), males and females tended to have shorter stature.

In studies conducted in provinces of Turkey such as Istanbul and Ankara, where strata differences are evident, the anthropometric dimensions of children growing up under optimal conditions have shown greater values (Neyzi et al., 1973; Onat and Ertem, 1995; Duyar, 1990; Nebigil et al., 1997; Özdemir et al., 2005). In contrast, children growing up in poverty are shorter and weaker (Gültekin et al., 2006). Unfortunately, there have not been enough studies in Turkey to understand the effects of adverse living conditions on physical development and body composition in the final dimensions (Özener, 2010). Özener (2010) determined that poor individuals in the 18-year-old group were weaker and shorter than their wealthy peers. Saatçioğlu (1972) found that the anthropometric values of university graduates were greater in a group aged 20-45 comprised of university graduates and skilled and unqualified workers. It was emphasized in that study that the class structures of the sample were similar to those of their families and revealed the relationship between socio-economic level and anthropometric dimensions. The results obtained with these data are comparable to other cross-sectional studies conducted in Turkey (Saatçioğlu, 1972; Neyzi et al., 1973; Onat and Ertem, 1995; Duyar, 1990; Nebigil et al., 1997; Özdemir et al., 2005; Özener, 2010). It shows that different socio-economic backgrounds lead to significant differences in height in adults.

### **Socio-economics Differences on Body Parts**

A group of studies conducted on children suggested no significant correlation between leg length and socio-economic level (Cankur et al., 1993; Tuncer, 2007; Webb et al., 2008; Kinra et al., 2011; Sohn, 2015). It was stated that childhood conditions affected both parts of the body in the same way (Webb et al., 2008), and that leg length was not a sensitive indicator distinct from sitting height (Patel et al., 2011). On the other hand, most of the studies have shown that the variation observed in stature between generations is mainly due to leg length (Himes, 1979; Tanner et al., 1982; Ohyama et al., 1987; Takamura et al., 1988; Duyar, 1995; Hauspie et al., 1997; Cole, 2003; Malina et al., 2004; Koca Özer, 2007). Leitch (1951) suggested that good nutritional conditions in infancy and childhood affect leg length and that leg length is associated with improved living conditions. According to Bogin (2013), good nutrition and health conditions accelerate the growth of the legs. A longer leg length is always a reflection of advantageous living conditions and good health (Bogin, 2012). According to Himes (1979), although height depends on bone growth in every part of the body, the growth rates of these two parts differ, and long bones respond more or less to the long-term factor than do the vertebrae. In addition, Wadsworth et al. (2002) found out that leg length was related to breast milk and energy intake. Buschang et al. (1986) stated that the differences between a well-nourished and a malnourished group were a result of their leg length, and this also explained their height difference. Some similar studies have argued that leg length increases as socio-economic conditions improve and rise (Bogin et al., 2002; Duyar, 1997b), and decreases as socio-economic conditions worsen (Li et al., 2007).

Individuals under optimal conditions are considered to be more advantaged in terms of nutrition and health. Hence, the HSG provides these advantages more easily. In relation to this, in high socio-economic conditions, leg length tends to be affected positively, and this finding provides substantial support to the data previously presented. The SHR value was one percentage point

greater in both LSGs, which showed that the low socio-economic group had shorter legs. As a result, it could be assumed that the limbs are affected less than other body parts in both low socio-economic groups.

In this sample, similar to the other studies, leg length was positively affected in the HSG, who had better life conditions in childhood. This observed change is very evident among males. Vercellotti and Piperata (2012) argued that intra-population variation is apparent in the body proportions of Amazonian females and males. According to their study, the legs of males are longer than those of females. Oliver (1969) stated that males have longer dimensions than females of the same height. This distinction is probably due to the differences in growth between the sexes. Bowles (1932 as cited in Himes, 1979) observed a difference between parents and children and determined that the difference was more significant in leg length in boys and sitting height in girls. The data of the present study are in parallel with these findings. The fact that females are less affected is related to limited leg growth in the growing period due to the release of the hormone estrogen in the pre-pubertal period (Bostancı, 1955; Schooling et al., 2008). Therefore, in adolescence, sitting height is greater in girls than in boys, and leg length is greater in boys than in girls (Malina et al., 2004; Bundak, 2010; Hattori et al., 2011). In addition, although it is not entirely clear, this maturation process in girls brings them closer to adulthood. Therefore, girls have a shorter time to respond to environmental stresses (Bogin, 2021). According to the data obtained, this makeup gained in adolescence may be reflected in limited size.

### ***Socio-economics Differences in Body Limb Proportions***

According to Jantz et al. (2016), the differences observed in height usually stem from the bones of the limbs. Differences observed in the limbs indicated that the lower limbs of the body exhibited more allometric structure than the upper limbs, and the upper limbs were more isometric with height (Jantz and Jantz 1995, 1999; Tacar et al., 1999; Kryst et al., 2019). Some researchers have even suggested that external factors affected the distal limbs more (radius-ulna and tibia-fibula), especially the tibia length, among all body limbs (Holliday and Ruff, 2001; Auerbach and Sylvester, 2011; Koziel et al., 2016). In this study, the allometric structure of the body was evident in the face of socio-economic conditions. Socio-economic conditions affected the lower and upper limbs differently in both sexes. This differentiation was more noticeable in males. Duyar and Pelin (2003) determined that the height also increased as the relative tibia length rose in different socio-economic groups. In the results of the present study, upper leg and tibia lengths decreased as life conditions worsened. The proportional value of the upper leg length and tibia length with height was constant in females, but more variable in males. Therefore, it can be said that different conditions affect the tibia length more. Indeed, as in the Samsun example, Koziel et al. (2016) drew attention to differences in lower leg length in an ethnically homogeneous Polish sample and suggested that this was due to differences observed in social conditions rather than to genetic structure. Also, Duyar (1997a) stated that the change in the lower limbs making up the leg caused differences within and between societies. The results of this study indicate that the crural index increases in HSG, while the brachial index increases in both LSGs. According to this, it may be proposed that the distal limbs cause variation in arms and legs in males and females.

### ***Effect of Physical Stress on Body Size and Proportions***

The underlying causes of outcomes observed in the low socio-economic group have a complex relationship. However, income, nutrition, and intensive work are particularly determinative of height. Extreme poverty and constant malnutrition during growth cause growth retardation and short stature (Steckel, 1995, 2016). In this study, both LSGs had lower values of height, total lower leg length, sitting height, and overall arm length compared to individuals growing under optimal conditions. In heavy-working individuals in the LSG, these values were even lower (Table 5). Tanner (1981) stated that the growth retardation seen in child workers in British

industrialization was not temporary but continued into adulthood. He emphasized that the reason for this was also poor nutrition and living conditions.

Baysal (2003) states that the nutrition level of children forced to work by social and economic inequalities is very low. On the other hand, the energy needs of working children are greater than non-working children (Duyar and Özener, 2003; Etiler et al., 2011). Studies conducted on worker groups and child workers demonstrated that working individuals had an unbalanced and inadequate diet (Soydal et al., 2001; Özarlan and Güneşli, 1983; Tomak et al., 2009; Kaner et al., 2015), while the most common health problem among working children was malnutrition (Omokhodion and Omokhodion, 2004; Ibrahim et al., 2018). In a study on Vietnamese children, O'Donnell et al. (2005) stated that working does not affect growth. However, many studies have maintained that working children are shorter and weaker than non-working children (Tanner, 1981; Raina et al., 1990; Ambadekar et al., 1999; Duyar and Özener, 2003, 2005; Özener and Duyar, 2004; Omokhodion and Omokhodion, 2004; Pasdar et al., 2014; Demir, 2018).

Studies on this subject principally concentrate on the relationship between socio-economic level and nutrition in children. However, a study in which Hawamdeh and Spencer (2002) compare children with their siblings is noteworthy. According to the results of the study, the height of children working at the age of 11-15 was significantly less than that of their siblings aged 10-15. Since their siblings were at the same socio-economic level, it was seen that the growth retardation in child workers could not be explained only by nutrition. In the same way, Shah (1984) reported that children who started working at the age of 14 or earlier were 4cm shorter than those who started working after the age of 18. They said that the reason for this was both insufficient nutrition and the increase in long hours of hard work. The social and economic differences between the HWG and the NHWG are broadly similar to this. As Table 1 shows, both groups have caused a continuation of the poverty which they inherited from their families. In this way, it can be said that these two groups have relatively similar probabilities of exposure to physiological stresses such as nutrition and illness. The observed difference in the HWG within this similarity can only be explained by physical pressure connected to conditions of heavy work. In addition to physical pressure, working children are exposed to inadequate lighting, ventilation and heating and poor hygiene conditions, depending on their line of work and work environment (İşeri et al., 2005; Tor, 2010; Göl, 2016). All these circumstances cause significant growth retardation, short stature, spinal degeneration, and lifelong deformities in child workers (Çağlayan et al., 2010; Rahman et al., 2014; ILO, 2020; İşeri et al., 2005; Hawamdeh et al., 2001).

Among the limited number of studies concerning adults, that of Cortez et al. (2007) claimed that adult females and males aged 23-25 with a working background were shorter in stature. However, Cortez et al. (2007) emphasized that the parameters they determined were insufficient, and therefore their result was controversial. On the other hand, Dantas and Santana (2010) found that females and males aged 18-65 with a childhood work history were relatively short. Saatçioğlu (1972), in a study conducted in Turkey in general, found that qualified workers were 2cm taller than unqualified males and 1cm taller than unqualified women. Similarly, Walker et al. (1988) reported that professionals aged 40-59 in England were 6cm taller than unskilled manual workers. In a study comparing the anthropometric dimensions of different occupational groups, Hsiao et al. (2002) discovered that the height of agricultural workers was 2.8 cm less in females and 2.5 cm less in males in all occupations. In this study, height was 19 mm less in females from the HWG and 25 mm less in males from the HWG. This result is also evident in sitting height and total lower leg length. In a study conducted in Japanese society, Kouchi (2004) found that the sitting heights of working children had increased rapidly in the previous 30 years. Likewise, Duyar and Özener (2003) conducted a comparative study on male child workers in Turkey. They stated that physical strength did not affect the body at the same rate, and that the difference in the total lower leg lengths and tibia lengths was clear (Duyar and Özener, 2003).

The intermembral index showed the most significant proportional difference. This index value was 1.5 percentage points greater in the HWG females and 0.9 percentage points in males

(Table 7). Heavy workers had longer arms than nonheavy workers. This was observed more clearly in females. On the other hand, the SHR was similar in both groups. Similarly, Demir (2018) stated in a comparative study on working girls that the ratio of height to arm and leg lengths developed proportionally in working and non-working individuals. On the contrary, Duyar and Özener (2003) found that heavy-working boys had relatively longer bodies and longer arms. Also, in a study comparing different occupational groups, Hsiao et al. (2002) claimed that females dealing with machinery and repair work had longer upper arms. All these data are a clearer indicator not so much of the mean differences between HGW and NHWG, but of the change created by physical pressure in the observed differentiation.

Duyar and Özener (2003) suggest that these observed changes can be explained by the adaptation of the human skeletal structure to stresses. Several studies have determined that length measures are more affected by genetic structure than are width measures (Susanne, 1977; Sharma, 1987; Bogin, 2021). However, as explained in the material and method section, the sample was considered to be genetically homogeneous, the effects of different stresses are also evident in length measures. It has been stated that the diaphyseal bone has plasticity (Trinkaus et al., 1994) and that the transverse dimensions of the bone can change significantly under mechanical stimuli (Ruff et al., 1993; Trinkaus et al., 1994; Ruff, 2019). Based on Wolf's Law, 'bone functional adaptation' explains the response of the bone to physical stress, i.e., its adaptation and shaping to the mechanical environment (Larsen, 2015; Ruff, 2019). The primary forces affecting the bone are tension, compression, shearing, bending, and torsion (Larsen, 2015). Among these forces, tension and compression can give an idea about the shortening and elongation tendencies of body limbs in the HWG. Tension occurs when equal and opposite forces are applied outward, while the mechanism of the compression is the opposite (Larsen, 2015). Probably, the longer arms of the heavy working group are related to their body and arm heavy working. It may be a result of repeated tension movements in connection with their work, and the shorter lower member length may result from compression from above. This result shows that along with width measurements, lengths can be affected by physical pressures.

The effect levels of physical stresses are also evident between the sexes. While there are no proportional differences in the lower limbs of females, it was seen that especially the distal limbs are affected by physical stresses in males. This distinction observed between females and males stems from the difference in the response of the sexes to stress. It is widely postulated that females are more 'buffered' than males in the face of environmental stresses (Stinson, 1985; Bogin, 2021). However, Stinson (1985) stated that this result is open to testing, and researchers should also consider the cultural environment in which people live. For instance, Vercellotti and Piperata (2012) pointed out that although adult Amazonian females had more disadvantages in their bio-cultural background, this was not reflected in their body proportions. This study indeed had a similar outcome. In the rural areas of Samsun, males usually work in paid jobs outside the village, while females share the work in agricultural production, animal care, childcare, and domestic work (Gündüz Hoşgör and Suzuki Him, 2016). Likewise in this study, the work of heavy-working females was mainly in agriculture. Despite the more intense stress, it is possible that the HWG females were less affected by such physical stresses. On the other hand, traditional Turkish family structure regards boys as socially and economically more functional. Hence, males are valued more with the expectation of this functionality (Kağıtçıbaşı, 1993). However, this study indicated that males were relatively more affected by external factors despite their socio-cultural advantages. This outcome supports the hypothesis that environmental stresses impact males more (Stinson, 1985; Peck and Vägerö, 1987; Vercellotti and Piperata, 2012; Bogin, 2021).

In conclusion, similar to the numerous studies on children have shown, the effects of different social, economic, and physical stresses were observed in dimensions of adults. The HSG had values representing optimum conditions in all measurements. These differences were observed in body proportions. Leg length was greater in the HSG, while in both LSGs, arms were longer. It can be said that this difference, which was observed in both sexes, originates with distal limbs. According

to this, LSG males and females are represented with shorter legs and longer arms. In this, the lower limbs tend to be more affected by external factors, in a way which supports the literature.

This cross-sectional study gives very important information on physical stress on the human body and proportional relations. According to the results of this study, it can be said that in disadvantageous conditions, physical pressures can cause an interruption in growth. Tests were made as to whether labour affected growth and development and it was found that height, sitting height, total lower leg length, and overall arm length were greater in the NHWG. The difference in limbs was relatively small, and this was the case for both sexes. The values of the upper limbs of heavy working individuals were proportionally greater. In particular, the arms of the heavy-working group were relatively longer. Almost no differences were observed in the body and limbs of females, except for their arms. On the contrary, more significant differences were observed in males. It can be concluded that not only the physiological stress related to the socioeconomic situation, but also physical stress, is effective in shaping the body size and proportion. The results of heavy working conditions resulted in long arms and short legs in HWG.

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## References

- Acar S, Meydan MC, Bilen Kazancık L and Işık M (2019) İllerin ve bölgelerin sosyo-ekonomik gelişmişlik sıralaması araştırması (SEGE-2017) *Türkiye Cumhuriyeti Sanayi ve Teknoloji Bakanlığı Kalkınma Ajanları Genel Müdürlüğü*, Ankara (In Turkish).
- Ambadekar NN, Wahab SN, Zodbey SP and Khandait DW (1999) Effect of child labour on growth of children. *Public Health*, **113**, 303–306.
- Aran M, Demir S, Sarıca Ö and Yazıcı H (2010) Türkiye’de yoksulluk ve eşitsizlikteki değişimler (2003-2006). Devlet Planlama Teşkilatı ve Dünya Bankası Refah ve Sosyal Politika Analitik Çalışma Programı Raporu:1(In Turkish).
- Auerbach BM and Sylvester AD (2011) Allometry and apparent paradoxes in human limb proportions: Implications for scaling factors. *American Journal of Physical Anthropology*, **144**, 382–391.
- Baysal A (2003) Sosyal eşitsizliklerin beslenmeye etkisi. *Cumhuriyet Üniversitesi Tıp Fakültesi Dergisi*, **25**, 66–72 (In Turkish).
- Bogin B, Smith, P, Orden AB, Silva MIV and Loucky J (2002) Rapid change in height and body proportions of Maya American children. *American Journal of Human Biology*, **14**, 753–761.
- Bogin B (2012) Leg length, body proportion, health and beauty. In Cameron N and Bogin B (eds) *Human Growth and Development*. Academic Press, Second Edition. 343–373.
- Bogin B (2013) A short introduction to growth. In Hermanussen M (ed) *Auxology Studying Human Growth and Development*. Schweizerbart Science Publishers, Germany.
- Bogin B (2021) *Patterns of human growth*. Cambridge University Press, Third Edition.
- Bostancı EY (1955) Ankara’da Türk okul çocuklarında üst ve alt taraf kısımlarının büyümesi üzerine bir araştırma *Ankara Dil-Tarih Coğrafya Fakültesi Dergisi*. **13**, 69–136 (In Turkish).
- Bundak R (2010) *Türk çocuklarında oturma yüksekliği ve oturma yüksekliği/boy oranının referans değerleri*. Uzmanlık Tezi. İstanbul Üniversitesi Çocuk Sağlığı Enstitüsü, İstanbul (In Turkish).
- Buschang PH, Malina RM and Little BB (1986) Linear growth of zapotec schoolchildren: Growth status and yearly velocity for leg length and sitting height. *American Journal of Human Biology*, **13**, 225–234.

- Çağlayan C, Hamzaoglu O, Yavuz CI and Yuksel S** (2010) Working conditions and health status of child workers: Cross-sectional study of the students at an apprenticeship school in Kocaeli. *Pediatrics International*, **52**, 6–12.
- Candaş A, Yılmaz V, Günseli S and Yakut-Çakar B** (2010) Türkiye’de eşitsizlikler: kalıcı eşitsizliklere bir bakış *Boğaziçi Üniversitesi Sosyal Politika Formu*. İstanbul (In Turkish).
- Cankur NŞ, Gülesen Ö, İkiz İ, Şendemir E, Oygucu İH, Çimen A and Erem TF** (1993) Gemlik ilçesi ilkököl öğrencilerinde antropometrik ölçümlerle büyüme ve gelişmenin değerlendirilmesi: Uyluk ve bacak uzunluklarının incelenmesi *Uludağ Üniversitesi Tıp Fakültesi Dergisi*, **2**, 159–163 (In Turkish).
- Cole TJ** (2003) The secular trend in human physical growth: A biological view. *Economics and Human Biology*, **1**, 161–168.
- Cortez SAE, Barbieri MA, Saraiva M da CP, Bettiol H, da Silva AAM and Cardoso VC** (2007) Does child labour affect final height? *Occupational Medicine*, **57**(2), 118–125.
- Dangour AD, Schilg S, Hulse JA and Cole TJ** (2002) Sitting height and subischial leg length centile curves for boys and girls from Southeast England. *Annals of Human Biology*, **29**(3), 290–305.
- Dantas RA and Santana VS** (2010) Child and adolescent labour, socioeconomic status, and reduced adult height. *International Journal of Occupational and Environmental Health*, **16**(2), 143–149.
- Demir M** (2018) *Çocuk işçiler:Çalışan kız çocuklarının bedensel gelişimi*. Yüksek Lisans Tezi. İstanbul Üniversitesi Sosyal Bilimler Enstitüsü, İstanbul (In Turkish).
- Dempster WT, Sherr LA and Priest JG** (1964) Conversion scales for estimating humeral and femoral lengths and the lengths of functional segments in the limbs of American Caucasoid males. *Human Biology*, **36**, 246–62.
- DPT** (2003) *İllerin ve bölgelerin sosyo-ekonomik gelişmişlik sıralaması araştırması*. Yayın No: DPT 2671, Ankara (In Turkish).
- Duyar İ** (1990) 10 yaş grubu çocukların antropometrik ölçülerinde eşeyssel ve sosyo-ekonomik konuma göre görülen farklılıklar. *Ankara Üniversitesi Dil ve Tarih-Coğrafya Fakültesi Dergisi*, **34**, 69–79 (In Turkish).
- Duyar İ** (1995) Ankara’da yaşayan çocukların bazı antropometrik ölçülerinde 1950-1986 yılları arasında gözlenen değişimler. *Hacettepe Üniversitesi Edebiyat Fakültesi Dergisi*, **12**, 1–13 (In Turkish).
- Duyar İ** (1997a) Okul çağı çocuklarında bedenün üst ve alt kısımlarının büyümesi: I- oturma yüksekliyi ve sosyo-ekonomik faktörlerin vücut oranlarına etkisi. *Beslenme ve Diyet Dergisi*, **26**, 5–10 (In Turkish).
- Duyar İ** (1997b) Okul çağı çocuklarında bedeninin üst ve alt kısımlarının büyümesi II- alttaraf uzunluğu ve allometrik büyüme. *Beslenme ve Diyet Dergisi*, **26**, 31–35 (In Turkish).
- Duyar İ and Özener B** (2003) *Çocuk işçiler: çarpık gelişen bedenler*. Ütopya Yayınevi (In Turkish).
- Duyar İ and Pelin C** (2003) Body height estimation based on tibia length in different stature groups. *American Journal of Physical Anthropology*, **122**, 23–27.
- Duyar İ and Özener B** (2005) Growth and nutritional status of male adolescent laborers in Ankara, Turkey. *American Journal of Physical Anthropology*, **128**, 693–698.
- Duyar İ** (2013) Çalış(tır)ılan çocuklarda bedensel yıpranmalar. *İnsan Bilim Dergisi*, **2**(1), 1–14 (In Turkish).
- Duyar İ** (2017) Çalıştırılan çocukların beden gelişimi ve sağlık sorunları. *Türk Tabipler Birliği Mesleki Sağlık ve Güvenlik Dergisi*, 65–74 (In Turkish).
- Eiben OG and Mascie-Taylor CGN** (2004) Children’s growth and socio-economic status in Hungary. *Economics and Human Biology*, **2**, 295–320.
- Erdoğan S** (2004) 1980-2000 Yılları Arasında Türkiye’de Gelir Dağılımı. *Sosyal Ekonomik Araştırmalar Dergisi*, **4**(8), 46–57. (In Turkish).
- Etlier N, Çağlayan C, Cizmecioglu FM, Yavuz CI, Hatun Ş and Hamzaoglu O** (2011) The effect of labour on physical growth of children: comparison of the result of two studies conducted in İzmit. *Turkish Archives of Pediatrics*, **46**, 105–10.
- Eveleth PB** (2001) Thoughts on secular trends in growth and development, In: Dasgupta P and Hauspie R (eds). *Perspectives in Human Growth, Development and Maturation*. Springer-Science+Business Media, B.V, pp. 137–147.
- Frisancho AR** (2007) Relative leg length as a biological marker to trace the developmental history of individuals and populations: Growth delay and increased body fat. *American Journal of Physical Anthropology*, **19**, 703–710.
- Godina EZ, Khomyakova IA and Zadorozhnaya LV** (2016) Secular changes in body dimensions and sexual maturation in children of Arkhangelsk city. *Anthropologischer Anzeiger*, **73**, 45–59.
- Göl İ** (2016) Sanayi sitesinde çalışan çocuk ve genç işçilerin çalışma koşulları ile sağlık durumları ve sağlığın önemi algılarının değerlendirilmesi. *TAF Preventive Medicine Bulletin*, **15**, 347–353 (In Turkish).
- Gunnell D, Smith GD, Frankel S, Kemp M, and Peters T** (1998) Socio-economic and dietary influences on leg length and trunk length in childhood: a reanalysis of the Carnegie (Boyd Orr) survey of diet and health in pre-war Britain (1937–39). *Paediatric and Perinatal Epidemiology*, **12**(S1), 96–113.
- Gültekin T, Hauspie R, Susanne C and Güleç E** (2006) Growth of children living in the outskirts of Ankara: Impact of low socio-economic status, *Annals of Human Biology*, **33**, 43–54.
- Hancock C, Bettiol S and Smith L** (2016) Socioeconomic variation in height: Analysis of National Child Measurement Programme data for England. *Archives of Disease in Childhood*, **101**, 422–426.
- Hsiao H, Long D and Snyder K** (2002) Anthropometric differences among occupational groups. *Ergonomics*, **45**(2), 136–152.

- Hattori K, Hirohara T and Satake T** (2011) Body proportion chart for evaluating changes in stature, sitting height and leg length in children and adolescents. *Annals of Human Biology*, **38**, 556–560.
- Hauspie RC, Vercauteren M and Susanne C** (1997) Secular changes in growth and maturation: An update. *Acta Paediatrica*, **86**, 20–27.
- Hawamdeh H, Spencer N and Waterston T** (2001) Work, family socioeconomic status, and growth among working boys in Jordan. *Archives of Disease in Childhood*, **84**, 311–4.
- Hawamdeh H and Spencer N** (2002) Growth of working boys in Jordan: a cross-sectional survey using non-working male siblings as comparisons. *Child: care, health and development*, **28**(1), 47–49.
- Himes J H** (1979) Secular changes in body proportions and composition. *Monographs of the Society for Research in Child Development*, **44**, 28–58.
- Holliday TW and Ruff CB** (2001) Relative variation in human proximal and distal limb segment lengths. *American Journal of Physical Anthropology*, **166**, 26–33.
- Gündüz Hoşgör A and Suziki Him M** (2016) Küreselleşme ve Türkiye’de kırsal kadının ücretli emeği: rapana venosa üretimi zinciri üzerinden batı Karadeniz bölgesinde bir vaka analizi. *Sosyoloji Araştırmaları Dergisi*, **19**, 108–130 (In Turkish).
- Howe LD, Tilling K, Galobardes B, Smith GD, Gunnell D and Lawlor DA** (2012) Socioeconomic differences in childhood growth trajectories: At what age do height inequalities emerge? *Journal of Epidemiology and Community Health*, **66**(2), 143–148.
- Ibrahim A, Abdalla SM, Jafer M, Abdelgadir J and De Vries N** (2018) Child labor and health: A systematic literature review of the impacts of child labor on child’s health in low- and middle-income countries. *Journal of Public Health*, **41**, 18–26.
- International Labour Organization (ILO)** (2020) Çocuk işçiliği. <https://www.ilo.org/ankara/areas-of-work/child-labour/lang-tr/index.htm> (Accessed on 21th August 2021).
- İşeri B, Sözen G, Melik O, Yavaşcan O, Başkesen A, Çoker I and Yaprak I** (2005) Çalışan çocuk; sosyo-kültürel özellikler ve sağlık taraması İzmir otomotiv sanayi. *İzmir Tepecik Hastanesi Dergisi*, **15**, 45–56 (In Turkish).
- Jantz LM and Jantz RL** (1995) Allometric Secular Change in the Long Bones from the 1800s to the Present. *Journal of Forensic Sciences*, **40**(5), 762–767.
- Jantz LM and Jantz RL** (1999) Secular change in long bone length and proportion in the United States, 1800–1970. *American Journal of Physical Anthropology*, **110**(1), 57–67.
- Jantz RL, Jantz L and Devlin JL** (2016). Secular changes in the postcranial skeleton of American whites. *Human Biology*, **88**, 65–75.
- Johnston FE** (1998) Morphology. In: Ulijaszek S, Johnston FE, Preece MA (eds) *The Cambridge Encyclopaedia of Human Growth and Development*. Cambridge University Press, pp. 193–195.
- Kağıtçıbaşı Ç** (1993) Türkiye’de aile kültürü. *Kadın Araştırmaları Dergisi*. **1**, 49–58 (In Turkish).
- Kalaycıoğlu S, Kardam F, Tuzun S and Ulusoy M** (1998) Türkiye için bir sosyoekonomik statü ölçütü geliştirme yönünde yaklaşım ve denemeler. *Toplum ve Hekim*, **13**, 126–137 (In Turkish).
- Kalaycıoğlu S, Kardam F, Rittersberger-Tılıç H, Çelik K and Türkyılmaz S** (2008) Ankara kent merkezinde toplumsal tabakalaşma, hareketlilik ve sosyoekonomik statü araştırması, Proje No: SOBAG 104 K 039, Ankara (In Turkish).
- Kaner G, Soyulu M, Başmısırlı E and İnanç N** (2015) Kayseri’de mobilya üretiminde çalışan işçilerin beslenme durumu ve alışkanlıklarının belirlenmesi. *Beslenme ve Diyet Dergisi*, **43**, 191–199 (In Turkish).
- Kinra S, Sarma KR, Hards M, Smith GD and Ben-Shlomo Y** (2011) Is relative leg length a biomarker of childhood nutrition? Long-term follow-up of the Hyderabad Nutrition Trial. *International Journal of Epidemiology*, **40**(4), 1022–1029.
- Koca Özer B** (2007) Growth reference centiles and secular changes in Turkish children and adolescents. *Economics and Human Biology*, **5**, 280–301.
- Koca Özer B** (2008) Secular trend in body height and weight of Turkish adults. *Anthropological Science*, **116**, 191–199.
- Koç I, Eryurt MA, Adalı T and Seçkiner P** (2008) Türkiye’nin demografik dönüşümü. *Hacettepe Üniversitesi Nüfus Etütleri Enstitüsü*, Ankara (In Turkish).
- Kouchi M** (2004) Secular changes in the Japanese head form viewed from somatometric data. *Anthropological Science*, **112**, 41–52.
- Koziel S, Gomula A and Nowak-Szczepeńska N** (2016) The association between social factors and body length proportions in Polish schoolchildren from Lower Silesia. *Anthropological Review*, **79**, 397–408.
- Koziel S, Gomula A and Malina RM** (2019) Sex-dependent effect of post-migration adaptation on height and relative lower leg length in Polish youth. *Annals of Human Biology*, **46**, 27–34.
- Kuh DL, Power C, and Rodgers B.** (1991). Secular trends in social class and sex differences in adult height. *International Journal of Epidemiology*, **20**, 1001–1009.
- Kryst Ł, Żegleń M, Dasgupta P, Saha R, Das R and Das S** (2019) Secular changes in limb lengths and proportions from 1952 to 2011 in children, adolescents, and young adults from Kolkata (India). *American Journal of Physical Anthropology*, **51**(4), 603–618.
- Larsen CS** (2015) *Bioarchaeology interpreting behaviour from the human skeleton*. Cambridge University Press, Second edition.
- Lasker GW and Mascie-Taylor CGN** (1989) Effects of social class differences and social mobility on growth in height, weight and body mass index in a British cohort. *Annals of Human Biology*, **16**, 1–18.
- Leitch I** (1951) Growth and health. *British Journal of Nutrition*, **5**, 142–151.

- Li L, Dangour AD and Power C (2007) Early life influences on adult leg and trunk length in the 1958 British birth cohort. *American Journal of Physical Anthropology*, **19**, 836–843.
- Lindgren G (1998). Changing human growth patterns, In: Ulijaszek S, Johnston FE, Preece MA *The Cambridge Encyclopaedia of Human Growth and Development*. Cambridge University Press, pp. 380–387.
- Lohman TG, Roche AF and Martorell R (1988) *Anthropometric Standardization Reference Manual*, Human Kinetics Books.
- Mascie-Taylor CGN (1991) Biosocial influences on stature: A review. *Journal of Biosocial Science*, **23**, 113–128.
- McCrary C, O’Leary N, Fraga S, Riberio AI, Barros H, Kartiosuo N, Raitakari O, Kivimäki M, Vineis P, Layte R, Consortium L. (2017) Socioeconomic differences in children’s growth trajectories from infancy to early adulthood: Evidence from four European countries. *Journal of Epidemiology and Community Health*, **71**, 981–989.
- Malina RM, Pena Reyes ME, Tan SK, Buschang PH, Little BB and Koziel S (2004) Secular change in height, sitting height and leg length in rural Oaxaca, southern Mexico: 1968–2000. *Annals of Human Biology*, **31**(6), 615–633.
- Mumm R, Ipsen MJ and Hermanussen M (2016) The association of weight, weight variability and socioeconomic situation among children. *European Journal of Clinical Nutrition*, **70**, 650–652.
- Mumm R, Czernitzki AF, Bents D and Musalek M (2017) Socioeconomic situation and growth in infants and juveniles. *Anthropologischer Anzeiger*, **74**, 101–107.
- Nebigil I, Hizel S, Tanyer G, Dallar Y and Coskun T (1997) Heights and weights of primary school children of different social background in Ankara, Turkey. *Journal of Tropical Pediatrics*, **43**, 297–300.
- Nezvi O, Yalcindag A and Alp H (1973) Heights and weights of Turkish children. *Journal of Tropical Pediatrics*, **19**, 5–13.
- O’Donnell O, Rosati FC and Van Doorslaer E (2005) Health effects of child work: Evidence from rural Vietnam. *Journal of Population Economics*, **18**, 437–467.
- Ohyama S, Hisanaga A, Inamasu T, Yamamoto A, Hirata M and Ishinishi N (1987) Some secular changes in body height and proportion of Japanese medical students. *American Journal of Physical Anthropology*, **73**, 179–183.
- Oliver G (1969) *Practical Anthropology*. Charles C Thomas Publisher, USA.
- Omokhodion FO and Omokhodion SI (2004) Health status of working and non-working school children in Ibadan, Nigeria. *Annals of Tropical Paediatrics*, **24**, 175–178.
- Onat T and Ertem B (1995) Age at menarche: relationships to socioeconomic status, growth rate in stature and weight and skeletal and sexual maturation. *American Journal of Physical Anthropology*, **7**(6), 741–750.
- OECD (2015). <https://www.oecd.org/turkey/> (Accessed on 28th September 2021).
- OKA (2015) *Samsun ili sosyal analizi*, Samsun, Türkiye (In Turkish).
- OKA (2019) *Samsun ili mevcut durum raporu*, Samsun, Türkiye (In Turkish).
- Özarslan U and Güneşli U (1983) Antalya sanayi bölgesinde çalışan çırakların enerji harcamaları, beslenme ve sağlık durumları üzerinde bir araştırma. *Beslenme ve Diyet Dergisi*, **12**, 57–66 (In Turkish).
- Özdemir O, Erçevik E and Çalışkan D (2005) Farklı sosyoekonomik düzeye sahip iki ilköğretim okulunda öğrencilerin büyümelerinin değerlendirilmesi. *Ankara Üniversitesi Tıp Fakültesi Mecmuası*, **58**, 23–29 (In Turkish).
- Özener EB and Duyar İ (2004) Farklı ülkelerde çalışan çocukların büyüme örüntüleri: z-skorlarına dayalı bir karşılaştırma. *Hacettepe Üniversitesi Edebiyat Fakültesi Dergisi*, **21**, 1–13 (In Turkish).
- Özener EB (2010) Kentsel Yoksulluğun Ankara’da yaşayan genç erkeklerin büyüme yapısı ve beden bileşimi üzerine etkisi. *Gaziantep Üniversitesi Sosyal Bilimler Dergisi*, **9**, 55–68 (In Turkish).
- Pasdar Y, Darbandi M and Nachvak SM (2014) Nutritional status of working children as a neglected group in Kermanshah West of Iran. *Journal of Community Health Research*, **3**, 124–131.
- Patel R, Lawlor DA, Kramer MS, Davey Smith G, Bogdanovich N, Matush L and Martin RM (2011) Socioeconomic inequalities in height, leg length and trunk length among children aged 6.5 years and their parents from the Republic of Belarus: Evidence from the promotion of breastfeeding intervention trial (PROBIT). *Annals of Human Biology*, **38**, 592–602.
- Peck MN and Lundberg O (1995) Short stature as an effect of economic and social conditions in childhood. *Social Science & Medicine*, **41**, 733–738.
- Peck MN and Vågerö DH (1987). Adult body height and childhood socioeconomic group in the Swedish population. *Journal of Epidemiology & Community Health*, **41**, 333–337.
- Pomeroy E, Stock JT, Stanojevic S, Miranda JJ, Cole TJ and Wells JCK (2012) Trade-offs in relative limb length among Peruvian children: extending the thrifty phenotype hypothesis to limb proportions. *PLoS One*, **7**(12).
- Rahman MN, Mistry SK and Hossain MI (2014) Nutritional Status of Child labourers in Dhaka city of Bangladesh: Findings from a Cross Sectional Study. *Bangladesh Journal of Child Health*, **38**(3), 130–136.
- Raina V, Bhan VK and Bhat NA (1990) Nutritional status of school age girls working in different handicraft centres of Srinagar City. *British Journal of Industrial Medicine*, **47**, 502–504.
- Ruff CB, Trinkaus E, Walker A and Larsen CS (1993) Postcranial robusticity in Homo. I: Temporal trends and mechanical interpretation. *American Journal of Physical Anthropology*, **91**(1), 21–53.
- Ruff CB (2019) Biomechanical analyses of archaeological human skeleton. In: Katzenberg MA and Grauer AL (eds). *Biological Anthropology of the Human Skeleton* Third Edition. Wiley Blackwell, pp. 189–225.

- Saatçiođlu A** (1972) Türkiye’de antropolojik bazı karakterlerin sosyo-ekonomik guruplar arasında gösterdiđi deđişimler üzerinde biyometrik bir inceleme. *Antropoloji*, 7, 175–199 (In Turkish).
- Schooling CM, Jiang CQ, Heys M, Zhang WS, Lao XQ, Adab P, Cowling BJ, Thomos GN, Cheng KK, Lam TH, Leung GM** (2008) Is leg length a biomarker of childhood conditions in older Chinese women? The Guangzhou Biobank Cohort Study. *Journal of Epidemiology and Community Health*, 62, 160–166.
- Selim R, Günçavdı O, Bayar AA** (2014) Türkiye’de bireysel gelir dağılımı eşitliklilikleri: fonksiyonel gelir kaynakları ve bölgesel eşitsizlikler. Yayın No: TUSİAD-T/2014-06/554 (In Turkish).
- Sharma K** (1987) Genetic variance estimates and familial resemblance for body size traits. *Acta Genet Med Gemellol (Roma)*, 36, 549–555.
- Shah PM** (1984) The health care of working children. *Child Abuse&Neglect*, 8(4), 541–544.
- Sohn K** (2015) Is leg length a biomarker of early life conditions? Evidence from a historically short population. *American Journal of Physical Anthropology*, 27, 538–545.
- Soydal U, Yıldırım RC and Aycan S** (2001) Ankara Toprak ve Gübre Araştırma Enstitüsü Müdürlüğü’nde çalışanların beslenme özellikleri ve demir eksikliği anemisi görülme sıklığı. *Beslenme ve Diyet Dergisi*, 30, 25–34 (In Turkish).
- Steckel RH** (1995) Stature and the Standard of Living. *Journal of Economic Literature*, 33, 1903–1940.
- Steckel RH** (2012) Social and economic effects on growth. In Cameron, N. and Bogin, B. (eds). *Human Growth and Development*. Academic Press, Second Edition, pp. 224–245.
- Steckel RH** (2016) Biological measures of well-being. In Komlos J and Kelly IR (eds). *The oxford handbook of economics and human biology*. Oxford University Press, pp. 32–52.
- Stinson S** (1985) Sex differences in environmental sensitivity during growth and development. *American Journal of Physical Anthropology*, 28(6), 123–147.
- Stinson S** (2009) Nutritional, developmental, and genetic influences on relative sitting height at high altitude. *American Journal of Human Biology*, 21, 606–613.
- Stinson S** (2012) Growth variation: biological and cultural factors. In Stinson S, Bogin B, O’Rourke D (eds). *Human Biology an Evolutionary and Biocultural Perspective*, Wiley-Blackwell Publication.
- Susanne C** (1977) Heritability of anthropological characters. *Human Biology*, 49(4), 573–580.
- Susanne C** (1979) Socioeconomics differences in growth patterns. In Johnston, FE, Roche AF, Susanne C (eds). *Human Physical Growth and Maturation Methodologies and Factors.*, pp. 329–339. New York.
- Tacar O, Dogruyol S and Hatipoglu ES** (1999) Lower and upper limb length of urban and rural 7-11 years old Turkish school children. *Anthropologischer Anzeiger*, 57, 269–276.
- Takamura K, Ohyama S, Yamada T and Ishinishi N** (1988) Changes in body proportions of Japanese medical students between 1961 and 1986. *American Journal of Physical Anthropology*, 77, 17–22.
- Tanner JM** (1981) *A history of the study of human growth*. Cambridge University Press.
- Tanner JM, Hayashi T, Preece MA and Cameron N** (1982) Increase in length of leg relative to trunk in Japanese children and adults from 1957 to 1977: comparison with British and with Japanese Americans. *Annals of Human Biology*, 9, 411–423.
- Tanner JM** (1988) Human growth and constitution. In Harrison GA, Tanner JM, Pilbeam DR, Baker PT (eds). *Human Biology: An Introduction to Human Evolution, Variation, Growth and Adaptability*, Third Edition, Oxford Science Publications.
- Tomak L, Coşkun M, Elmaciođlu F and Pekşen Y** (2009) Samsun çıraklık eğitim merkezindeki çırakların antropometrik ölçümlerinin saptanması. *Fırat Tıp Dergisi*, 14, 186–192 (In Turkish).
- Tor H** (2010) Türkiye’de çocuk işçiliğinin boyutları. *Journal of World of Turks*, 2, 25–42 (In Turkish).
- Towne B, Demerath EW and Czerwinski SA** (2012) The Genetic epidemiology of growth and development. In Cameron N and Bogin B (eds) *Human Growth and Development*. Academic Press, Second Edition pp. 173–223.
- Trinkaus E, Churchill SE and Ruff CB** (1994) Postcranial robusticity in Homo. II: Humeral bilateral asymmetry and bone plasticity. *American Journal of Physical Anthropology*, 93(1), 1–34.
- Tuncer I** (2007) Konya il merkezindeki 11–16 yaş grubu kız öğrencilerde sosyoekonomik durum, antropometrik vücut ölçümleri ve menarşla büyüme ve gelişmenin değerlendirilmesi. *Süleyman Demirel Üniversitesi Tıp Fakültesi Dergisi*, 14, 25–28 (In Turkish).
- T.C. Aile ve Sosyal Politikalar Bakanlığı** (2014) Türkiye’de kadın işgücü profili ve istatistiklerinin analizi. Ankara (In Turkish).
- TURKSTAT and ILO** (1999) Child labour in Turkey- national child labour survey report. [https://www.ilo.org/ipcc/informationresources/WCMS\\_IPEC\\_PUB\\_5104/lang-en/index.htm](https://www.ilo.org/ipcc/informationresources/WCMS_IPEC_PUB_5104/lang-en/index.htm) (Accessed on 20th August 2021).
- TURKSTAT** (2012) Working Child. Ankara. Yayın No:4113.
- TURKSTAT** (2017) <https://www.tuik.gov.tr/Home/Index>
- TURKSTAT** (2020) Gelir ve yaşam koşulları anketi 2019, <https://tuikweb.tuik.gov.tr/PreHaberBultenleri.do?id=33820> (Accessed 20th August 2021).
- TÜRK-İŞ** (2021) <http://www.turkis.org.tr/default.asp> (Accessed on 25th November 2021) (In Turkish).
- Hacettepe University Institute of Population Studies** (2014) 2013 Turkey Demographic and Health Survey. Hacettepe University Institute of Population Studies, T.R. Ministry of Development and TÜBİTAK, Ankara, Turkey.

- Vercellotti G and Piperata BA** (2012) The use of biocultural data in interpreting sex difference in body proportions among rural Amazonians. *American Journal of Human Biology*, **147**(1), 113–127.
- Wadsworth MEJ, Hardy RJ, Paul AA, Marshall SF and Cole TJ** (2002) Leg and trunk length at 43 years in relation to childhood health, diet and family circumstances; Evidence from the 1946 national birth cohort. *International Journal of Epidemiology*, **31**, 383–390.
- Walker M, Shaper AG, and Wannamethee G** (1988). Height and social class in middle-aged British men. *Journal of Epidemiology & Community Health*, **42**, 299–303.
- Webb E, Kuh D, Peasey A, Pajak A, Malyutina S, Kubinova R, Topor-Madry R, Denisova D, Copkova N, Marmot M, Bobak M** (2008) Childhood socioeconomic circumstances and adult height and leg length in central and eastern Europe. *Journal of Epidemiology and Community Health*, **62**, 351–357.
- Weiner JS and Lourie JA** (1981) *Practical Human Biology*, London: Press.
- World Bank** (2021) The World Bank in Turkey. <https://www.worldbank.org/tr/country/turkey/overview> (Accessed on 25th November 2021).
- Živičnjak M, Narančić NS, Szivovicza L, Franke D, Hrenović J, Bišof V** (2003) Gender-specific growth patterns for stature, sitting height and limbs length in Croatian children and youth (3 to 18 years of age). *Collegium Antropologicum*, **27**, 321–334.