

## **SPORTS ANTHROPOLOGICAL AND SOMATOTYPICAL COMPARISON BETWEEN YOUNG MALE SHOTPUTTERS AND JAVELIN THROWERS OF DIFFERENT PERFORMANCE CLASSES AND RECREATIONAL ATHLETES**

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### **ABSTRACT**

This study examines anthropometric and somatotypical differences between German male junior shot putters ( $n = 19$ ) and javelin throwers ( $n = 19$ ).

Recreational athletes ( $n = 11$ ) served as the control group (age range 16 – 23 years).

Overall, the shot-putters were larger and had longer legs and arms as compared to the junior javelin throwers. For the smaller javelin throwers of the higher performance category shorter legs compared to the height of the hull were observed on average. There was a notably shorter leg of the spear throwers. The powerful javelin throwers had longer arms than the less powerful.

For all anthropometric widths and depths, and the circumferences and the body weight, the junior shout putters achieved higher values than the spear throwers and recreational athletes.

The skinfold thicknesses, the body fat mass and the BMI were highest among the shot putters.

The shot putters had the highest values for endomorphy and pyknomorphia (Knussmann), on the other hand, the lowest values for ectomorphy.

For the shot putters body height, shoulder width, hand width, foot width, chest circumference, minimal forearm circumference, calf circumference, arm span, plastic index and macrosomia were positively related to performance. Some skinfolds (calf, thigh) correlated negatively with the shot put distances.

For the javelin throwers radiale, stylium, dactylium and ectomorphy correlated negatively with the throw widths, but the AKS index, the BMI, the Quelet index, the Rohrer index, the Livi index, the Pelidisi index, the Broca

index, mesomorphy, the metric index and plastic index correlated positively with the performance.

The higher class shot putters of the present study achieved a mean somatotype of 2.9 – 5.6 – 1.1 and the higher class javelin throwers of 2.1 – 4.9 – 1.8. As the shot putters and the javelin throwers of the present investigation were rather young, there is still a significant development potential for the mesomorphic component in comparison to Olympians.

**Keywords:** *sports anthropological investigation, somatotypical investigation, shot putters, junior athletes, javelin throwers, sports anthropometry*

## INTRODUCTION

Shot put competitions were first recorded in early 19th century. They were a part of the British Amateur Championships beginning in 1866. The shot put competition for men has been a part of the modern Olympics since their revival in 1896. The first javelin throwing competition at the Olympic Games was held in 1906.

The present study focused on sports anthropometric and somatotypical differences in German junior shot putters and javelin throwers of different performance classes in comparison to recreational athletes.

## PARTICIPANTS AND METHODS

The present study examines anthropometric and somatotypical differences between German male junior shot putters (higher performance level  $n = 10$ , best shot put distance  $17.6 \pm 0.9$  m, the current shot put distance  $17.4 \pm 0.9$  m; the lower performance level  $n = 9$ , the best shot put distance  $15.1 \pm 1.6$  m, the current shot put distance  $14.5 \pm 1.7$  m; the age range 16–21 years) and

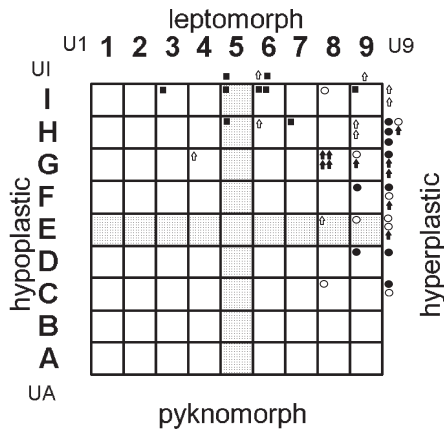
German male junior javelin throwers (the higher performance level  $n = 10$ , the best throw widths  $71.3 \pm 2.7$  m, the current throw widths  $68.5 \pm 3.1$  m; the lower performance level  $n = 9$ , the best throw widths  $57.4 \pm 6.5$  m, the current throw widths  $55.6 \pm 5.7$  m; the age range 16–21 years).

Recreational athletes (soccer, tennis, hockey) served as the control group (the age range 16–23 years; the lower performance level: the district league ( $n=5$ ); the higher performance level: the regional league ( $n=6$ )). Each proband participated voluntarily and the data were used anonymously. Anthropometric data and computed constitutional and somatotypical parameters in this work correspond to international standards (CONRAD 1963, HEATH&CARTER 1967+1990, KNUSSMANN 1996, MARTIN&KNUSSMANN 1988,

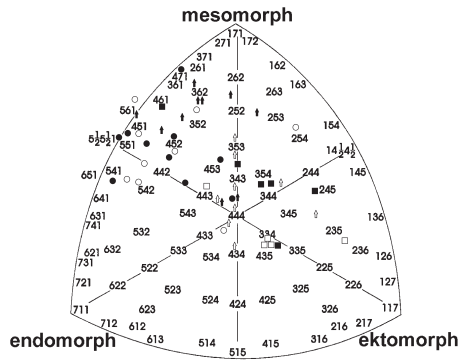
RASCHKA 2006, TITTEL&WUTSCHERK 1972). The analysis of differences was tested by ANOVA, correlations were tested by the Pearson correlation coefficients.

**RESULTS**

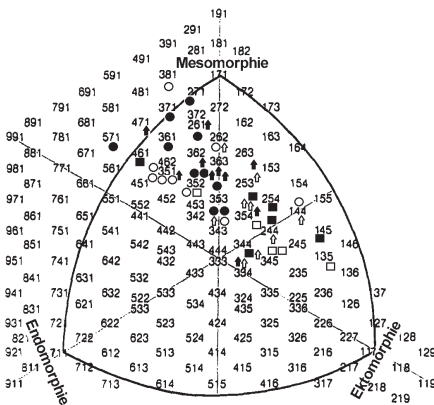
The distribution of constitutional types after CONRAD and the somatotypes after PARNELL and HEATH & CARTER are summarized in Figures 1–3.



**Figure 1.** Shot putters (circles; n=19), javelin throwers (arrows, n=19), recreational athletes (squares, n=11), in the chessboard pattern graphic after CONRAD, higher performance classes (filled, dark symbols), lower performance classes (unfilled blank symbols)



**Figure 2.** Shot putters (circles; n=19), javelin throwers (arrows, n=19), recreational athletes (squares, n=11), in the somatochart after PARNELL, higher performance classes (filled, dark symbols), lower performance classes (unfilled blank symbols)



**Figure 3.** Shot putters (circles; n=19), javelin throwers (arrows, n=19), recreational athletes (squares, n=11), in the somatochart after HEATH and CARTER, higher performance classes (filled, dark symbols), lower performance classes (unfilled blank symbols)

In the following table all collected anthropometric parameters are listed.

**Table 1.** Anthropometric and index parameters of shot putters (n= 19), javelin throwers (n=19), recreational athletes (n=11), differentiated as higher performance classes and lower performance classes ( $p \leq 0.05$  \*,  $p \leq 0.01$  \*\*,  $p \leq 0.001$  \*\*\*)

Parameter	Higher performance level			Lower performance level		
	Shot putter (n = 10)	Javelin thrower (n=10)	Recreational athletes (n = 6)	Shot putter (n = 9)	Javelin thrower (n = 9)	Recreational athletes (n = 5)
Height (cm)	189.8±7.4**	183.3±5.7**	180.0±6.7**	188.7±7.3**	187.8±5.7**	181.4±4.7**
Gnathion (cm)	164.8±7.1**	158.8±5.3**	155.9±6.6**	164.4±6.5**	163.3±7.2**	157.0±4.5**
Suprasternale(cm)	154.6±6.3**	148.4±5.0**	146.3±5.9**	153.9±6.3**	152.3±5.2**	147.5±4.3**
Acromiale (cm)	156.1±6.8**	149.4±5.6**	147.7±5.5**	156.1±5.8**	154.3±5.3**	148.6±4.1**
Radiale (cm)	119.4±6.1**	113.9±5.0**	114.1±4.0**	120.7±4.6**	119.2±4.1**	114.4±3.7**
Styilion (cm)	91.8±4.7*	87.2±3.9*	89.1±2.3*	92.9±3.7*	92.2±4.5*	88.8±2.2*
Dactylon (cm)	71.2±4.6	67.2±3.8	69.6±2.3	72.0±2.5	71.2±3.7	69.5±2.4
Iliocristale (cm)	115.1±6.1**	109.6±4.8**	107.9±5.0**	115.4±5.2**	114.1±3.9**	109.2±2.9**
Iliospinale (cm)	108.3±5.3*	104.0±4.7*	102.2±4.8*	107.7±4.6*	108.2±4.4*	103.7±2.1*
Trochanterion(cm)	92.5±6.1	88.3±5.3	90.1±2.1	92.1±5.7	93.1±4.6	89.0±2.9
Tibiale (cm)	53.0±2.4*	51.4±2.6*	50.3±3.0*	53.5±2.8*	54.1±2.8*	52.2±3.2*
Sphyrion (cm)	9.2±0.7	9.0±0.7	8.9±0.9	8.6±0.9	9.4±0.8	9.4±0.4
Sitting height(cm)	97.8±4.1**	95.6±3.4**	92.6±3.7**	96.6±4.0**	96.0±3.1**	92.9±3.6**
Zygomatic breadth (cm)	13.6±0.7	13.3±1.0	13.3±0.4	13.8±0.5	13.4±0.5	13.1±0.4
Morph.facial height(cm)	12.9±0.7	12.4±0.6	12.3±0.5	12.6±0.6	12.4±0.8	12.5±0.6
Arm span (cm)	197.2±7.7***	191.8±7.0***	182.4±7.9***	194.4±7.4***	191.7±5.1***	183.6±4.9***
Shoulder width (cm)	46.3±3.1**	45.2±3.0**	41.8±2.7**	44.1±2.1**	42.8±4.1**	41.0±1.8**
Chest width (cm)	33.0±2.0***	30.0±1.6***	27.8±2.5***	31.4±1.8***	28.4±2.0***	27.6±1.3***
Chest depth (cm)	22.3±2.7***	20.5±1.1***	19.7±1.9***	22.6±3.3***	20.0±1.4***	18.3±1.8***
Pelvis width (cm)	32.1±2.6***	28.3±1.2***	27.8±2.0***	30.5±2.6***	27.5±1.3***	27.4±2.0***
Epiphysis width Humerus cm	7.1±0.5*	6.7±0.5*	6.5±0.6*	6.9±0.3*	6.8±0.5*	6.3±0.4*
Radioulnar breadth(cm)	5.7±0.3***	5.4±0.3***	5.1±0.2***	5.5±0.3***	5.3±0.3***	5.0±0.1***
Hand breadth(cm)	8.2±0.3***	7.7±0.4***	7.2±0.5***	8.0±0.3***	7.7±0.3***	7.0±0.7***
Epiphysis width femur	10.6±0.5***	9.9±0.3***	9.9±0.6***	10.4±0.4***	9.8±0.3***	9.7±0.5***
Ankle breadth (cm)	8.0±0.1**	7.7±0.6**	7.3±0.5**	7.7±0.4**	7.6±0.4**	7.3±0.1**
Neck circumference(cm)	43.1±2.0***	41.6±1.8***	37.7±2.2***	40.6±1.0***	39.8±1.6***	37.3±1.5***
Chest circumference, respiratory centre (cm)	112.7±8.2***	103.8±4.4***	95.7±8.6***	105.9±7.4***	97.8±5.8***	91.9±6.3***
Chest circumference, in inspiration (cm)	115.0±7.9***	106.5±4.7***	99.0±9.0***	108.9±7.0***	100.9±5.9***	95.7±5.6***
Chest circumference, in expiration (cm)	111.8±7.8***	102.1±4.2***	95.3±8.6***	105.4±7.4***	96.7±5.9***	90.7±5.3***
Waist circumference cm	94.3±8.7***	82.9±2.8***	79.1±5.6***	89.1±7.4***	79.5±4.1***	76.8±5.1***
Pelvis circumference	99.8±9.5***	86.2±3.2***	85.6±8.2***	94.3±7.3***	84.2±3.3***	83.6±7.3***

Parameter	Higher performance level			Lower performance level		
	Shot putter (n = 10)	Javelin thrower (n=10)	Recreational athletes (n = 6)	Shot putter (n = 9)	Javelin thrower (n = 9)	Recreational athletes (n = 5)
Upper arm circumf. in extension (cm) right side	36.4±2.2***	33.5±1.9***	30.2±2.1***	35.1±3.2***	31.0±2.0***	28.7±2.6***
Upper arm circumf. in flexion (cm) right side	38.1±2.3***	35.6±2.1***	32.3±1.6***	37.2±3.0***	33.3±2.3***	30.6±2.5***
Upper arm circumf. in extension (cm) left side	35.9±1.9***	33.0±1.7***	29.8±2.3***	35.2±2.7***	30.4±2.3***	28.0±2.5***
Upper arm circumf. in flexion (cm) left side	37.3±2.0***	35.2±2.1***	31.5±1.9***	36.9±3.0***	32.5±2.9***	29.8±2.5***
Forearm circumference maximum(cm) right side	31.4±1.1***	29.8±1.5***	27.0±1.5***	30.7±1.6***	28.3±1.9***	26.4±1.7***
Forearm circumference minimum (cm) right side	19.2±0.4***	17.8±0.8***	16.4±1.3***	18.7±0.9***	17.7±1.0***	16.4±0.6***
Forearm circumference maximum(cm) left side	30.3±1.1***	29.1±1.3***	26.2±1.7***	30.1±1.4***	27.1±1.7***	25.9±1.4***
Forearm circumference minimum (cm) left side	18.9±0.4***	17.8±0.7***	16.1±1.2***	18.5±0.8***	17.2±0.8***	16.1±0.8***
Hand circumference(cm) dominant side	22.7±0.7***	21.9±1.0***	19.8±1.3***	22.4±1.0***	21.5±1.0***	20.0±0.9***
Thigh circumference (cm) right side	66.3±3.6***	61.1±3.4***	55.1±3.8***	64.0±4.0***	57.9±3.6***	52.6±2.6***
Thigh circumference (cm) left side	65.0±3.1***	60.4±2.9***	54.4±4.0***	63.3±3.7***	57.3±4.0***	52.3±4.0***
Calf circumference (cm) right side	43.0±2.2***	39.5±2.2***	36.6±3.0***	40.2±2.3***	38.2±2.4***	37.2±1.4***
Calf circumference (cm) left side	43.0±2.4***	39.9±1.9***	37.0±3.2***	40.9±2.3***	38.5±2.3***	37.8±1.7***
Lower leg circumference (cm) minimum right side	25.4±0.8***	23.6±1.2***	22.6±1.5***	24.3±1.4***	23.9±1.7***	23.3±0.8***
Lower leg circumference (cm) minimum left side	25.8±0.9***	24.0±1.1***	22.5±2.1***	24.7±1.5***	23.9±1.8***	23.5±0.9***
Anthr. foot length (cm)	26.9±1.0*	26.8±1.1*	25.8±1.1*	27.4±1.3*	27.0±1.2*	24.9±2.4*
Techn. foot length (cm)	25.4±1.2	25.2±1.0	24.5±0.8	25.4±1.3	25.1±2.3	24.0±1.1
Foot width (cm)	10.7±0.6***	10.0±0.4***	9.7±0.5***	10.1±0.6***	9.9±0.5***	9.6±0.4***
Foot circumference (cm) right side	27.4±1.3***	25.6±0.7***	24.6±1.2***	26.4±1.0***	25.8±1.1***	24.9±0.8***
Foot circumference (cm) left side	27.5±1.4***	25.6±0.8***	24.7±1.2***	26.6±1.0***	25.9±1.3***	24.7±0.7***
Age (years)	17.0±1.1*	18.3±1.6*	19.8±3.3*	18.0±1.7*	17.6±1.5*	18.8±2.2*
Weight (kg)	106.7±12.8***	86.6±7.0***	75.3±11.1***	98.2±12.0***	82.5±8.3***	72.0±7.0***
Body fat (%)Caliper	11.8±3.4**	9.5±1.5**	9.7±3.7**	11.8±2.2**	8.9±1.0**	9.0±1.9**
Body fat (kg) Caliper	9.8±3.6**	7.4±1.4**	7.5±3.4**	9.4±2.1**	6.7±1.0**	6.9±2.0**
BMI (kg/m <sup>2</sup> )	29.6±3.0***	25.8±1.5***	23.2±2.8***	27.6±2.5***	23.4±2.0***	21.9±2.1***

Parameter	Higher performance level			Lower performance level		
	Shot putter (n = 10)	Javelin thrower (n=10)	Recreational athletes (n = 6)	Shot putter (n = 9)	Javelin thrower (n = 9)	Recreational athletes (n = 5)
Quetelet-I. (g/cm)	5.6±0.6***	4.7±0.3***	4.2±0.5***	5.2±0.5***	4.4±0.4***	4.0±0.4***
Rohrer-I. (g/cm <sup>3</sup> )	1.56±0.2***	1.41±0.1***	1.29±0.2***	1.46±0.1***	1.25±0.1***	1.21±0.1***
Livi-I.( <sup>3</sup> √g/cm)	2.50±0.1***	2.41±0.1***	2.34±0.1***	2.44±0.1***	2.32±0.1***	2.29±0.1***
HWR (cm/ <sup>3</sup> √kg)	40.1±1.5***	41.5±0.9***	42.7±1.5***	41.0±1.4***	43.2±1.3***	43.7±1.5***
Pelidisi-I. ( <sup>3</sup> √(1/10kg/cm))	104.5±5.2***	99.7±2.7***	98.0±3.4***	102.8±4.5***	97.7±3.2***	96.5±3.4***
Broca-I. (%)	19.0±12.2***	4.0±6.2***	-5.9±11.1***	10.8±10.3***	-6.0±8.3***	-11.4±8.5***
Triceps skinfold (mm) right side	10.2±4.3**	7.0±3.5**	6.4±2.4**	9.6±4.3**	6.1±1.6**	5.8±1.5**
Triceps skinfold (mm) left side	9.5±4.2**	6.7±3.1**	6.5±2.2**	9.1±3.1**	6.1±1.6**	6.5±2.0**
Forearm skinfold (mm) non dominant side	7.7±2.7**	5.3±1.6**	5.5±1.4**	7.2±3.5**	4.7±0.6**	4.9±1.5**
Suprailiac skinfold (mm) right side	8.1±3.2*	5.9±1.6*	7.2±4.9*	8.3±2.6*	5.3±1.5*	6.3±2.6*
Suprailiac skinfold (mm) left side	8.1±3.7**	6.2±1.5**	6.4±4.5**	8.9±2.4**	5.6±1.2**	5.5±2.0**
Subscapular skinfold non dominant side (mm)	11.4±5.2**	10.3±1.9**	10.1±3.4**	12.1±3.2**	9.2±1.7**	10.0±3.2**
Thigh skinfold (mm) non dominant side	17.2±3.2**	13.9±4.0**	11.6±4.2**	17.7±5.3**	13.0±3.1**	13.5±5.8**
Calf skinfold (mm) non dominant side	13.9±4.0***	10.9±2.9***	9.3±3.4***	16.7±5.4***	10.8±2.9***	11.1±4.7***
Head height (cm)	25.0±1.2	24.6±0.9	24.1±1.0	24.2±1.9	24.5±2.5	24.4±0.6
Neck length (cm)	10.3±2.2	10.3±2.0	9.5±0.9	10.5±2.2	11.0±2.9	9.5±0.6
Arm length (cm)	84.9±3.3***	82.2±2.5***	78.1±3.7***	84.1±3.5***	83.0±2.6***	79.1±2.5***
Length of upper arm and forearm (cm)	64.3±3.3***	62.2±2.5***	58.6±4.2***	63.2±2.5***	62.1±2.1***	59.9±2.7***
Upper arm length (cm)	36.7±1.7**	35.5±1.4**	33.6±2.0**	35.4±1.7**	35.1±1.6**	34.2±1.5**
Forearm length (cm)	27.6±2.6*	26.7±1.8*	25.0±3.4*	27.8±1.4*	27.0±1.8*	25.7±1.8*
Hand length (cm)	20.6±1.2	20.0±1.5	19.5±1.4	20.9±1.3	21.0±1.8	19.3±1.0
Leg length (cm)	103.3±5.3*	99.0±4.7*	97.2±4.8*	102.7±4.6*	103.2±4.4*	98.7±2.1*
Length of thigh and calf (cm)	99.1±5.3*	95.0±4.2*	93.3±4.5*	99.1±4.6*	98.8±4.4*	94.3±2.1*
Thigh length (cm)	55.3±3.2**	52.7±2.8**	51.9±2.2**	54.2±2.3**	54.1±2.2**	51.5±1.8**
Calf length (cm)	43.8±2.4	42.4±2.1	41.4±2.4	44.8±2.9	44.7±2.8	42.8±3.2
Metrik-Index/CONRAD	-0.4±0.7***	-0.8±0.2***	-1.1±0.5***	-0.5±0.6***	-1.3±0.5***	-1.4±0.4***
Plastik-Index/CONRAD	100.4±3.7***	97.0±4.4***	88.6±4.8***	97.2±3.6***	92.6±5.5***	87.4±2.5***
Pyknomorphy/ Knussmann	1.5±2.2***	0.0±1.7***	-0.3±1.7***	0.8±2.0***	-1.5±1.4***	-2.4±0.9***

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Makrosomia/ Knussmann	8.8±1.6***	7.1±1.8***	4.9±1.2***	7.6±1.9***	6.7±1.8***	3.4±2.5***
Endomorphy/PARNELL	4.2±0.6***	3.3±0.5***	3.2±0.8***	3.9±0.7***	3.1±0.4***	3.1±0.7***
Mesomorphy/PARNELL	4.8±0.9*	5.2±1.1*	4.2±1.1*	4.8±1.2*	3.9±0.7*	3.4±0.7*
Ektomorphy/PARNELL	1.6±0.7***	2.1±0.7***	3.4±1.4***	1.8±0.8***	3.3±0.9***	3.9±1.1***
Endomorphy/ Heath-Carter	2.9±1.0**	2.1±0.6**	2.1±0.9**	2.7±0.8**	1.8±0.3**	2.0±0.7**
Mesomorphy/ Heath-Carter	5.6±1.1***	4.9±1.2***	4.1±1.1***	5.1±1.1***	3.6±0.7***	3.4±0.9***
Ektomorphy/ Heath-Carter	1.1±0.8***	1.8±0.6***	2.8±1.0***	1.5±0.9***	3.0±1.0***	3.4±1.1***
AKS-Index	1.42±0.10***	1.28±0.10***	1.16±0.10***	1.32±0.10***	1.14±0.10***	1.09±0.10***

Overall, the shot-putters were larger and had the longer legs and arms as compared to the junior javelin throwers. For the smaller javelin throwers of the higher performance category shorter legs compared to the height of the hull were observed on average. There was a notably shorter leg of the spear throwers. The powerful javelin thrower had longer arms than the less powerful.

For all anthropometric widths and depths, and the circumferences and the body weight the junior shout putters achieved higher values than the spear throwers and recreational athletes.

The skinfold thicknesses, the body fat mass and the BMI were highest among the shot putters.

The shot putters had the highest values for endomorphy and pyknomorpha (Knussmann), on the other hand, the lowest values for ectomorphy.

In the following table the correlations between performance and anthropometric / somatotypical parameters are listed.

For the shot putters body height, shoulder width, hand width, food width, chest circumference, minimal forearm circumference, calf circumference, arm span, plastic index and macrosomia were positively related to performance. Some skinfolds (calf, thigh) correlated negatively with the shot put distances.

For the javelin throwers radiale, stylium, dactylium and ectomorphy correlated negatively with the throw widths, but the AKS index, the BMI, the Quetelet index, the Rohrer index, the Livi index, the Pelidisi index, the Broca index, mesomorphy, metric index and plastic index correlated positively with the performance.

**Table 2.** Correlations between anthropometric parameters, best and current shot put distances, best and current javelin throw widths ( $p \leq 0.05$  \*,  $p \leq 0.01$  \*\*,  $p \leq 0.001$  \*\*\*)

r Parameter	Shot putter		Javelin thrower	
	best shot put distance	current shot put distance	best throw width	current throw width
Age	-0.14	-0.38*	0.29	0.27
Height (cm)	0.38*	0.34	-0.32	-0.28
Gnathion (cm)	0.33	0.27	-0.30	-0.25
Suprasternale(cm)	0.35	0.33	-0.32	-0.26
Acromiale (cm)	0.30	0.28	-0.33	-0.30
Radiale (cm)	0.18	0.17	-0.46*	-0.44*
Styilion (cm)	0.19	0.20	-0.43*	-0.39*
Dactylion (cm)	0.21	0.19	-0.45*	-0.44*
Iliocristale (cm)	0.26	0.25	-0.39*	-0.37
Iliospinale (cm)	0.29	0.32	-0.33	-0.28
Trochanterion(cm)	0.16	0.21	-0.42*	-0.40*
Tibiale (cm)	0.31	0.30	-0.39	-0.37
Sphyrion (cm)	0.30	0.36	-0.22	-0.15
Sitting height(cm)	0.36	0.25	-0.13	-0.10
Zygomatic breadth (cm)	-0.07	-0.16	0.09	0.14
Morph.facial height(cm)	0.20	0.27	-0.05	0.00
Arm span (cm)	0.43*	0.40*	0.12	0.13
Shoulder width (cm)	0.48*	0.48*	0.27	0.21
Chest width (cm)	0.40*	0.37	0.37	0.36
Chest depth (cm)	0.03	0.00	0.31	0.28
Pelvis width (cm)	0.41*	0.36	0.26	0.30
Spinal distance	0.43*	0.49*	0.21	0.25
Epiphysis width Humerus cm	0.17	0.11	-0.02	0.02
Radioulnar breadth(cm)	0.47	0.43	0.06	0.03
Hand breadth(cm)	0.45*	0.31	0.16	0.07
Epiphysis width femur	-0.03	-0.03	0.14	0.16
Ankle breadth (cm)	0.36	0.39	0.19	0.13
Neck circumference(cm)	0.57**	0.54**	0.50*	0.48*
Chest circumference, respiratory centre (cm)	0.44*	0.40*	0.49*	0.50**
Chest circumference, in inspiration (cm)	0.43*	0.39*	0.47*	0.46*
Chest circumference, in expiration (cm)	0.44*	0.40*	0.45*	0.46*
Waist circumference cm	0.36	0.30	0.46*	0.42*



r Parameter	Shot putter		Javelin thrower	
	best shot put distance	current shot put distance	best throw width	current throw width
Pelvis circumference	0.36	0.28	0.41*	0.40*
Upper arm circumf. in extension (cm) right side	0.25	0.16	0.50*	0.51**
Upper arm circumf. in flexion (cm) right side	0.23	0.13	0.47*	0.46*
Upper arm circumf. in extension (cm) left side	0.22	0.12	0.47*	0.48*
Upper arm circumf. in flexion (cm) left side	0.17	0.08	0.42*	0.42*
Forearm circumference maximum(cm) right side	0.32	0.25	0.41*	0.39*
Forearm circumference minimum (cm) right side	0.70***	0.61**	0.10	0.07
Forearm circumference maximum(cm) left side	0.19	0.15	0.54**	0.53**
Forearm circumference minimum (cm) left side	0.57**	0.49*	0.33	0.33
Hand circumference(cm) dominant side	0.44*	0.44*	0.44*	0.40*
Thigh circumference (cm) right side	0.22	0.14	0.48*	0.44*
Thigh circumference (cm) left side	0.19	0.11	0.45*	0.42*
Calf circumference (cm) right side	0.62**	0.52**	0.40*	0.37
Calf circumference (cm) left side	0.58**	0.50**	0.44*	0.42*
Lower leg circumference (cm) minimum right side	0.40*	0.42*	0.06	0.08
Lower leg circumference (cm) minimum left side	0.32	0.38*	0.20	0.24
Anthr. foot length (cm)	0.15	0.11	-0.17	-0.15
Techn. foot length (cm)	0.41*	0.36	0.04	0.06
Foot width (cm)	0.44*	0.46*	0.22	0.24
Foot circumference (cm) right side	0.36	0.44*	0.05	0.08
Foot circumference (cm) left side	0.33	0.41*	0.08	0.11
Weight (kg)	0.46	0.38	0.36	0.34
Body fat (%)Caliper	0.10	-0.08	0.21	0.21
Body fat (kg) Caliper	0.19	0.01	0.22	0.23
BMI (kg/m <sup>2</sup> )	0.28	0.21	0.62**	0.58**
Quetelet-I. (g/cm)	0.41*	0.32	0.52**	0.49*
Rohrer-I. (g/cm <sup>3</sup> )	0.12	0.07	0.64**	0.59**
Livi-I.( <sup>3</sup> √g/cm)	0.12	0.07	0.64**	0.59**
HWR (cm <sup>3</sup> √kg)	-0.11	-0.06	-0.64***	-0.59**
Pelidisi-I. ( <sup>3</sup> √(1/10kg/cm))	0.09	0.10	0.51**	0.45*
Broca-I. (%)	0.25	0.18	0.63**	0.59**
Triceps skinfold (mm) right side	0.18	0.08	0.14	0.07
Triceps skinfold (mm) left side	0.01	-0.08	0.07	0.02
Forearm skinfold (mm) non dominant side	0.32	0.39*	0.25	0.29

r Parameter	Shot putter		Javelin thrower	
	best shot put distance	current shot put distance	best throw width	current throw width
Suprailiac skinfold (mm) right side	0.10	-0.08	0.23	0.25
Suprailiac skinfold (mm) left side	-0.01	-0.18	0.22	0.25
Subscapular skinfold non dominant side (mm)	0.35	0.18	0.19	0.16
Thigh skinfold (mm) non dominant side	-0.32	-0.43*	0.12	0.09
Calf skinfold (mm) non dominant side	-0.41*	-0.50*	-0.03	-0.03
Head height (cm)	0.34	0.39*	0.02	-0.03
Neck length (cm)	0.02	-0.08	-0.10	-0.10
Arm length (cm)	0.33	0.32	-0.03	0.03
Length of upper arm and forearm (cm)	0.36	0.31	0.04	0.06
Upper arm length (cm)	0.49*	0.47*	0.30	0.37
Forearm length (cm)	0.08	0.02	-0.20	-0.24
Hand length (cm)	0.03	0.14	-0.10	-0.03
Leg length (cm)	0.28	0.30	-0.33	-0.30
Length of thigh and calf (cm)	0.24	0.26	-0.31	-0.28
Thigh length (cm)	0.24	0.28	-0.17	-0.12
Calf length (cm)	0.20	0.17	-0.37	-0.36
Metrik-Index/CONRAD	0.01	-0.005	0.56**	0.52**
Plastik-Index/CONRAD	0.55**	0.52**	0.41*	0.36
Pyknomorphy/Knussmann	0.02	0.00	0.48*	0.46*
Makrosomia/Knussmann	0.58**	0.58**	0.15	0.10
Endomorphy/PARNELL	0.09	-0.05	0.17	0.15
Mesomorphy/PARNELL	-0.24	-0.19	0.60**	0.59**
Ektomorphy/PARNELL	-0.05	-0.04	-0.60**	-0.55**
Endomorphy/Heath-Carter	0.12	-0.06	0.21	0.18
Mesomorphy/Heath-Carter	0.04	0.00	0.55**	0.54**
Ektomorphy/Heath-Carter	-0.09	-0.04	-0.65***	-0.60**
AKS-Index	0.14	0.13	0.66***	0.60**

## **DISCUSSION**

In an international comparison of body heights and some other selected anthropometric parameters of the investigated shot putters and javelin throwers they rank in the span of the available literature data, as the following table illustrates.

CARTER established in 1984 a common somatotype for the top athletes who participated in the Olympics in Mexico City in 1968 and the Olympics of Montreal in 1976. For the shot putters a somatotype of 3.2 – 7.1 – 1.1, for the javelin throwers of 2.3 – 5.9 – 2.1 was found. In comparison, the higher class shot putters of the present study achieved a mean somatotype of 2.9 – 5.6 – 1.1 and the higher class javelin throwers of 2.1 – 4.9 – 1.8. This results in the greatest variations in both disciplines for the mesomorphic component.

As shot putters and javelin throwers of the present investigation were rather young, there is still a significant development potential for the mesomorphic component. The Olympians were usually about 28 years old on average.

An important result of the present study is a clear sports anthropological picture of the types of constitution for the junior javelin throwers and junior shot putters: While the shot putter is large and heavy, the javelin thrower appears comparatively smaller, lighter and more athletic with higher values of mesomorphy.

**Table 3.** Comparison of selected anthropometric parameters of the investigated shot putters and javelin throwers with available international data

Parameter	Shot putters					Javelin throwers			
	Tittel	Tanner	Correnti/ Zauli	Tittel et al.	This study	Tanner	Correnti/ Zauli	Tittel et al.	This study
Height (cm)	185.1	190.8	187.1	194.5	189.8	186.5	182.3	183.8	183.3
Weight (kg)	92.2	105.0	100.3	114.3	106.7	92.9	87.3	83.9	86.6
Sitting height (cm)		100.9		97.6	97.8	98.1		94.2	95.6
Upper arm length (cm)			36.3	35.1	36.7		35.1	36.3	35.5
Forearm length (cm)				27.8	27.6			26.1	26.7
Hand length (cm)				21.5	20.6			20.5	20.0
Arm length (cm)	85.9	84.2		74.4	84.9	83.6		82.9	82.2
Thigh length (cm)				53.8	55.3			50.1	52.7
Calf length (cm)				45.3	43.8			40.8	42.4
Leg length (cm)	88.7	89.8		99.1	99.1	88.4		90.9	95.0
Foot length (cm)				28.9	26.9			27.7	26.8
Shoulder width (cm)	42.5	46.0	44.0	40.5	46.3	45.3	40.8	41.6	45.2
Chest width (cm)		31.8	31.3	34.0	33.0	30.9	29.4	31.4	30.0
Chest depth (cm)		22.5	22.5	26.0	22.3	22.8		21.9	20.5
Chest circumference, respiratory centre (cm)				115.0	112.7			105.1	103.8
Chest circumference, in inspiration (cm)				118.0	115.0			109.1	106.5
Chest circumference, in expiration (cm)				113.0	111.8			102.3	102.1
Upper arm circumference (cm)		37.6	40.7	37.0	38.1	35.0		32.6	35.6
Thigh circumference (cm)		67.0		65.0	66.3	62.1		57.5	61.1
Calf circumference (cm)			41.3	45.0	43.0	41.4		39.2	39.5
Epiphysis width Humerus (cm)		8.1	7.7		7.1	7.5			6.7
Epiphysis width Femur (cm)		11.1			10.6	10.3			9.9
BMI (kg/m <sup>2</sup> )	26.9	29.1	28.7	30.4	28.8	26.9	26.4	25.0	24.7

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