

## **SPORTS ANTHROPOLOGICAL AND SOMATOTYPICAL COMPARISON BETWEEN MALE WRESTLERS AND HAPKIDOIN OF DIFFERENT PERFORMANCE LEVELS**

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### **ABSTRACT**

The present study compares the anthropometry and somatotyping of  $n = 40$  healthy male wrestlers (age range 15–37 years) and  $n = 40$  Hapkidoin (age range 23–29 years) with respect to various performance categories.

On average, the mean age of wrestlers was lower, compared to hapkidoin. The wrestlers of both performance classes are considerably smaller (mean height 170 cm) than the hapkidoin (high performance class 176.5 cm, lower performance class 180 cm). When comparing the weight classes of the wrestlers, the average body height increases continuously with increasing weight class in conjunction with most other anthropometric parameters.

In the chessboard pattern graphic to Conrad, the hapkidoin appear rather moderately pyknomorphic as well as slender, the wrestlers are moderately leptomorphic and metrosome as well as smaller.

In Parnell's somatochart, the wrestlers have an average somatotype of 5 – 3 – 3, the hapkidoin of 5 – 3 – 4. In the somatochart of Heath & Carter, an average somatotype of 6 – 3 – 2 is shown for both combat sport collectives, whereby the wrestlers tend to the endomorphic axis.

**Keywords:** *sports anthropology; comparison; Hapkido; wrestling; male athletes*

### **INTRODUCTION**

Wrestling represents one of the oldest forms of combat. Babylonian and Egypt reliefs show wrestlers using most of the holds known in the present-day sport. Hapkido (also Hap Ki Do) is a Korean martial art, which originated in Japanese Daitō-ryū Aiki-jūjutsu. Through the influence of other fighting styles

to Hapkido it developed into an independent martial art that is coined by a comprehensive curriculum.

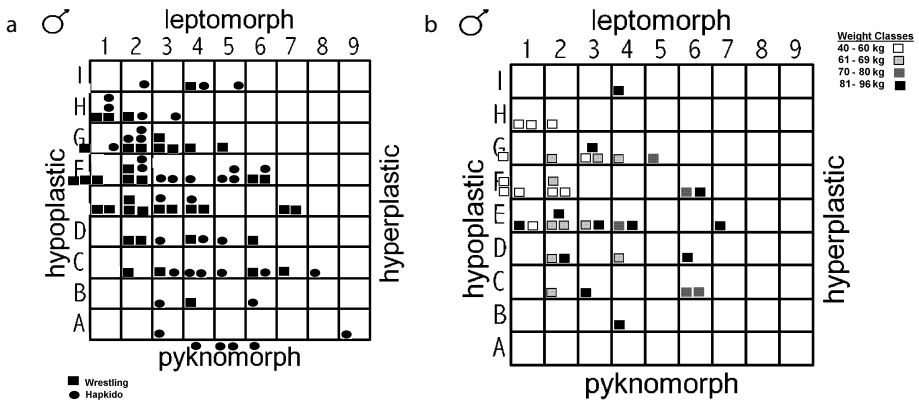
### PARTICIPANTS AND METHODS

The present study compares the anthropometry and somatotyping of n = 40 healthy male wrestlers (age range 15–37 years) and n = 40 Hapkido (age range 23–29 years) with respect to various performance categories.

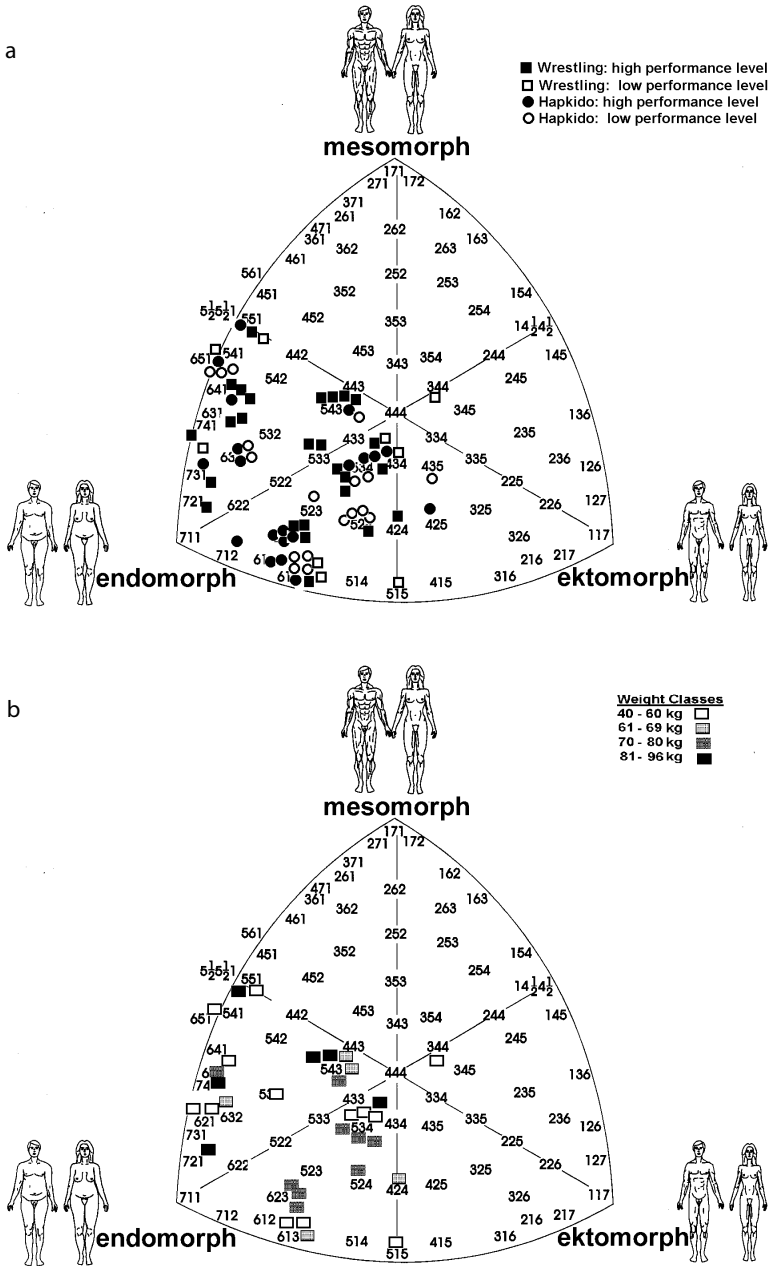
Each proband participated voluntarily and the data were used anonymously. Anthropometric data and computed constitutional and somatotypical parameters in this work correspond to international standards (Conrad 1963, Heath & Carter 1967+1990, Knußmann 1996, Martin & Knußmann 1988, Raschka 2006, Tittel & Wutscherk 1972). The analysis of differences was tested by ANOVA.

### RESULTS

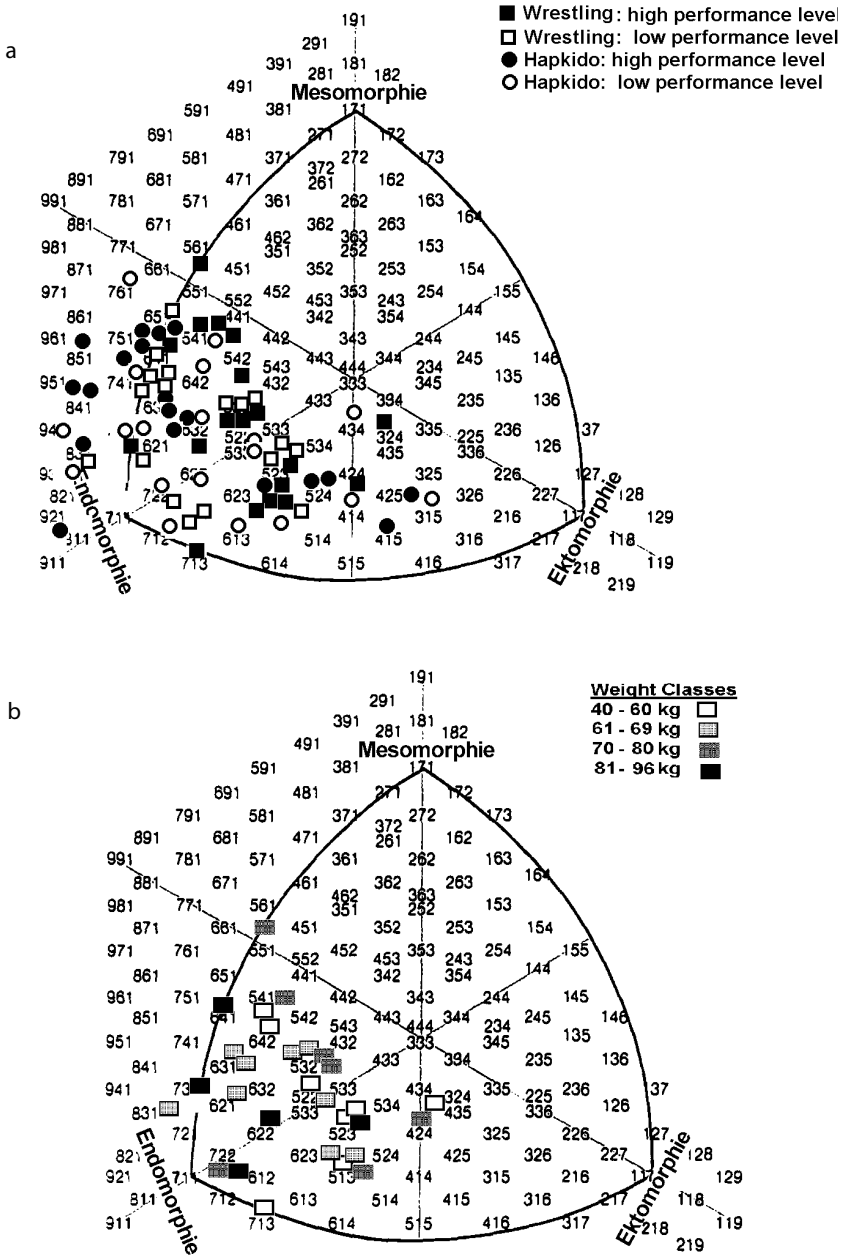
The distribution of constitutional types after Conrad (1963) and the somatotypes after Parnell (1954) and Heath & Carter (1967) are summarized in Figures 1–3.



**Figure 1a+b.** Male constitutional types of wrestlers and Hapkido fighters in the chessboard pattern graphic after Conrad (1963): a) first chessboard graphic: wrestling vs. Hapkido; b) second chessboard graphic: wrestling differentiated according to weight classes.



**Figure 2a+b.** Male constitutional types of wrestlers and Hapkido fighters in the somatochart after Parnell (1954): a) first somatochart: wrestling vs. Hapkido; b) second somatochart: wrestling differentiated according to weight classes.



**Fig. 3a+b.** Male constitutional types of wrestlers and Hapkido fighters in the somatochart after Heath & Carter (1967): a) first somatochart: wrestling vs. Hapkido; b) second somatochart: wrestling differentiated according to weight classes.

The sports anthropometric parameters of male wrestlers and hapkidoin of different performance levels are listed in Table 1, the sports anthropometric parameters of male wrestlers, differentiated according to weight classes, are listed in Table 2.

**Table 1.** Sports anthropometric parameters of male wrestlers and hapkidoin of different performance levels

Parameter	Hapkido Higher Class	Hapkido Lower Class	Wrestling Higher Class	Wrestling Lower Class
Age (years)	33.6±11.9	30.8±11.7	18.9±3.1	20.9±6.2
Height (Vertex; cm)	176.8±6.8	180.1±7.6	170.4±8.6	169.5±8.4
Gnathion (cm)	153.2±6.5	156.2±7.6	147.2±8.0	145.9±7.7
Suprasternale (cm)	144.2±6.3	147.0±6.4	144.2±6.3	147.0±6.4
Acromiale (cm)	146.8±6.9	149.7±6.8	141.5±8.1	140.5±7.4
Radiale (cm)	110.0±6.2	113.9±5.7	106.8±6.0	105.4±6.4
Styilion (cm)	85.8±5.2	88.3±4.9	82.5±5.3	81.8±5.3
Dactyilion (cm)	65.6±4.2	69.6±5.3	62.4±4.0	62.9±6.3
Iliocristale (cm)	106.1±4.9	109.9±5.6	104.0±5.7	103.2±5.7
Iliospinale (cm)	99.7±5.1	102.7±5.6	96.4±5.9	95.8±5.4
Tibiale (cm)	47.4±2.6	49.0±2.4	46.4±3.7	45.4±3.8
Sphyrion (cm)	6.8±1.0	6.2±0.9	6.2±1.1	6.3±1.4
Sitting height (cm)	90.9±3.4	92.9±3.0	88.1±3.7	87.6±4.8
Arm span (cm)	182.2±7.6	182.3±8.1	175.8±9.3	175.2±9.1
Shoulder width (cm)	34.9±3.9	33.6±2.5	31.4±2.5	31.2±2.4
Chest width (cm)	30.9±3.6	31.1±2.9	29.4±2.3	29.7±3.1
Chest depth (cm)	21.5±2.3	21.9±3.9	20.3±1.5	20.4±2.3
Pelvis width (cm)	27.5±2.5	27.7±2.9	25.3±1.4	25.8±2.7
Spinal distance (cm)	23.8±2.5	24.4±2.2	23.2±2.8	23.9±2.5
Epiphysis width Femur (cm)	7.6±1.4	7.6±1.5	6.3±0.7	6.6±0.9
Epiphysis width Humerus (cm)	6.9±0.5	7.0±0.9	6.9±0.6	6.8±0.7
Hand breadth (cm)	8.2±0.8	7.9±0.8	8.3±1.6	7.9±0.6
Middle finger length (cm)	9.7±0.7	9.6±0.9	8.8±0.8	9.1±0.8
Anthropometric foot length relieved	25.8±1.3	26.0±1.3	25.4±1.5	25.4±1.7
Anthropometric foot length loaded	26.1±1.3	26.3±1.4	25.7±1.4	25.9±1.7

Parameter	Hapkido Higher Class	Hapkido Lower Class	Wrestling Higher Class	Wrestling Lower Class
Technological foot length	20.9±1.6	20.9±2.1	20.8±1.4	20.8±1.5
Height of head	23.6±1.5	23.9±1.4	23.2±1.6	23.7±1.5
Neck length	9.0±1.7	9.2±2.2	9.0±2.1	8.7±1.5
Arm length	81.1±3.6	80.1±5.8	79.4±5.2	77.5±5.5
Upper and lower arm length	61.0±2.7	61.4±3.2	59.0±3.2	59.2±2.7
Upper arm length	36.7±2.5	35.7±2.1	34.6±2.9	35.1±2.1
Lower arm length	25.1±1.8	25.6±1.6	24.4±1.8	23.8±1.8
Hand length	20.1±1.7	19.7±1.6	20.1±2.1	19.8±2.1
Morphologic leg length	94.7±5.1	97.7±5.6	92.9±5.9	92.0±4.7
Physiognomic leg length	85.8±5.8	87.3±4.9	82.3±5.6	81.8±4.9
Thigh and lower leg length	88.9±4.6	92.6±5.1	87.2±6.2	85.9±5.0
Thigh length	48.5±3.2	49.8±3.7	47.3±5.8	46.7±3.5
Lower leg length	40.6±2.3	42.8±2.0	40.3±3.6	39.1±3.6
Heel width	6.1±0.6	6.1±0.5	5.9±0.3	5.9±0.3
Foot width	10.2±0.7	10.3±0.6	9.5±0.7	9.7±0.8
Neck circumference (cm)	38.1±2.5	39.1±2.3	40.2±1.8	38.7±3.2
Chest circumference (respiratory centre, cm)	94.9±8.1	96.9±9.9	92.9±6.1	96.9±26.7
Chest circumference in inspiration (cm)	100.6±7.2	102.6±8.9	97.6±5.9	97.9±7.8
Chest circumference in expiration (cm)	92.4±8.3	94.3±9.2	90.6±5.9	89.8±7.6
Waist circumference (cm)	83.9±9.5	84.7±10.8	77.3±4.5	77.3±6.9
Pelvis circumference (cm)	89.6±8.6	90.4±9.5	84.8±8.5	86.2±8.6
Upper arm circumference in flexion (cm)	33.9±2.9	33.2±2.9	34.9±2.7	33.3±4.2
Upper arm circumference extension(cm)	30.4±2.9	29.9±2.7	30.8±2.8	29.7±3.6
Forearm circumf. maximum (cm), dominant side	27.3±1.9	27.5±2.1	28.1±1.6	27.6±2.7
Forearm circumference minimum (cm)	17.3±1.3	17.4±1.2	17.7±1.2	17.4±1.2
Hand circumference (cm)	20.6±1.2	20.4±1.5	20.9±1.2	20.3±1.4
Thigh circumference (cm)	54.9±4.0	54.8±4.4	54.5±3.5	53.1±4.9
Calf circumference (cm)	37.9±2.7	37.6±3.1	35.7±2.2	35.9±3.3
Lower leg circumference minimum (cm)	25.3±2.4	25.0±1.8	23.3±1.8	23.6±1.8

Parameter	Hapkido Higher Class	Hapkido Lower Class	Wrestling Higher Class	Wrestling Lower Class
Foot circumference (cm)	25.9±1.6	26.1±1.4	24.8±1.1	24.8±1.9
Morphological facial height (cm)	12.6±1.0	12.7±0.9	12.5±1.1	12.3±0.9
Zygomatic breadth (cm)	12.5±1.2	12.8±1.1	12.1±0.8	12.1±1.1
Subscapular skinfold (mm)	20.8±7.6	19.9±8.0	15.7±4.9	15.3±4.4
Triceps skinfold (mm)	23.1±5.9	22.3±5.6	20.5±3.9	24.7±4.2
Forearm skinfold (mm)	9.8±2.7	9.6±2.7	14.1±2.1	14.4±2.3
Suprailiac skinfold (mm)	26.5±11.3	25.7±9.2	16.9±5.2	18.8±5.9
Thigh skinfold (mm)	20.3±7.4	17.6±5.5	19.9±4.8	21.8±8.9
Calf skinfold (mm)	17.4±6.9	17.3±6.2	20.2±4.7	21.5±5.2
Body fat percentage (calipermetry;%)	27.7±9.5	24.5±8.6	18.6±4.5	19.9±5.2
Body fat percentage (BIA;%)	19.1±5.2	18.2±7.0	18.7±8.2	19.6±9.3
Plastik-Index after Conrad	83.3±5.5	81.4±5.2	80.5±4.5	79.2±5.5
Metrik-Index after Conrad	-0.1±0.9	-0.3±0.9	-0.5±0.4	-0.4±0.6
Pyknomorphy after Knußmann	-6.8±3.3	-5.9±1.5	-4.8±1.5	-4.8±1.8
Makrosomia after Knußmann	-2.0±2.5	-1.7±3.1	-3.3±3.1	-3.3±2.6
Endomorphy after Parnell	5.3±0.8	5.1±0.5	5.1±0.7	5.3±0.4
Mesomorphy after Parnell	2.5±1.2	2.3±1.1	2.9±1.4	2.8±1.0
Ectomorphy after Parnell	3.9±1.4	4.0±1.0	2.9±0.9	3.1±0.9
Endomorphy after Heath&Carter	6.2±1.7	6.0±1.6	5.2±0.9	5.7±0.7
Mesomorphy after Heath&Carter	3.0±1.5	2.5±1.3	2.6±1.4	2.6±1.0
Ectomorphy after Heath&Carter	2.0±1.4	2.1±1.1	1.6±0.8	1.8±0.9
Body weight (kg)	77.9±12.5	81.5±14.6	71.3±10.5	70.3±13.9
BMI (kg/m <sup>2</sup> )	24.6±3.5	25.0±3.1	24.4±2.1	24.1±2.9
Pelidisi-Index (kg/cm)	100.9±6.2	100.2±4.2	101.2±2.7	101.0±3.3
Quetelet-Index (g/cm)	4.4±0.6	4.5±0.7	4.2±0.5	4.1±0.6
Lean Body Mass LBM (kg)	77.8±12.5	81.5±14.5	71.3±10.5	70.3±13.9
AKS-Index (BIA)	1.1±0.3	0.9±0.2	1.2±0.2	1.2±0.2
AKS-Index (Caliper)	1.0±0.2	1.0±0.2	1.2±0.2	1.2±0.1
Body Surface (m <sup>2</sup> )	1.9±0.2	2.0±0.2	1.8±0.2	1.8±0.2
Rohrer-Index (g/cm <sup>3</sup> )	1.4±0.2	1.4±0.2	1.4±0.1	1.4±0.1
Broca-Index (%)	0.7±14.1	1.3±12.2	1.4±8.4	1.0±11.2
Height-Weight-Ratio (inches/3.√lb)	13.0±0.7	13.0±0.5	12.9±0.4	12.9±0.4

**Table 2.** Sports anthropometric parameters of male wrestlers, differentiated according to weight classes

Parameter – male wrestlers – weight classes	40–60 kg	61–69 kg	70–80 kg	81–96 kg
Age (years)	17.6±3.6	19.8±3.8	19.8±4.1	23.1±7.3
Height (Vertex; cm)	160.6±4.4	168.1±3.7	172.4±4.7	181.6±3.2
Gnathion (cm)	138.4±4.2	144.6±4.1	148.7±4.3	157.3±3.8
Suprasternale (cm)	129.8±3.6	135.9±3.4	140.2±3.6	147.4±2.8
Acromiale (cm)	132.8±4.0	139.2±4.1	143.3±4.4	151.3±4.0
Radiale (cm)	99.9±3.9	104.9±2.6	107.2±4.2	114.6±3.0
Styilion (cm)	76.4±2.5	81.1±2.5	83.8±3.3	89.1±2.8
Dactyilion (cm)	57.8±2.9	61.8±1.4	63.1±2.8	69.8±5.3
Iliocristale (cm)	98.3±3.3	101.9±2.2	104.9±4.4	111.2±3.3
Iliospinale (cm)	90.6±3.1	94.4±2.6	97.8±4.5	103.4±2.7
Tibiale (cm)	42.9±3.2	45.7±2.2	47.1±3.2	48.8±4.0
Sphyrion (cm)	6.1±1.2	5.7±0.6	6.3±0.9	7.1±1.9
Sitting height (cm)	83.5±3.6	87.3±2.2	88.9±2.5	93.1±1.9
Arm span (cm)	166.6±5.1	172.5±6.3	178.2±4.4	187.9±4.6
Shoulder width (cm)	29.5±1.8	30.9±1.7	31.5±2.1	34.1±1.8
Chest width (cm)	26.7±1.5	29.1±1.2	30.5±2.1	32.9±1.3
Chest depth (cm)	18.8±1.6	20.1±1.8	20.6±0.8	22.3±1.9
Pelvis width (cm)	24.4±1.4	25.2±0.9	25.4±2.4	27.9±2.0
Spinal distance (cm)	22.9±2.7	22.6±3.1	23.6±1.6	25.8±2.2
Epiphysis width Humerus (cm)	6.6±0.7	6.9±0.5	6.8±0.6	7.4±0.4
Epiphysis width Femur (cm)	8.1±0.6	8.3±0.6	8.3±0.9	9.1±0.9
Middle finger length (cm)	6.4±0.5	7.9±0.8	7.9±0.3	9.0±0.9
Anthropometric foot length relieved	23.9±0.9	25.0±1.0	25.9±1.1	27.3±1.0
Anthropometric foot length loaded	24.5±0.7	25.2±1.0	26.2±1.1	27.8±1.2
Technological foot length	19.3±0.9	20.5±1.2	20.9±1.0	22.6±1.2
Height of head	22.2±1.6	23.6±1.2	23.7±1.5	24.3±1.6
Neck length	8.6±1.4	8.7±2.6	8.5±1.5	9.9±1.5
Arm length	75.0±2.2	77.5±3.5	80.1±2.2	82.3±9.4
Upper and lower arm length	57.0±2.7	58.2±2.4	59.9±1.8	62.1±2.1
Upper arm length	32.8±2.6	34.3±1.8	36.1±1.7	36.6±2.2
Lower arm length	23.6±2.2	23.8±1.4	23.9±1.8	25.6±1.2
Hand length	18.6±1.5	19.3±1.8	20.2±1.5	22.3±1.9



Parameter – male wrestlers – weight classes	40–60 kg	61–69 kg	70–80 kg	81–96 kg
Morphologic leg length	87.4±2.8	91.8±4.9	93.7±4.0	98.6±2.4
Physiognomic leg length	77.1±3.8	80.8±2.6	83.6±3.4	88.4±3.7
Thigh and lower leg length	81.3±3.8	86.4±4.9	87.8±3.9	92.5±4.1
Thigh length	44.4±2.8	46.5±6.8	47.2±2.1	50.9±4.1
Lower leg length	36.9±3.4	39.9±2.4	40.7±2.9	41.7±4.0
Heel width	5.8±0.4	5.9±0.3	5.8±0.3	6.1±0.2
Foot width	9.3±0.8	9.6±0.7	9.6±0.7	10.0±0.9
Neck circumference (cm)	36.4±2.1	40.1±1.8	39.9±1.1	42.4±1.0
Chest circumference (respiratory centre, cm)	83.8±3.5	91.4±2.2	95.0±2.9	102.0±3.2
Chest circumference in inspiration (cm)	89.6±3.3	96.4±2.2	100.3±2.7	107.1±3.3
Chest circumference in expiration (cm)	82.2±3.7	89.5±1.9	92.4±2.8	99.3±3.2
Waist circumference (cm)	71.8±3.3	76.1±2.3	77.6±4.1	85.8±2.4
Pelvis circumference (cm)	81.4±5.2	84.1±7.6	86.4±6.7	91.8±12.0
Upper arm circumference in flexion (cm)	30.4±2.8	34.5±2.6	34.2±2.1	38.4±1.9
Upper arm circumference extension(cm)	26.7±2.1	30.2±2.1	30.9±1.7	34.3±1.8
Forearm circumf. maximum (cm), dominant side	25.4±1.3	27.8±0.8	28.3±1.4	30.8±1.2
Forearm circumference minimum (cm)	16.5±0.6	17.7±1.0	17.7±1.1	18.7±0.9
Hand circumference (cm)	19.9±1.2	20.7±0.8	20.3±1.2	22.0±1.3
Thigh circumference (cm)	49.4±3.7	54.0±2.2	54.6±1.9	58.6±3.6
Calf circumference (cm)	33.2±2.0	35.6±2.1	36.5±2.0	38.9±2.1
Lower leg circumference minimum (cm)	21.9±1.6	23.2±1.1	23.7±1.1	25.5±1.4
Foot circumference (cm)	23.7±1.5	24.8±0.9	24.7±1.2	26.3±1.8
Morphological facial height (cm)	11.9±0.7	12.3±1.2	12.6±1.0	12.9±0.8
Zygomatic breadth (cm)	11.6±1.2	12.2±0.7	12.2±0.7	12.6±1.1
Subscapular skinfold (mm)	13.0±4.3	14.4±3.0	16.2±3.9	19.3±5.2
Triceps skinfold (mm)	21.2±4.9	21.2±5.4	23.7±3.1	24.8±3.9
Forearm skinfold (mm)	14.8±2.6	14.3±2.7	13.6±1.7	14.3±1.4
Suprailiac skinfold (mm)	17.0±5.4	15.3±2.8	19.5±7.0	20.1±5.5
Thigh skinfold (mm)	21.5±7.8	21.0±7.1	17.4±5.5	24.7±7.1
Calf skinfold (mm)	21.2±5.4	19.7±5.6	19.5±3.5	23.6±5.0
Body fat percentage (calipermetry; %)	17.4±5.0	17.7±2.3	20.7±5.6	22.0±4.8
Body fat percentage (BIA;%)	20.2±11.6	18.4±7.9	19.6±9.8	18.0±2.6

Parameter – male wrestlers – weight classes	40–60 kg	61–69 kg	70–80 kg	81–96 kg
Plastik-Index after Conrad	74.7±2.8	79.3±1.9	80.2±3.3	86.9±2.7
Metrik-Index after Conrad	-0.8±0.3	-0.4±0.4	-0.4±0.6	-0.2±0.4
Pyknomorphy after Knußmann	-5.1±1.6	-4.7±1.4	-4.7±1.8	-4.9±1.8
Makrosomia after Knußmann	-5.3±2.0	-4.4±2.6	-2.9±1.8	0.3±0.9
Endomorphy after Parnell	5.1±0.8	5.1±0.3	5.4±0.6	5.4±0.6
Mesomorphy after Parnell	2.6±1.4	3.3±1.4	2.6±1.0	3.1±1.1
Ectomorphy after Parnell	3.4±1.0	2.9±0.9	2.8±0.9	2.8±0.5
Endomorphy after Heath&Carter	5.3±1.0	5.1±0.7	5.6±0.8	5.8±0.8
Mesomorphy after Heath&Carter	2.2±1.2	2.8±1.6	2.5±0.9	3.2±1.0
Ectomorphy after Heath&Carter	2.2±1.0	1.6±0.7	1.6±0.8	1.3±0.5
Body weight (kg)	56.4±5.3	68.2±1.7	74.0±3.6	89.3±4.3
BMI (kg/m <sup>2</sup> )	21.8±2.2	24.0±1.7	24.9±1.6	26.9±1.4
Pelidisi-Index (kg/cm)	98.8±3.2	100.9±2.8	101.8±2.4	101.8±2.4
Quetelet-Index (g/cm)	3.5±0.3	4.1±0.2	4.3±0.2	4.9±0.2
Lean Body Mass LBM (kg)	56.4±5.3	68.2±1.7	74.0±3.6	89.3±4.3
AKS-Index (BIA)	1.1±0.2	1.2±0.2	1.2±0.2	1.2±0.2
AKS-Index (Caliper)	1.2±0.2	1.2±0.2	1.2±0.1	1.1±0.1
Body Surface (m <sup>2</sup> )	1.6±0.1	1.8±0.0	1.9±0.1	2.1±0.1
Rohrer-Index (g/cm <sup>3</sup> )	1.4±0.2	1.4±0.1	1.5±0.1	1.5±0.1
Broca-Index (%)	-6.6±1.0	0.5±6.9	2.5±7.3	9.9±4.4

## DISCUSSION

On average, the mean age of wrestlers was lower (18.9 years in the higher performance class and 20.9 years in the lower performance class), compared to hapkidoin (33.5 years in the higher performance class, 30.8 years in the lower performance class). The differences are explained by the fact that wrestling is primarily exercised as a sport, hapkido rather as a hobby.

The wrestlers of both performance classes are considerably smaller (mean height 170 cm) than the hapkidoin (high performance class 176.5 cm, lower performance class 180 cm). When comparing the weight classes of the wrestlers, the average body height increases continuously with increasing weight class in conjunction with most other anthropometric parameters.

In the chessboard pattern graphic to Conrad, the hapkidoin appear rather moderately pyknomorphic as well as slender, the wrestlers are moderately leptomorphic and metrosome as well as smaller.

In Knussmann's typology the hapkidoin have a more muscular appearance. The wrestlers tend to microsomy and leptomorphy.

In Parnell's somatochart, the wrestlers have an average somatotype of 5 – 3 – 3, the hapkidoin of 5 – 3 – 4.

In the somatochart of Heath & Carter, an average somatotype of 6 – 3 – 2 is shown for both combat sport collectives, whereby the wrestlers tend to align themselves to the endomorphic axis.

While hapkidoin have not yet been investigated, the average somatotypes of Judoka were 3.6 – 7 – 1.9 (Farmosi 1980), Karateka 2.6 – 5.2 – 2.6 (Claessens et al., 1986) and a mixture type (whu-shu, kung-fu, karate, judo) at 2.7 – 4.7 – 2.7 (Gualdi-Russo et al., 1993).

In further studies the different wrestling styles like Freestyle and Graeco-Roman style are to be investigated and compared.

## REFERENCES

1. Claessens A., Beunen G., Lefevre J., Martens G., Wellens R. (1986). Body structure, somatotype, and motor fitness of top-class Belgian judoists and karateka: a comparative study. In *Kinanthropometry III*, ed. T. Reilly, J. Watkins, and J. Borms, 53–57. London: E. & F.N. Spon.
2. Conrad K. (1963). *Der Konstitutionstypus*. Berlin: Springer.
3. Farmosi I. (1980). Body-composition, somatotype and some motor performance of judoists. *Sports Med Phys Fitness*, 20, 431–434.
4. Gualdi-Russo E., Graziani I. (1993). Anthropometric somatotype of Italian sport participants. *J Sports Med Phys Fitness*, 33, 282–291.
5. Heath B.H., Carter L.J.E. (1967). A modified somatotype method. *Am J Phys Anthropol*, 27, 57–74.
6. Heath B.H., Carter L.J.E. (1990). *Somatotyping – development and applications*. Cambridge Studies in Biological Anthropology. Redwood Press.
7. Knußmann R. (1996). *Vergleichende Biologie des Menschen*. Lehrbuch der Anthropologie. Stuttgart: Gustav Fischer.
8. Kretschmer E. (1921). *Körperbau und Charakter*. Berlin: Springer.
9. Martin R., Knußmann R. (1988). *Anthropologie*. Handbuch. Band I. Stuttgart: Fischer.
10. Parnell R.W. (1954). Somatotyping by physical anthropometry. *Am J Phys Anthropol*, 12, 209–239.

11. Raschka C. (2006). Sportanthropologie. Köln: Sportverlag Strauß.
12. Tittel K., Wutscherk H. (1972). Sportanthropometrie. Leipzig: Barth.

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