

ANTHROPOMETRIC AND MORPHOLOGICAL CHARACTERISTICS OF RUNNERS

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Summary

In this study we present the anthropometric and morphological characteristics of 46 national level track-and-field athletes. 20 morphological body measures were taken on a sample of 15 sprinters (S), 13 endurance sprinters (S4), 9 middle-distance runners (MD) and 9 long-distance runners (LD). Body fat percentage, body mass index and body constitution type were also calculated. Canonical discriminative analysis showed significant difference between the athletes of various running events, for the measures of body volume and body fat, and no significant difference in the variables of longitudinal and transversal dimensions of the skeleton. ANOVA and Student t-test for independent samples showed statistically significantly higher thigh and lower leg circumference in sprinters, as well as greater upper arm skinfold in middle-distance runners. The mesomorphic component is a dominant characteristic of body constitution of the runners in all events, whereas the ectomorphic component is the least marked.

Key words: runners, track&field, anthropometrics, body composition, discriminative analysis

Introduction

The measurement and apprehension of the basic morphological characteristics of the athlete is the foundation on which a training process may be built. Specific anthropometric characteristics are needed to be successful in certain sporting events, although, expert opinions often differ when it comes to this matter. Body composition analysis is also a standard procedure, that helps to improve and optimise the athlete's training process, as well as to determine health status and eventual osteoporosis or obesity.

There are number of papers dealing with anthropometrics and body type of athletes in various sports (Heath et al., 1967), as well as different playing positions in a specific sport (Matković et al., 2003, Jeličić et al, 2002). Rare, but very interesting are studies on the influence of morphological characteristics on top sport achievements, as the research carried out on javelin throwers (Čoh and co., 2002). Running events in track-and-field are marked by an exceptional variety of duration of a single event, energetic demands and the tempo of energy release. Considering the fact that runners need to carry their weight, which means they need to overcome the force of gravity on different distances, unlike, for example, rowers and swimmers, this stipulates a specific (lean) body composition as a prerequisite for more efficient and economic performance in a single event.

Although previous research has demonstrated that athletes in all running events have less body fat compared to most other disciplines (Martin et al., 1997; Jackson et al., 1985; Gore, 2000; Matković et al., 2003.; Medved, 1987; Hawes and Sovak, 1994), according to our knowledge, no systematic research regarding the morphological characteristics of the athletes in various running events, has been conducted so far.

The aim of this study is to investigate morphological (volume and body composition) and anthropometric (longitudinal and transversal dimensions of the skeleton) characteristics and eventual differences between top national track-and-field athletes, in regard to specific events (sprinters, endurance sprinters, middle-distance and long-distance runners).

Subjects and methods

The sample consisted of 46 runners, divided in four groups: 15 sprinters (100 and 200m, S), 13 endurance sprinters (400m, S4), 9 middle-distance runners (MD) and 9 long-distance runners (LD). The average age of all runners was 21.2 ± 4.9 yrs (S= 20.9 ± 4.9 ; S4= 20.2 ± 5.1 ; MD= 18.8 ± 2.4 and LD= 25.4 ± 4.3). All subjects are ranked in the top 15 on the Croatian Athletic Association rank-list for the specific event.

All measurements were conducted at the Sports Diagnostic centre at the Faculty of Kinesiology, University of Zagreb, according to the standards and instructions of the International Biological Program. 20 morphological body measures were taken: height, weight, leg length, arm length, arm span, shoulder width, elbow diameter, knee diameter, circumferences of upper arm, forearm, thigh, lower leg, chest and abdomen, skinfolds of the back, upper arm, chest, abdomen, thigh, lower leg and suprailliac. Body composition (percentage of lean body mass and body fat), body mass index and body somatotype (according to Heath-Carter, 1984) were calculated from anthropometric measures.

Body composition of the athletes was assessed by the skinfold method (Jackson et al, 1985), and the equation for the assessment of body density (BD). The value of body density was inserted into the equation for the estimation of body fat (% of the body fat = $(495/BD - 450)$; Siri, 1956). New methods for assessment of body composition are developed, but it appears that the skinfold method is still the standard, when it comes to practical field and/or even laboratory testing.

The method of Heath and Carter, which is based on the Sheldon's somatotype classification, was applied to determine the somatotype characteristics. Somatotype is defined by three numbers which express the value of three components:

- a) endomorph - a human physical type (somatotype) tending toward roundness, being calculated from the value of three skinfolds,
- b) mesomorph - a human physical type (somatotype) that is marked by greater than average muscular development, being calculated from muscular-skeletal characteristics, height, circular dimensions of the limbs (upper arm and lower leg), and elbow and knee diameter,
- c) ectomorph - a human physical type (somatotype) tending toward linearity, which expresses the longitudinal dimension of the body, regarding the height and weight.

Basic statistical descriptive parameters have been calculated - mean (AS), standard deviation (SD), range (R), for all subjects and for each group (S, S4, MD, LD) separately. The differences between the groups were analysed with the canonical discriminant analysis. The differences between all groups of runners in the manifested space have been analysed by ANOVA, whereas paired t-tests for independent variables were used to test the differences between particular variables between groups.

Results and discussion

The wide age span, from 17 to 36 years of age, confirms the fact that runners can maintain their sports career for very long, which is especially noticeable in sprint and long-distance events (especially half-marathon and marathon). In this sample, which comprised athletes of different running events who were, or still are a part of the junior or senior national team, the youngest athletes were middle-distance runners and the oldest, expectedly, were long-distance runners.

Basic descriptive parameters and the results of ANOVA for anthropometric and morphological characteristics of the subjects are shown in Table 1. The average height of all subjects, as well as for particular groups, is almost identical to the average height of the male population in Croatia (Mišigoj–Duraković, 1996). The lack of specific measures of longitudinal body dimensionality for any group of runners, implies that those measures cannot be used in the selection of children for specific running events.

The values of body fat percentage and the sum of all skinfolds indicate that runners, regardless the event, have prominently less body fat compared to other athletes of most sport disciplines (Martin et al., 1997; Jackson et al., 1985; Gore, 2000). The only statistically significant difference between groups is for the upper arm skinfold, which was higher in middle-distance runners compared to others. The lowest body mass index (the relation between weight and square height) was in distance runners, and the highest in sprinters. Considering similar body fat percentage in all groups, higher BMI indicates higher lean body mass, which is confirmed by the values of the mesomorph component, as well as by the values of the circumference parameters of the limbs (Table 1). Sprinters had the highest values in all body volume measures, 400 meter runners had slightly lower values, whereas middle and long-distance runners had about equal values. Sprinters have a significantly higher circumference of the lower leg, compared to all other groups of runners ($p < 0,05$), while the circumference of the thigh differed only between sprinters and long-distance runners ($p < 0,05$). The same trend is observed for other body volume parameters, and is open for debate what the results would be for a larger sample of subjects, tested during the competitive part of the season.

The somatotype of croatian runners is similar between groups. They have a moderate ectomorph constitution, which means a moderate muscularity and elongated shape, as the dominant features of the constitution. The endomorphic component is the least developed, as expected. The somatotype of croatian runners is comparable to the somatotype of the 1984 Olympics participants (Carter, 1984): sprinters 1,7 – 5,2 – 2,8, 400 meter runners 1,5 – 4,6 – 3,4, middle-distance runners 1,5 – 4,3 – 3,6, long-distance runners 1,4 – 4,2 – 3,7. The endomorphic component is somewhat more marked in our runners, while the mesomorphic, and even more the ectomorphic component are less marked. One might question the influence of the annual phase in the training cycle on the variation of anthropometric and morphologic features. This study was performed at the beginning of the annual training cycle, so we could assume a somewhat higher body fat percentage and endomorphic component.

Table 1. Average values and results of ANOVA for anthropometric and morphological characteristics of subjects

	AS ± SD (n=46)	S (n=15)	S4 (n=13)	MD (n=9)	LD (n=9)	F	p-level
Height (cm)	181.4±5.7	182.5	181.3	180.8	180.2	0.19	0.90
Leg length (cm)	102.6±3.4	103.1	102.5	102.3	102.2	0.15	0.93
Arm length (cm)	78.8±3.1	79.5	78.4	77.4	79.7	1.62	0.20
Arm span (cm)	182.7±6.9	183.9	182.1	179.8	184.1	0.98	0.41
Knee diameter (cm)	9.6±0.5	9.8	9.67	9.64	9.36	1.94	0.14
Elbow diameter (cm)	6.9±0.3	6.9	6.9	6.9	6.8	0.69	0.56
Shoulder width (cm)	40.8±1.7	41.1	40.3	40.6	41.3	0.59	0.63
Circ. of the upper leg(cm)	56.0±3.0	57.5	55.9	55.5	54.3	2.35	0.09
Circ. of the upper arm (cm)	28.5±2.3	28.9	28.9	27.6	27.8	1.08	0.37
Circ. of the forearm (cm)	26.3±1.4	26.4	27.1	25.6	26.0	2.39	0.08
Circ. of the lower leg (cm)	37.1±1.8	38.3	36.8	36.1	36.6	4.02	0.01
Circ. of the abdomen (cm)	78.3±3.7	79.1	78.3	78.5	77.4	0.56	0.64
Skinfold of the back (mm)	8.4±1.9	8.2	8.6	9.1	7.9	0.63	0.60
Skinfold of the upper arm(mm)	6.7±2.1	6.3	6.0	8.78	6.7	3.92	0.01
Skinfold of the thigh (mm)	8.7±3.6	7.8	7.7	10.4	9.6	1.31	0.29
Skinfold of the chest (mm)	4.7±1.3	4.6	4.5	5.3	4.8	0.84	0.48
Skin-fold of the shank (mm)	5.5±1.9	5.6	5.1	5.9	5.3	0.42	0.74
Skinfold suprailliacal (mm)	7.0±3.7	5.9	7.2	9.7	6.0	2.52	0.07
Skinfold of the abdomen (mm)	8.2±3.9	8.4	7.5	10.0	7.5	1.02	0.39
Body weight (Kg)	72.4±6.6	75.1	72.6	70.2	70.2	1.37	0.27
Body fat percentage (%)	5.9±2.3	5.5	5.4	7.1	6.3	1.22	0.31
Body mass index	21.9±1.6	22.6	22.0	21.5	21.4	1.46	0.24
Sum of 7 skinfolds (mm)	49.2±14.9	46.9	46.6	59.3	46.8	1.79	0.16
S_I – endomorph com.	2.2±0.74	1.9	2.2	2.7	1.9	2.70	0.06
S_II– mesomorph com.	3.7±0.9	4.0	3.9	3.6	3.2	1.50	0.23
S_III- ectomorph com.	3.4±0.9	3.2	3.2	3.6	3.6	0.77	0.52

Legend: see page 2

The latent differences between the groups of runners have been analysed by the use of canonical discriminant analysis (Table 2). The hypothetical existence of morphological distinctions between the athletes of various running events has been confirmed (Canonical $R_1=0,85$; $p<0,05$). The centroid of the sprinters group has been polarised to one pole ($C_S = 2,13$), and the centroid of the long-distance runners and 400 meter runners has been polarised on the other pole of the first (and only statistically significant) discriminative function ($C_{LD} = -1,73$ i $C_{S4} = -1,15$). The centroid of the middle-distance runners took position in the middle of the discriminative function ($C_{MD} = 0,31$). No single measure contributed to the factorial structure of the discriminative function, most probably because of the high correlation of anthropometric and morphological variables.

The results of a separate canonical discriminant analysis based only on the variables for body volume, mass and body composition measures are presented in Table 2. The first statistically significant discriminative function ($p<0,01$) clearly explained the difference between the groups of athletes of various running events. The position of the sprinters group centroid on the negative pole ($C_S = -1,24$), and the position of the long-distance, middle-distance and 400 meter runners centroid on the positive pole of the discriminative function ($C_{LD} = 1,01$, $C_{MD} = 0,38$ i $C_{S4} = 0,47$) confirmed previous statements that short-distance runners are more muscular (Table 2.). Namely, the factorial structure of the first discriminative function emphasises the influence of the volume and body mass variables, especially the musculature of the lower extremities (circumference of the thigh and lower leg). The musculature of the lower extremities generates strong, powerful movements starting from the reaction and pushing out of the starting block, through the acceleration, and maintenance of the maximal velocity on the running distance.

Table 2. Results of canonical discriminant analysis for the variables of body volume, mass, and body fat of the subjects

	DF 1	DF 2	DF 3
Thigh circumference upper leg	-0.42	-0.14	-0.07
Upper arm circumfer. upper arm	-0.17	-0.20	-0.31
Forearm circumfer. forearm	-0.01	-0.27	-0.66
Lower leg circumfer. shank	-0.50	0.22	-0.39
Abdomen circumfer the abdomen	-0.13	-0.17	0.07
Body weight	-0.30	-0.01	-0.26
Body fat percentage	0.11	0.02	0.49
Body mass index	-0.31	-0.10	-0.22
Sum of 7 skinfolds Σ KN	0.08	-0.11	0.60
	DF 1	DF 2	DF 3
LD	1.01	1.06	-0.20
MD	0.38	-0.30	1.04
S	-1.24	0.21	-0.07
S4	0.47	-0.77	-0.50
Rc	0.68	0.56	0.49
p-level	0.01	0.07	0.15

Diskriminant functions (DF), canonical correlation (Rc), error size (p)

The centroid position on the discriminative function, voluminosity (body weight and circumferences of different body segments) and body fat, of the group of long-distance runners is determined primarily by lower circumferences of the thigh and lower leg. Namely, the weekly training volume of the long-distance runners often reaches 180 km or more. Considering the fact that such training regime is characterised by moderate intensity, higher muscular mass gives no advantage, and, as well as excessive body fat, would make an unnecessary extra load.

The centroid position of the 400m and middle-distance runners group placed in the middle between the sprinters and long-distance runners is logical and expected, regarding the energy demands of such events, as well as the volume and characteristics of the training process. Top performers in 400m, 800m and 1500m events demand highly developed aerobic and anaerobic systems (Janssen, 2001; Martin et al. 1997), although the share of particular energy sources varies in differing proportion from event to event – the shorter the track, the more dominant is the anaerobic energy supply, and *vice versa*, in long-distance events it is mostly aerobic.

Conclusion

Average values of the basic anthropometric measures (weight and height) of Croatian nationally top-ranked runners in various running events are similar to those of the general population. In comparison to the general population, as well as to other sports disciplines, track-and-field athletes have lower body fat percentage, and statistically significantly higher values for circumferences of all body segments.

A mesomorphic component is dominant in runners of all events, the ectomorphic component is less dominant, whereas the endomorphic component is the least marked.

The canonical discriminant analysis showed that runners of various running events statistically differ in morphological measures, especially in dimensions of body volume and body fat. On the manifest level, only thigh and lower leg circumference statistically differ, being significantly higher in sprinters, as well as the upper arm skinfold, which is significantly higher in middle-distance runners.

References

1. Carter, J.E.L. (1984). Physical structure of Olympic Athletes. Part II: Kinanthropometry of Olympic Athletes. Medicine and Sports Science. Karger Basel; New York.
2. Čoh, M., Milanović, D., Emberešić, D. (2002). Morfoložical Anthropometric Characteristics of Elite Junior Male and Female Javelin Throwers. Coll. Antropol. 26 Suppl.: 77-83.
3. Gore, C.J. (2000). Physiological tests for elite athletes. Champaign, IL. Human Kinetics.
4. Hawes MR, Sovak D (1994). Morphological prototypes, assessment and change in elite athletes. J Sports Sci;12(3):235-42.
5. Heath, B.H., Carter, J.E.L. (1967). A modified somatotype method. Amer J Anthropol, 21: 57 – 74.
6. Jackson, A.S., Pollock, M.L. (1985). Practical Assessment of Body Composition. The Physician and Sports Medicine, 5: 76 – 90
7. Janssen, P (2001). Lactate Threshold Training. Human Kinetics. USA.
8. Jeličić, M., Sekulić, D., Marinović, M. (2002). Anthropometric Characteristics of High Level European Junior Basketball Players. Coll. Antropol. 26 Suppl.: 69-76.
9. Marinović, M. (2004). Morphological characteristics of the Croatian rowers. Veslanje – Časopis hrvatskih veslačkih klubova. 4(117), 6-8.
10. Martin, D.E., Coe, P.E. (1997). Better Training for Distance Runners. Human Kinetics. USA

11. Matković, Br., Mišigoj-Duraković, M., Matković, B., Janković, S., Ružić, L., Leko, G., Kondrič, M. (2003). Morphological Differences of Elite Croatian Soccer Players According to the Team Position. *Coll. Antropol.* 27 Suppl.1: 167-174.
12. Medved, R. (1987). *Sportska medicina*. Zagreb: Jumea.
13. Mišigoj – Duraković, M. (1996). *Morphological anthropometrics in sports*. Zagreb: Fakultet za fizičku kulturu Sveučilišta u Zagrebu.
14. Mišigoj – Duraković, M., Heimer, S., Matković, BR. (1998). Morphological and functional characteristics of the student population at the University of Zagreb. *Kineziologija*, 30 (2): 31 – 37.
15. Siri, W.E. (1956). *The Gross composition of the body*. NY Acad Press, 239 – 80.