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COMPARISON OF ANTHROPOMETRIC CHARACTERISTICS BETWEEN PROFESSIONAL TRIATHLETES AND CYCLISTS

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ABSTRACT: Anthropometric characteristics of athletes are considered to be an important determinant of success in sport. The aim of the present study was to compare several anthropometric parameters and subjective characteristics of professional elite triathletes with anthropometric profiles of professional cyclists and sportive students. In total 93 volunteers (21 male and female triathletes, 26 male cyclists and as a control group 46 male and female students) participated in this study. Eight different anthropometric parameters were measured and a five-page questionnaire containing 35 general questions had to be completed. Interestingly, there were no significant differences between the arm span, the lengths of the lower limb and the circumference of waist and hip between male triathletes and cyclists. As expected, the athletes had significantly lower heart rates and lower weights as compared to the controls. Further results showed that male cyclists had a higher BMI, larger thighs and were taller as compared to the male triathletes. The present study could not evaluate specific anthropometric characteristics as predictive factors of performance in elite athletes. Thus, individual successful performance is linked to discipline and talent rather than to a specific anthropometric profile.

KEY WORDS: anthropometry, triathletes, cyclists, heart rate

INTRODUCTION

Anthropometric characteristics of an individual athlete are considered to be an important determinant of success in sport. In German sport history, especially in the autocratic sports policy during the communistic regimen of the former German Democratic Republic, anthropometric measurements were used to define physiological characteristics for specific sports, e.g. athletics, weight lifting or cycling, and thereby to select promising young athletes for international competitions.

Various reports exist trying to show the influence of anthropometric properties on exercise performance in different sports, e.g. swimming [1], middle and long distance running [2-6], tennis [7], rowing [8], kayaking [9], or cycling [10, 11], and also for many team sports (e.g. rugby [12], football [13, 14] and soccer [15-17]). Zampagni et al. [1] reported that hand-grip strength, age and height in short distance swimming, and age and height in long distance swimming, are positively related to performance. Tanaka and Matsuura [3] concluded that anthropometric factors have the same degree of influence on performance as physiological factors. Arrese and Ostariz [5] assessed the skinfold thickness in the lower limb as positively related to performance and even to be used as a predictive factor for all distance runners. Sanchez-Munoz et al. [7] found no differences in tennis playing high ranked or low ranked boys, but in girls with wider humoral and femoral breadth and taller height. Furthermore, a compact and robust physique seems to be positive for female canoe and kayak paddlers [9]. Most studies measured more anthropometric data than they could relate to the performance of the athletes. Only a few anthropometric parameters were found useful for talent identification and development programmes in several sport disciplines.

Triathlon is a multisport discipline consisting of sequential swimming, cycling (drafting allowed) and running. The contemporary World Championship series and the World Cup series are held over a short distance comprising 1.5 km swimming, 40 km cycling and 10 km running (in contrast to the ironman-distance which is held over a long distance with 3.8 km swimming, 180 km cycling and 42.195 km running). The physiological characteristics of triathletes have been substantially reviewed [18-20]. O'Toole and Douglas [19] conclude that in short-distance athletes the maximal oxygen uptake (VO2max) is related to the performance as compared to elite triathletes. Peak oxygen uptake (VO2peak) and ventilatory threshold (Tvent) were found to be good predictors in cycling and running performance [20]. The triathlete needs to use the whole body for all three disciplines: the upper limbs for swimming, the lower limbs for submaximal cycling and endurance running. Thus, it could be supposed that the anthropometric characteristics of a professional mono-discipline athlete such as a cyclist differ from those of a professional triathlete.

The present study compares for the first time various anthropometric and other parameters (e.g. profiles of favourite training strategies, supportive use of psychotherapy or physiotherapy, nutrition amenities, etc.) of male and female triathletes, male cyclists and male and female sportive students as controls to evaluate potential specific anthropometric profiles for these specific sports.

MATERIALS AND METHODS

Subjects. We investigated two groups of male and female professional athletes (cyclists and triathletes) and one control group (age 18-35 years). The groups consisted of 21 international professional elite triathletes (11 female, 10 male), 26 professional elite cyclists (male) and 49 active students who practise sports (26 males, 23 females). The triathletes were examined and interviewed at the World Cup Series 2010 (Monterrey, Mexico; Holten, Netherlands; Tiszaujvaros, Hungary) and during a high altitude training camp in the Pyrenees. All athletes ranked under the best 150 triathletes in the world. The cyclists were examined and interviewed at the criterium cycling race `Nacht von Hannover`. All had been placed at Olympic participation to World Championships and attendance at the races of the Giro d´ Italia and Tour de France, or had been placed among the best 10 of national or international championships during 2005 to 2010. The male and female controls were sportive students performing more than two times a week at least 30 minutes of sports activities. Most of them were medical students.

Questionnaire

The participants had to complete a five-page questionnaire with 35 questions about their physiological and psychological characteristics such as weight, body fat (%), age, hours of sleeping and the use of psychiatric support.

Anthropometry

Anthropometric measurements (including the height of the athletes and controls) were performed with a non-elastic measuring tape at eight different places: circumference of the hip measured on top of the anterior superior iliac spines and the waist at the level of the navel, the length of the legs (measured from the greater trochanter to the lateral malleolus), hand length (from the radio-carpal joint to the dactylion of the left hand), shoe size and the arm span (from the left to the right dactylion) in centimetres. Additionally, the circumference of the upper limb (measured from the acromio-clavicular joint to the olecranon at one-third of the upper arm length) and of the thigh (measured at one-third of the length between the greater trochanter and the knee-joint gap) were measured. All measurements were performed by the same investigator. The investigation was performed in accordance with the ethical standards of the Helsinki Declaration. Participants provided oral informed consent prior to testing.

Statistics

Data were processed with GraphPad Prism 5.04 and analysed with one-way ANOVA and Bonferroni tests. Results are presented as means ± SEM and differences were regarded as statistically significant if $p<0.05$.

RESULTS

In total 96 men and women (triathletes, cyclists and the control groups) participated in this study performed from March 2010 to October 2010. The athletes had performed their discipline for more than half of their lives (male triathletes: 12.7 years, female triathletes: 12.0 years and male cyclists: 17.3 years; Table 1).

Distinct differences were found concerning the peak and resting heart rate, the weight and the night-time sleeping hours between the investigated groups. Table 1 shows anthropometric and questionnaire results of the five study groups. Male triathletes and male cyclists have significantly higher peak heart rates and a significantly decreased resting heart rate as compared to the male controls (200.7 and 194.3 vs. 177.5 beats/min; 41.7 and 41.8 vs. 61.9 beats/min). Interestingly, only the female triathletes have an increased resting heart rate as compared to the corresponding female controls (41.7

TABLE 1. SELECTED ANTHROPOMETRIC AND QUESTIONNAIRE RESULTS OF THE FIVE STUDY GROUPS

	Age [years]	Training years	Peak heart rate [beats · min^{-1}]	Resting heart rate	Weight [kg]	Psychotherapy	Night-time sleeping [hours]	Hand length [cm]	Shoe size
Triathletes (m)	26.2 ± 3.4	12.7 ± 3.7*	200.7 ± 5.8§	41.7 ± 5.5§	69.4 ± 5.6*§	60%	9.1 ± 0.7§	19.7 ± 0.7	43.3 ± 2.8
Cyclists (m)	28.1 ± 5.0	17.3 ± 5.6	194.3 ± 8.7#	41.8 ± 5.6#	75.7 ± 5.3	19%	8.4 ± 0.7#	20.2 ± 0.6#	43.9 ± 1.5
Controls (m)	27.0 ± 3.1		177.5 ± 23.4	61.9 ± 10.2	74.6 ± 5.9	18%	6.9 ± 1.1	19.2 ± 0.9	43.3 ± 1.2
Triathletes (f)	26.8 ± 3.9	12.0 ± 4.5	188.1 ± 8.4	41.7 ± 5.7	54.0 ± 4.2$	64%	10.3 ± 0.7$	18.2 ± 1.0	38.3 ± 1.6
Controls (f)	25.5 ± 4.3		190.3 ± 35.8	63.8 ± 8.6	62.1 ± 6.7	17%	7.4 ± 0.8	18.0 ± 1.0	38.6 ± 1.4

Note: m - male; f - female; statistically significant differences between male triathletes and male cyclists are depicted with an asterisk: *(<0.05); statistically significant differences between. male triathletes and male controls are depicted with a paragraph sign: §(<0.05); statistically significant differences between male cyclists and male controls are depicted with a rhomb: #(<0.05); statistically significant differences between female and male triathletes are depicted with a dollar sign: $(<0.05).

vs. 63.8 beats/min). The peak heart rate is comparable between these two groups (188.1 vs. 190.3 beats/min).

The body weight in the racing season is significantly lower in male triathletes as compared to the cyclists and the male control group (69.4 vs. 75.7 and 74.6 kg). Similarly, the weight of female triathletes is significantly lower as compared to the female controls (54.0 vs. 62.1 kg). Interestingly, no difference between the weight of the professional cyclists and the male controls can be detected.

Furthermore, the sleeping time of the athletes is significantly longer as compared to their corresponding control groups (male triathletes: 9.1 h/24 h, female triathletes: 10.3 h/24 h, male cyclists 8.4 h/24 h, male controls: 6.9 h/24 h and female controls 7.4 h/24 h). Interestingly, the sleeping time of female triathletes is more than one hour longer than the sleeping time of male athletes.

64% of the female triathletes and 60% of the male triathletes report that they needed professional psychiatric help in the past year. In all other groups the percentage was over 20%.

Figure 1A shows the height of the five investigated groups. No significant difference could be found between the three male groups or both female groups.

Figure 1B shows the BMI of the five groups. Male cyclists have a higher BMI as compared to the male triathletes (22.3 vs. 20.7; not significant). Furthermore, male and female triathletes show significantly reduced BMI levels as compared to their corresponding control groups (20.7 vs. 22.9, [$p<0.001$, $t=3.6$] and 19.0 vs. 21.5,

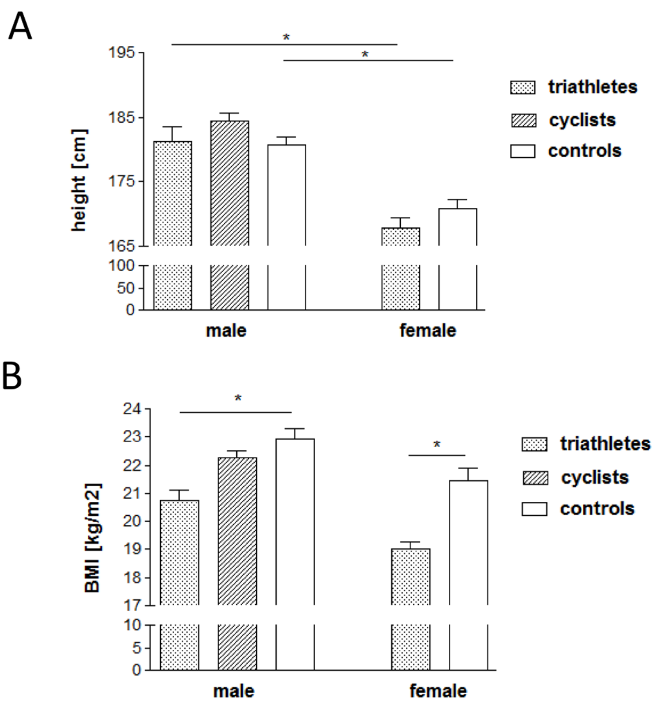

FIG. 1. MALE AND FEMALE TRIATHLETES ARE LEANER THAN THE CORRESPONDING CONTROL GROUPS AND ATHLETES ARE TALLER THAN THE CORRESPONDING SPORTIVE STUDENTS.
A) BMI (kg/m^{-2}) AND B) HEIGHT (cm) OF MALE AND FEMALE TRIATHLETES (DOTTED COLUMNS), MALE CYCLISTS (HATCHED COLUMN) AND SPORTIVE STUDENTS (WHITE COLUMNS).
Note: Statistically significant differences between the groups are depicted with an asterisk (*). All data are shown as means ± SEM.

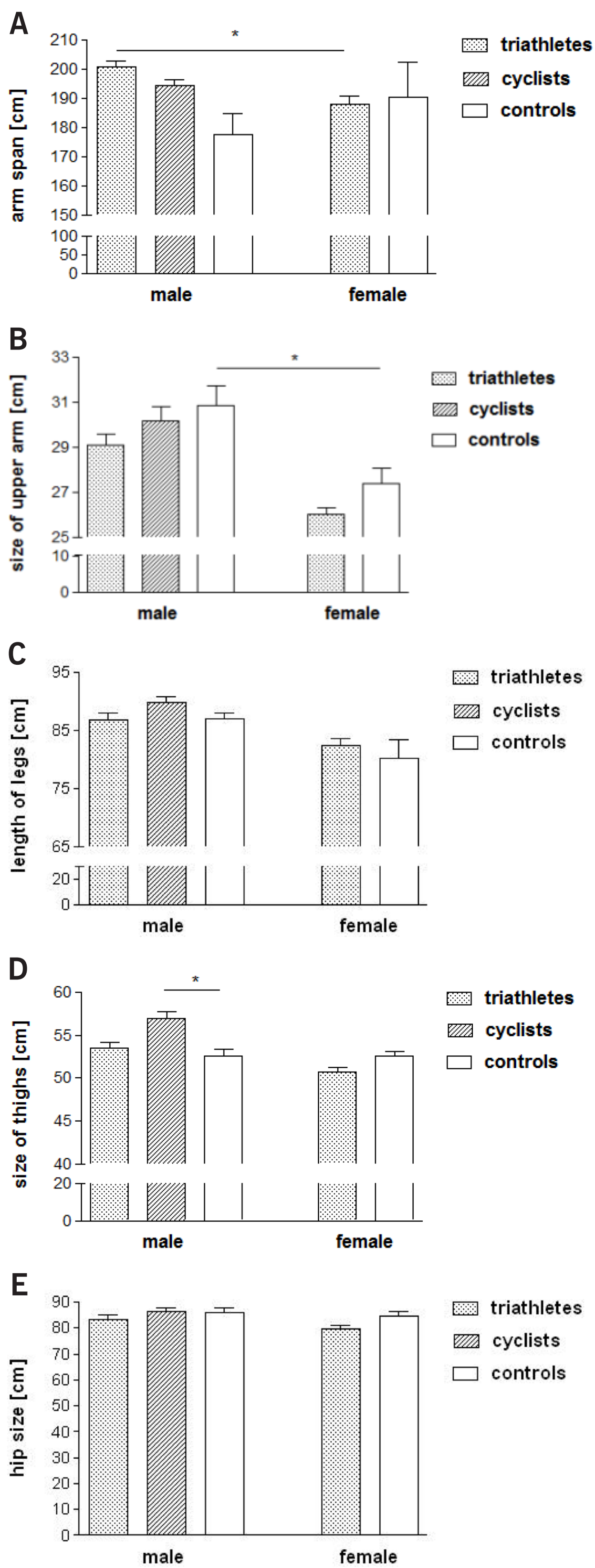

FIG. 2. DISTINCT DIFFERENCES IN VARIOUS ANTHROPOMETRIC PARAMETERS OF TRIATHLETES, CYCLISTS AND SPORTIVE CONTROLS. A DETAILED DESCRIPTION OF THE MEASUREMENTS OF THE DIFFERENT PARAMETERS CAN BE FOUND IN THE METHODS SECTION.
A) ARM SPAN (cm), B) UPPER ARM SIZE (cm), C) LENGTH OF LOWER LIMB (cm), D) SIZE OF THIGHS AND E) HIP SIZE (cm) OF MALE AND FEMALE TRIATHLETES (DOTTED COLUMNS), MALE CYCLISTS (HATCHED COLUMN) AND SPORTIVE STUDENTS (WHITE COLUMNS).
Note: Statistically significant differences between the groups are depicted with an asterisk (*). All data are shown as means + SEM.

[p<001, t=4.1]). Measurements of the arm span do not show significantly longer arms in the group of triathletes and cyclists as compared to the sportive students (Figure 2A). However, the arm span of male triathletes was significantly longer than the arm span of female triathletes (p<0.0001, t=4.3). The upper arm size (Figure 2B) and the lengths of the lower limbs (Figure 2C) were comparable in all investigated male groups. The upper arm size of the male controls was significantly thicker as compared to the corresponding female group (p<0.001, t=3.7). Figure 2D shows the circumference of the thigh. Male cyclists have significantly thicker thighs as compared to the male controls (57.0 vs. 52.6 cm, [p<0.001, t=4.0]). Interestingly, neither the circumference of the hip (Figure 2E) or the waist nor their ratio differed significantly between the investigated groups.

DISCUSSION

Anthropometric measurements may possibly be used to detect potentially successful athletes for a specific discipline. The present study aimed to evaluate differences in anthropometric parameters of professional three-discipline triathletes as compared to one-discipline cyclists.

In former studies Landers et al. stated that robustness, adiposity, segmental lengths and skeletal mass are proven factors correlating in short-distance triathletes with race performance [21]. Tanaka et al. on the other hand found that upper arm girth and the Ponderal index related to better results in 10,000 m running performance [3]. Still other studies could not detect anthropometric parameters with a significant influence on performance [10,22].

The present study evaluates anthropometric variables of male and female professional Olympic-distance triathletes. Additionally, a comparison with cyclists and non-professional athletes was performed to evaluate discipline-specific variables. Since the top athletes of this study have been performing their sports for more than half of their lives (male triathletes: 12.7 years; female triathletes: 12.0 years; male cyclists: 17.3 years), perfect adaptation to the challenges of their individual sport should be expected. The results could be useful to identify early talents or generate development programmes for the athletes.

Concerning the adaptation resulting from continuous swimming practice, we expected a certain body shape (e.g. upper arm size and length) of the triathletes compared to the other two groups. The group of Geladas showed gender-specifically that the upper limb length, the horizontal jump ability and the shoulder flexibility influence the performance in sprint (100m freestyle) swimming [23]. A study by Avlonitou demonstrated significant correlations between performance and height and upper and lower limb lengths in pre adolescent swimmers [24].

Interestingly, in the present study no significant differences concerning the arm span and upper arm size, leg length, hand length, or hip and waist circumference between the male triathletes (swimming training up to seven days a week) and the male cyclists could be detected. Surprisingly, for the majority of parameters there were additionally no differences as compared to the male control group. Since the skin fold thickness of the upper arm was not measured in the present study, no distinction between muscle and fat can be made. Thus, it is possible that several similarities can be traced back to different compartments (muscle vs. fat).

We assumed that the BMI of the athletes would be significantly lower than the BMI of the control group due to the number of training hours. Additionally, the measurements were performed during the high season of the athletes, when they are supposed to be in the best shape of the year. However, only the BMI of the triathletes was lower than the BMI of the cyclists and the male controls. One reason could be that a low body weight is not as important for cyclists as for runners/triathletes. Larsen et al. examined Kenyan and Caucasian runners and detected a significantly lower BMI of the Kenyan runners [4], which could explain the Kenyan dominance in long distance running. Thus, the BMI may solely be a reliable parameter for high performance for runners and triathletes. However, the lower BMI of the triathletes in the present study could not be explained by the size of the waist and hip. Both sizes and the hip/waist ratio were comparable in all male groups.

During cycling the quadriceps and biceps femoris muscles are responsible factors for high performance in cycling. As expected, the thigh size of the cyclists was greater as compared to the triathletes and the control group. McLean and Parker reported that sprint cyclists have greater thigh girth and more muscle mass as compared to endurance cyclists [10]. Nevertheless, to date no study exists comparing these parameters between cyclists and other athletes.

The upper arm girth showed no significant difference between triathletes, cyclists and controls. Knechtle et al. described an association between the upper arm circumference and the total running time in ultra endurance running [25]. By contrast, Zampani et al. measured various anthropometric parameters of elite swimmers in short, middle and long distances and concluded that only age and height are predictors for high performance in middle and long distance swimming [1].

Concerning the evaluation of the questionnaire, we found a surprisingly high number of female and male triathletes (64%; 60%) regularly demanding psychotherapeutic support. Resch et al. demonstrated that symptoms of depression (after a competition, following failure in a competition), chronic stress, anxiety, fatigue syndrome of overtraining, sleep disturbances, eating problems, burnout and others, could predispose the athlete to psychiatric problems [26]. Triathlon might be associated with a higher amount of individual training, while for cycling the team spirit and hence group support have a higher value.

CONCLUSIONS

In conclusion, the present study could not identify specific anthropometric characteristics of triathletes or cyclists that could be used as reliable predictive factors for the predestination of an athlete to perform a three-discipline rather than a one-discipline professional sport.

REFERENCES

1. Zampagni ML, Casino D, Benelli P, et al. Anthropometric and strength variables to predict freestyle performance times in elite master swimmers. J. Strength Cond. Res. 2008;22:1298-1307.
2. Weston AR, Karamizrak O, Smith A et al. African runners exhibit greater fatigue resistance, lower lactate accumulation, and higher oxidative enzyme activity. J. Appl. Physiol. 1999;86:915-923.
3. Tanaka K, Matsuura Y. A multivariate analysis of the role of certain anthropometric and physiological attributes in distance running. Ann. Hum. Biol. 1982; 9:473-482.
4. Larsen HB. Kenyan dominance in distance running. Comp. Biochem. Physiol. A. Mol. Integr. Physiol. 2003; 136:161-170.
5. Arrese AL, Ostariz ES. Skinfold thicknesses associated with distance running performance in highly trained runners. J. Sports Sci. 2006;24:69-76.
6. Bosch AN, Goslin BR, Noakes TD, et al. Physiological differences between black and white runners during a treadmill marathon. Eur. J. Appl. Physiol. Occup. Physiol. 1990;61:68-72.
7. Sanchez-Munoz C, Sanz D, Zabala M. Anthropometric characteristics, body composition and somatotype of elite junior tennis players. Br. J. Sports Med. 2007; 41:793-799.
8. Bourgois J, Claessens AL, Vrijens J, et al. Anthropometric characteristics of elite male junior rowers. Br. J. Sports Med. 2000;34:213-216.
9. Ackland TR, Ong KB, Kerr DA, et al. Morphological characteristics of Olympic sprint canoe and kayak paddlers. J. Sci. Med. Sport 2003;6:285-294.
10. McLean BD, Parker AW. An anthropometric analysis of elite Australian track cyclists. J. Sports Sci. 1989;7:247-255.
11. Campion F, Nevill AM, Karlsson MK, et al. Bone status in professional cyclists. Int. J. Sports Med. 2010;31:511-515.
12. Gabbett TJ. Physiological and anthropometric characteristics of amateur rugby league players. Br. J. Sports Med. 2000;34:303-307.
13. Dupler TL, Amonette WE, Coleman AE, et al. Anthropometric and performance differences among high-school football players. J. Strength Cond. Res. 2010;24:1975-1982.
14. Hetzler RK, Schroeder BL, Wages JJ, et al. Anthropometry increases 1 repetition maximum predictive ability of NFL-225 test for Division IA college football players. J. Strength Cond. Res. 2010;24:1429-1439.
15. Reilly T, Bangsbo J, Franks A Anthropometric and physiological predispositions for elite soccer. J. Sports Sci. 2000;18:669-683.
16. Reilly T, Williams AM, Nevill A, et al. A multidisciplinary approach to talent identification in soccer. J. Sports Sci. 2000;18:695-702.
17. Rienzi E, Drust B, Reilly T, et al. Investigation of anthropometric and work-rate profiles of elite South American international soccer players. J. Sports Med. Phys. Fitness 2000;40:162-169.
18. Millet GP, Dreano P, Bentley DJ. Physiological characteristics of elite short- and long-distance triathletes. Eur. J. Appl. Physiol. 2003;88:427-430.
19. O'Toole ML, Douglas PS. Applied physiology of triathlon. Sports Med. 1995;19:251-267.
20. De Vito G, Bernardi M, Sproviero E, et al. Decrease of endurance performance during Olympic Triathlon. Int. J. Sports Med. 1995;16:24-28.
21. Landers GJ, Blanksby BA, Ackland TR, et al. Morphology and performance of world championship triathletes. Ann. Hum. Biol. 2000;27:387-400.
22. Knechtle B, Knechtle P, Andonie JL, et al. Influence of anthropometry on race performance in extreme endurance triathletes: World Challenge Deca Iron Triathlon 2006. Br. J. Sports Med. 2007;41:644-648.
23. Geladas ND, Nassis GP, Pavlicevic S. Somatic and physical traits affecting sprint swimming performance in young swimmers. Int. J. Sports Med. 2005;26:139-144.
24. Avlonitou E. Somatometric variables for preadolescent swimmers. J. Sports Med. Phys. Fitness 1994;34:185-191.
25. Knechtle B., Knechtle P., Schulze I., et al. Upper arm circumference is associated with race performance in ultra-endurance runners. Br. J. Sports Med. 2008;42:295-299.
26. Resch M. The psychological factors affecting athletic performance. Orv. Hetil. 2010;151:815-821.