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Research Article

DIFFERENCES IN THE LEVEL OF ANTHROPOMETRIC MEASURES AND BODY COMPOSITION BETWEEN DIFFERENT AGE CATEGORIES OF TAEKWONDO PLAYERS IN BOSNIA AND HERZEGOVINA

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Abstract

Doing sports or any physical activity nowadays really has great advantages and positive sides compared to being physically inactive. First of all, it affects the improvement and preservation of health, but also the improvement and increase of the level of anthropological characteristics, which is achieved by implementing adequate procedures for planning, implementing, and controlling exercise. The main goal of this research is to determine the importance of certain anthropometric characteristics and the differences between them in success in sports such as taekwondo. The research was conducted on a sample of 52 members of the taekwondo national team of Bosnia and Herzegovina, among three age groups: cadets, juniors, and seniors. For this research, 23 anthropometric points were measured in taekwondo players, as well as fat, muscle mass, water, and visceral fat based on which differences between cadets, juniors, and seniors can be indicated. Descriptive statistics and t-tests were used for data processing. The test results are divided into three categories: cadets-juniors, cadets-seniors, and juniors-seniors. After looking at the results of the first category, the conclusion is that there are very significant statistical differences between cadets and juniors in most of the measurements where n was in most cases less than 0.05 ($n<0.05$). Only the following parameters did not show significant statistical differences: bicondylar femoral width, arm length, upper arm length, forearm length, upper arm, back and abdominal skinfold, fat, and water. Furthermore, similar results were obtained for the relationship between cadets and seniors. Significant statistical differences are also evident in the mentioned case, except for the following parameters: bicondylar femoral width, width of the ankle joint, arm length, upper arm length, leg length, skin fold of the upper arm, back and abdomen, fat, and water. The only category in which it is visible that there are no significant statistical differences is juniors-seniors. Differences between anthropometric characteristics were established, which in most segments show significant statistical differences. To achieve top results and success in taekwondo, it is necessary to achieve several factors. In addition to regular and persistent training and exercise, it is necessary to pay attention to the lifestyle that is led in addition to training. Nutrition is certainly one of the most important factors, both for successful training and exercise and for achieving top results. Of course, leading a healthy life and adapting the athlete to the living conditions required of a taekwondo player are connected to nutrition. What is certainly important for every taekwondo player is the structure and composition of the body. It is desirable, considering the type and characteristics of this sport, that such athletes have an ectomorphic physique: without a lot of muscle mass and deposits, a high level of endurance, and a fast metabolism. An indispensable aspect of a successful taekwondo player is the percentage of subcutaneous fat. The percentage of subcutaneous fat tissue should be significantly lower compared to other athletes.

Keywords: Anthropometric Measurements, Body composition, Taekwondo, Age groups, Men, Bosnia and Herzegovina.

INTRODUCTION

Taekwondo is seen today as a physical activity in fighting with an opponent and self-defense, so today's work programs increasingly focus on the motor skills of the hands and feet, as well as on the morphological characteristics of the individual who engages in this activity (Šerović, Pleša-Bosnar & Dolani, 2004). Anthropometry is a research method of anthropology that deals with determining the dimensions of the human body and judging them. Anthropometry aims to quantitatively characterize the morphological (morphological anthropometry) and physiological (physiological anthropometry) features of the human body, which are different in different populations (Ujević & Kaurić-Grilec, 2013). Competitions in this activity consist of very short bursts, and high-intensity movements that require the acquisition of anaerobic energy (Fong *et al.,* 2014). Kinesiology is a word of Greek origin, formed from the word kinesis/kinetic - movement, exercise, movement and the word logos - science, word, proof, assertion.

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Kinesiology is the science of specially conditioned movement, the goal of which is to determine the lawfulness of transformational processes under the influence of that movement (Jurko *et al.,* 2015). The basic elements of taekwondo are: The technique in taekwondo facilitates the taking of appropriate actions during an opponent's attack, the appropriate use of available power, increasing the speed of movement, and reducing fatigue. It is the basis of this sport and is easily adopted. Forms represent a fight against an imaginary opponent in which the practitioner moves according to a precisely determined pattern and performs a predetermined series of defensive and offensive movements and techniques. Fighting - the lower limit for fighting is 9 years old when they become junior cadets, but there are competitions where children can try their hand at being fighters. Basic combat techniques are stances, movements, blocks, strikes, feints, and falls (Horvat, Miholić Jenko & Ćosić, 2016). It is an indisputable fact that sport plays a very large role in society today and that it is characterized by a form of social popularity. Events that directly affect sports, such as the Olympic Games, world championships, and continental championships, reach a huge viewership. All athletes strive to become a part of top sports and to record and achieve top results. To succeed in

sports, athletes invest and do their best, but sometimes that alone is not enough to achieve top results. What is important is that every activity is approached professionally and adequately. In addition to the athlete's motivation, will, and desire to succeed and achieve the best possible result, on the other hand,several other factors have a great influence on it. The science that deals with that type of factor and role is kinesiology. The goal of the research was to present a presentation of the normative characteristics of elite taekwondo players. The sample consisted of 40 male respondents, participants in the European championship for seniors in the Olympic categories.

The sample of variables consisted of 13 anthropometric points measured with appropriate measuring instruments, and 2 points related to the achieved ranking and weight category of the competitors. Based on the obtained results, it was concluded that there are differences between male weight categories. They are visible in all measured anthropometric points. The biggest difference is noticeable in the percentage of body fat and muscle mass, where the lowest weight categories have a slightly lower percentage of fat tissue. In contrast, the highest weight categories have a slightly higher muscle mass. The obtained normative values can help coaches in the planned transition from a lower to a higher weight category, the prerequisite of which is growth and development, taking into account the health of young taekwondo athletes (Mekić *et al.,* 2022). To achieve top results in sports, and therefore in taekwondo, it is necessary to first have certain knowledge and understanding about the character of the sport itself, as well as which and how certain factors affect the realization and success in the same. Today's trainers in Bosnia and Herzegovina base their work exclusively on martial arts, but few possess adequate and special knowledge of this sport. It is necessary to get quality education, attend various seminars, cooperate with other clubs, and implement a series of programs to acquire certain and sufficient knowledge for further work with taekwondo players. When practicing taekwondo and to achieve top results and success, it is necessary to know the structure and composition of the body, whether of boys, adolescents, or even those of older age groups.

MATERIAL AND METHODS

Participants

The research included a sample of 52 members (boys and adults) of the taekwondo national team of Bosnia and Herzegovina. Testing was conducted at different ages, and accordingly, they were divided into three groups: cadets, juniors, and seniors. The number of cadets is 20, juniors 20, and seniors 12.

The sample of variables

The sample of measuring instruments used in the research is a set of 23 variables for measuring anthropometric characteristics of taekwondo players, as well as fat, muscle mass, water, and visceral fat, based on which differences between cadets, juniors, and seniors can be indicated. To assess the anthropometric characteristics, the following 23 variables were measured, namely: weight (TEZ), height (VIS), sitting height (SVIS), bicondylar femoral width (BSBZ), lower leg length (DPOT), ankle width (SSZ), foot length (DUZS), upper leg circumference (OPN), lower leg circumference (OPP), arm length (DUR), upper arm length (DUN), forearm length (DUP), upper arm bicondylar width (BSN), hand width (SIS), upper arms circumference (relaxing position) (ONR), upper arm circumference (at contact) (ONK), shoulder width (SIR), chest width (SGK), leg length (DNG), pelvic width (SIK), upper arm skinfold (KNN), back skinfold (KNL), abdominal skinfold (KNT), as well as fat (MAS), muscle mass (MAM), water (VOD) and visceral fat (VIM). The given characteristics were measured with the following instruments: caliper, sliding compass, measuring tape, anthropometer, and Tanita scale.

Research Design

Anthropometric variables were measured according to standard procedures of the International Society for the Advancement of Kinanthropometry (ISAK) (Marfell-Jones *et al.,* 2006).Body composition was measured with an InBody720 scale (Aandstad, *et al.,* 2014). The validity of determining the body composition with InBody720 scales on a sample of children has been positively evaluated in some previous studies (Lim *et al.,* 2009; Tompuri *et al.,* 2015). All parents are informed in advance about the implementation of the research which explains the purpose and goal of the research. Therefore, the research was supported by all parents, with written consent.The study was approved by the Ethics Commission of the Faculty of Education, University of Sarajevo (World Medical Association, 2013). All parents were informed in advance about the implementation of the research, which explained the purpose and goal of the study. Therefore, the research was supported by all parents via written consent.

Statistical Analaysis

All data collected in this research were processed using descriptive statistics methods. To determine the differences between the categories in anthropometric characteristics were determined using the t-test for independent samples. The statistical program for personal computers SPSS for Windows version 20.0 was used for data processing. The level of inference was set at $p<0.05$.

RESULTS

Looking at the results of the t-test (Table 1), between cadets and juniors in terms of anthropometric characteristics, it can be noticed that there are statistically significant differences between the mentioned categories. A significant number of characteristics is less than 0.05 ($p<0.05$), which speaks in favor of the fact that there are very large differences between these two age groups. The only parameters in which no differences were found, that is, which are not statistically significant, are: bicondylar femoral width (t-test=-0.840, $p>0.05$), arm length (t-test=-2.631, $p>0.05$), upper arm length (t-test=-2.480, $p>0.05$), forearm length (t-test=-2.729, $p>0.05$), upper arm skinfold (t-test=1.374, $p>0.05$), back skinfold (t-test= 2.124, $p>0.05$, abdominal skinfold (t-test= 1.211, $p>0.05$), fat (t-test= 1.472, $p>0.05$) and water (t-test= 0.363, $p>0.05$).

Looking at the test results, (Table 2) presents the data for the junior and senior categories and a comparison of their anthropometric characteristics. Looking at the table, you can see clear differences between these two categories, and in support of this, it is said that $p<0.05$ in most of the observed characteristics.

Table 1.Results of t-test in anthropometric characteristics between cadets and juniors-Independent Sample Test

		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. ErrorDifference	95% Confidence Interval of the Difference	
									Lower	Upper
Weight	Equal variances assumed	0,630	0,432	-5,112	38	0,000	-15,54500	3,04090	-21,70098	-9,38902
	Equal variances not assumed			-5,112	36,220	0,000	-15,54500	3,04090	-21,71093	-9,37907
Height	Equal variances assumed	0,671	0,418	-6,100	38	0,000	-16,41500	2,69091	-21,86246	-10,96754
	Equal variances not assumed			-6,100	37,413	0,000	-16,41500	2,69091	-21,86526	-10,96474
Sitting height	Equal variances assumed	0,739	0,395	-4,193	38	0,000	-7,70000	1,83661	-11,41803	-3,98197
	Equal variances not assumed			-4,193	37,108	0,000	-7,70000	1,83661	-11,42097	-3,97903
Bicondylar femoral width	Equal variances assumed	0,194	0,662	-0,840	38	0,406	-0,19500	0,23225	-0,66517	0,27517
	Equal variances not assumed			-0,840	35,774	0,407	-0,19500	0,23225	-0,66613	0,27613
Lower leg length	Equal variances assumed	5,433	0,025	-4,541	38	0,000	-4,57500	1,00756	-6,61469	-2,53531
	Equal variances not assumed			-4,541	32,519	0,000	-4,57500	1,00756	-6,62604	-2,52396
Ankle width	Equal variances assumed	0,771	0,385	-2,783	38	0,008	-0,49500	0,17783	-0,85501	-0,13499
	Equal variances not assumed			-2,783	34,688	0,009	-0,49500	0,17783	-0,85614	-0,13386
Foot length	Equal variances assumed	0,765	0,387	-4,433	38	0,000	-1,99000	0,44890	-2,89875	-1,08125
	Equal variances not assumed			-4,433	36,029	0,000	-1,99000	0,44890	-2,90038	-1,07962
Upper leg circumference	Equal variances assumed	1,138	0,293	-3,195	38	0,003	-5,34000	1,67159	-8,72396	-1,95604
	Equal variances not assumed			-3,195	37,241	0,003	-5,34000	1,67159	-8,72622	-1,95378
Lower leg circumference	Equal variances assumed	1,424	0,240	-4,572	38	0,000	-4,38000	0,95795	-6,31927	-2,44073
	Equal variances not assumed			-4,572	33,759	0,000	-4,38000	0,95795	-6,32731	-2,43269
Arm length	Equal variances assumed	0,022	0,882	-2,613	38	0,013	-8,13500	3,11339	-14,43774	-1,83226
	Equal variances not assumed			-2,613	37,956	0,013	-8,13500	3,11339	-14,43798	-1,83202
Upper arm length	Equal variances assumed	11,825	0,001	-2,480	38	0,018	-2,61000	1,05222	-4,74011	-0,47989
	Equal variances not assumed			-2,480	28,621	0,019	-2,61000	1,05222	-4,76327	-0,45673
Forearm length	Equal variances assumed	0,041	0,841	-2,729	38	0,010	-2,91500	1,06813	-5,07732	-0,75268
	Equal variances not assumed			-2,729	30,080	0,011	-2,91500	1,06813	-5,09617	-0,73383
Bicondylar upper arm width	Equal variances assumed	0,028	0,869	-5,248	38	0,000	-0,82500	0,15721	-1,14325	-0,50675
	Equal variances not assumed			-5,248	37,969	0,000	-0,82500	0,15721	-1,14326	-0,50674
Hand width	Equal variances assumed	0,791	0,379	-5,809	38	0,000	-0,82000	0,14115	-1,10575	-0,53425
	Equal variances not assumed			-5,809	37,730	0,000	-0,82000	0,14115	-1,10581	-0,53419
Upper arm circumference-relaxing position	Equal variances assumed	0,369	0,547	-3,782	38	0,001	-2,68500	0,70987	-4,12206	-1,24794
	Equal variances not assumed			-3,782	37,464	0,001	-2,68500	0,70987	-4,12273	-1,24727
Upper arm circumference during contraction	Equal variances assumed	0,045	0,834	-4,588	38	0,000	-3,46500	0,75515	-4,99373	-1,93627
	Equal variances not assumed			-4,588	37,965	0,000	-3,46500	0,75515	-4,99377	-1,93623
Shoulder width	Equal variances assumed	12,620	0,001	-5,614	38	0,000	-6,83500	1,21742	-9,29954	-4,37046
	Equal variances not assumed			-5,614	29,291	0,000	-6,83500	1,21742	-9,32383	-4,34617
Chest width	Equal variances assumed	0,107	0,745	-4,852	38	0,000	-2,89500	0,59666	-4,10287	-1,68713
	Equal variances not assumed			-4,852	37,970	0,000	-2,89500	0,59666	-4,10290	-1,68710
Leg length	Equal variances assumed	0,124	0,727	-5,475	38	0,000	-10,29500	1,88034	-14,10155	-6,48845
	Equal variances not assumed			-5,475	37,933	0,000	-10,29500	1,88034	-14,10177	-6,48823
Pelvic width	Equal variances assumed	0,001	0,970	-4,562	38	0,000	-3,09000	0,67729	-4,46110	-1,71890
	Equal variances not assumed			-4,562	37,993	0,000	-3,09000	0,67729	-4,46111	-1,71889
Upper arm skinfold	Equal variances assumed	2,893	0,097	1,374	38	0,178	0,14250	0,10374	-0,06750	0,35250
	Equal variances not assumed			1,374	35,637	0,178	0,14250	0,10374	-0,06796	0,35296
Back skinfold	Equal variances assumed	12,952	0,001	2,124	38	0,040	0,17600	0,08285	0,00827	0,34373
	Equal variances not assumed			2,124	26,224	0,043	0,17600	0,08285	0,00576	0,34624
Abdominal skinfold	Equal variances assumed	3,071	0,088	1,211	38	0,234	0,62700	0,51792	-0,42147	1,67547
	Equal variances not assumed			1,211	20,541	0,240	0,62700	0,51792	-0,45154	1,70554
Fat	Equal variances assumed	1,855	0,181	1,472	38	0,149	2,39000	1,62388	-0,89738	5,67738
	Equal variances not assumed			1,472	36,667	0,150	2,39000	1,62388	-0,90131	5,68131
Muscle mass	Equal variances assumed	0,430	0,516	-6,636	38	0,000	-14,59500	2,19925	-19,04715	-10,14285
	Equal variances not assumed			-6,636	37,860	0,000	-14,59500	2,19925	-19,04769	-10,14231
Water	Equal variances assumed	1,244	0,272	0,363	37	0,719	1,14632	3,15654	-5,24945	7,54208
	Equal variances not assumed			0,371	22,993	0,714	1,14632	3,08947	-5,24484	7,53747

Table2.Results of t-test in anthropometric characteristics between cadets and seniors-Independent Sample Test

		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Weight	Equal variances assumed	0,008	0,929	-9,262	30	0,000	-35,46333	3,82888	-43,28296	-27,64371
	Equal variances not assumed			-9,353	24,019	0,000	-35,46333	3,79171	-43,28871	-27,63795
Height	Equal variances assumed	2,400	0,132	-8,582	30	0,000	-25,67000	2,99114	-31,77873	-19,56127
	Equal variances not assumed			-9,314	28,831	0,000	-25,67000	2,75617	-31,30844	-20,03156
Sitting height	Equal variances assumed	0,096	0,758	-7,389	30	0,000	-16,05833	2,17336	-20,49692	-11,61974
	Equal variances not assumed			-7,663	25,974	0,000	-16,05833	2,09555	-20,36600	-11,75066
Bicondylar femoral width	Equal variances assumed	0,431	0,517	-2,118	30	0,043	-0,47167	0,22272	-0,92653	-0,01681
	Equal variances not assumed			-2,187	25,658	0,038	-0,47167	0,21569	-0,91532	-0,02801
Lower leg length	Equal variances assumed	0,243	0,625	-6,527	30	0,000	-6,00167	0,91953	-7,87961	-4,12373
	Equal variances not assumed			-6,401	21,903	0,000	-6,00167	0,93762	-7,94666	-4,05667
Ankle width	Equal variances assumed	1,687	0,204	-2,813	30	0,009	-0,56500	0,20084	-0,97516	-0,15484
	Equal variances not assumed			-3,269	29,546	0,003	-0,56500	0,17282	-0,91816	-0,21184
Foot length	Equal variances assumed	0,904	0,349	-5,885	30	0,000	-3,82833	0,65051	-5,15685	-2,49982
	Equal variances not assumed			-5,482	18,556	0,000	-3,82833	0,69837	-5,29241	-2,36425
Upper leg circumference	Equal variances assumed	0,193	0,664	-6,055	30	0,000	-10,89333	1,79913	-14,56764	-7,21902
	Equal variances not assumed			-6,027	22,962	0,000	-10,89333	1,80757	-14,63291	-7,15376
Lower leg circumference	Equal variances assumed	0,021	0,887	-5,945	30	0,000	-7,42333	1,24869	-9,97349	-4,87317
	Equal variances not assumed			-6,081	24,970	0,000	-7,42333	1,22072	-9,93760	-4,90906
Arm length	Equal variances assumed	0,107	0,746	-2,657	30	0,013	-9,31000	3,50369	-16,46548	-2,15452
	Equal variances not assumed			-2,673	23,740	0,013	-9,31000	3,48289	-16,50251	-2,11749
Upper arm length	Equal variances assumed	8,001	0,008	-2,564	30	0,016	-2,70833	1,05642	-4,86583	-0,55084
	Equal variances not assumed			-2,243	15,344	0,040	-2,70833	1,20733	-5,27667	-0,14000
Forearm length	Equal variances assumed	2,596	0,118	-4,462	30	0,000	-3,54000	0,79333	-5,16019	-1,91981
	Equal variances not assumed			-4,769	27,988	0,000	-3,54000	0,74226	-5,06048	-2,01952
Bicondylar upper arm width	Equal variances assumed	4,990	0,033	-9,102	30	0,000	-2,29500	0,25214	-2,80994	-1,78006
	Equal variances not assumed			-7,834	14,645	0,000	-2,29500	0,29294	-2,92070	-1,66930
Hand width	Equal variances assumed	0,039	0,845	-9,412	30	0,000	-1,76833	0,18788	-2,15203	-1,38463
	Equal variances not assumed			-8,856	19,164	0,000	-1,76833	0,19967	-2,18601	-1,35065
Upper arm circumference-relaxing position	Equal variances assumed	0,828	0,370	-8,780	30	0,000	-8,54000	0,97262	-10,52636	-6,55364
	Equal variances not assumed			-8,208	18,771	0,000	-8,54000	1,04042	-10,71943	-6,36057
Upper arm circumference during contraction	Equal variances assumed	2,641	0,115	-9,575	30	0,000	-9,85167	1,02894	-11,95305	-7,75029
	Equal variances not assumed			-8,690	17,110	0,000	-9,85167	1,13370	-12,24239	-7,46095
Shoulder width	Equal variances assumed	4,537	0,041	-7,930	30	0,000	-12,48000	1,57375	-15,69402	-9,26598
	Equal variances not assumed			-8,674	29,192	0,000	-12,48000	1,43880	-15,42184	-9,53816
Chest width	Equal variances assumed	3,241	0,082	-10,018	30	0,000	-9,48333	0,94661	-11,41657	-7,55009
	Equal variances not assumed			-8,649	14,767	0,000	-9,48333	1,09650	-11,82368	-7,14298
Leg length	Equal variances assumed	1,030	0,318	-2,862	30	0,008	-8,84500	3,09092	-15,15750	-2,53250
	Equal variances not assumed			-2,443	14,324	0,028	-8,84500	3,61989	-16,59243	-1,09757
Pelvic width	Equal variances assumed	0,375	0,545	-8,848	30	0,000	-7,31833	0,82710	-9,00750	-5,62916
	Equal variances not assumed			-8,502	20,504	0,000	-7,31833	0,86078	-9,11107	-5,52559
Upper arm skinfold	Equal variances assumed	18,036	0,000	-1,539	30	0,134	-1,30750	0,84942	-3,04225	0,42725
	Equal variances not assumed			-1,185	11,123	0,261	-1,30750	1,10324	-3,73244	1,11744
Back skinfold	Equal variances assumed	18,139	0,000	-1,895	30	0,068	-1,64300	0,86717	-3,41400	0,12800
	Equal variances not assumed			-1,457	11,100	0,173	-1,64300	1,12739	-4,12166	0,83566
Abdominal skinfold	Equal variances assumed	6,008	0,020	-1,152	30	0,258	-1,42433	1,23606	-3,94870	1,10004
	Equal variances not assumed			-0,978	14,100	0,344	-1,42433	1,45602	-4,54511	1,69644
Fat	Equal variances assumed	1,147	0,293	2,636	30	0,013	5,05667	1,91859	1,13838	8,97496
	Equal variances not assumed			2,773	26,982	0,010	5,05667	1,82344	1,31515	8,79818
Muscle mass	Equal variances assumed	0,021	0,885	-13,348	30	0,000	-32,53833	2,43777	-37,51692	-27,55975
	Equal variances not assumed			-13,439	23,805	0,000	-32,53833	2,42114	-37,53748	-27,53919
Water	Equal variances assumed	1,950	0,173	0,754	29	0,457	1,88465	2,49906	-3,22651	6,99581
	Equal variances not assumed			0,642	13,664	0,532	1,88465	2,93731	-4,42983	8,19913

Table3.Results of t-test in anthropometric characteristics between juniors and seniors-Independent Sample Test

		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Weight	Equal variances assumed	0,781	0,384	-5,952	30	0,000	-19,91833	3,34643	-26,75266	-13,08401
	Equal variances not assumed			-5,673	19,974	0,000	-19,91833	3,51104	-27,24283	-12,59383
Height	Equal variances assumed	0,647	0,427	-3,399	30	0,002	-9,25500	2,72313	-14,81637	-3,69363
	Equal variances not assumed			-3,578	27,024	0,001	-9,25500	2,58644	-14,56170	-3,94830
Sitting height	Equal variances assumed	0,271	0,606	-4,265	30	0,000	-8,35833	1,95962	-12,36041	-4,35626
	Equal variances not assumed			-4,250	23,037	0,000	-8,35833	1,96679	-12,42660	-4,29007
Bicndylar femoral width	Equal variances assumed	0,669	0,420	-1,029	30	0,312	-0,27667	0,26895	-0,82593	0,27259
	Equal variances not assumed			-1,130	29,354	0,268	-0,27667	0,24491	-0,77730	0,22397
Lower leg length	Equal variances assumed	2,498	0,124	-1,146	30	0,261	-1,42667	1,24475	-3,96878	1,11545
	Equal variances not assumed			-1,253	29,179	0,220	-1,42667	1,13837	-3,75427	0,90094
Ankle width	Equal variances assumed	0,513	0,479	-0,453	30	0,653	-0,07000	0,15437	-0,38527	0,24527
	Equal variances not assumed			-0,494	28,999	0,625	-0,07000	0,14175	-0,35991	0,21991
Foot length	Equal variances assumed	3,045	0,091	-3,136	30	0,004	-1,83833	0,58614	-3,03539	-0,64127
	Equal variances not assumed			-2,770	15,758	0,014	-1,83833	0,66377	-3,24723	-0,42944
Upper leg circumference	Equal variances assumed	1,736	0,198	-2,808	30	0,009	-5,55333	1,97754	-9,59201	-1,51466
	Equal variances not assumed			-2,900	25,672	0,008	-5,55333	1,91475	-9,49160	-1,61507
Lower leg circumference	Equal variances assumed	1,000	0,325	-3,028	30	0,005	-3,04333	1,00493	-5,09568	-0,99099
	Equal variances not assumed			-2,820	18,533	0,011	-3,04333	1,07930	-5,30620	-0,78047
Arm length	Equal variances assumed	0,030	0,864	-0,328	30	0,745	-1,17500	3,58274	-8,49193	6,14193
	Equal variances not assumed			-0,333	24,390	0,742	-1,17500	3,53019	-8,45480	6,10480
Upper arm length	Equal variances assumed	0,201	0,657	-0,067	30	0,947	-0,09833	1,47867	-3,11817	2,92151
	Equal variances not assumed			-0,068	24,938	0,946	-0,09833	1,44618	-3,07718	2,88052
Forearm length	Equal variances assumed	0,597	0,446	-0,491	30	0,627	-0,62500	1,27203	-3,22283	1,97283
	Equal variances not assumed			-0,586	28,073	0,562	-0,62500	1,06600	-2,80835	1,55835
Bicondylar upper arm width	Equal variances assumed	4,507	0,042	-5,776	30	0,000	-1,47000	0,25449	-1,98974	-0,95026
	Equal variances not assumed			-4,998	14,859	0,000	-1,47000	0,29414	-2,09745	-0,84255
Hand width	Equal variances assumed	0,649	0,427	-5,264	30	0,000	-0,94833	0,18015	-1,31625	-0,58042
	Equal variances not assumed			-4,853	17,962	0,000	-0,94833	0,19541	-1,35894	-0,53773
Upper arm circumference-relaxing position	Equal variances assumed	1,986	0,169	-6,373	30	0,000	-5,85500	0,91879	-7,73142	-3,97858
	Equal variances not assumed			-5,791	17,178	0,000	-5,85500	1,01104	-7,98642	-3,72358
Upper arm circumference during contraction	Equal variances assumed	2,156	0,152	-6,123	30	0,000	-6,38667	1,04311	-8,51699	-4,25635
	Equal variances not assumed			-5,596	17,482	0,000	-6,38667	1,14134	-8,78964	-3,98369
Shoulder width	Equal variances assumed	0,504	0,483	-5,354	30	0,000	-5,64500	1,05442	-7,79841	-3,49159
	Equal variances not assumed			-5,025	19,013	0,000	-5,64500	1,12339	-7,99616	-3,29384
Chest width	Equal variances assumed	3,513	0,071	-6,896	30	0,000	-6,58833	0,95544	-8,53961	-4,63706
	Equal variances not assumed			-5,984	14,984	0,000	-6,58833	1,10103	-8,93534	-4,24133
Leg length	Equal variances assumed	1,290	0,265	0,463	30	0,647	1,45000	3,13140	-4,94518	7,84518
	Equal variances not assumed			0,398	14,618	0,696	1,45000	3,64043	-6,32707	9,22707
Pelvic width	Equal variances assumed	0,329	0,571	-5,074	30	0,000	-4,22833	0,83338	-5,93032	-2,52635
	Equal variances not assumed			-4,892	20,732	0,000	-4,22833	0,86436	-6,02729	-2,42938
Upper arm skinfold	Equal variances assumed	19,626	0,000	-1,713	30	0,097	-1,45000	0,84666	-3,17911	0,27911
	Equal variances not assumed			-1,316	11,073	0,215	-1,45000	1,10199	-3,87351	0,97351
Back skinfold	Equal variances assumed	20,719	0,000	-2,109	30	0,043	-1,81900	0,86268	-3,58082	-0,05718
	Equal variances not assumed			-1,616	11,020	0,134	-1,81900	1,12535	-4,29534	0,65734
Abdominal skinfold	Equal variances assumed	17,853	0,000	-1,947	30	0,061	-2,05133	1,05365	-4,20318	0,10051
	Equal variances not assumed			-1,499	11,124	0,162	-2,05133	1,36846	-5,05921	0,95654
Fat	Equal variances assumed	0,025	0,874	1,585	30	0,124	2,66667	1,68281	-0,77009	6,10342
	Equal variances not assumed			1,587	23,429	0,126	2,66667	1,67993	-0,80501	6,13835
Muscle mass	Equal variances assumed	0,543	0,467	-7,071	30	0,000	-17,94333	2,53745	-23,12549	-12,76117
	Equal variances not assumed			-7,232	24,958	0,000	-17,94333	2,48104	-23,05357	-12,83310
Water	Equal variances assumed	0,016	0,899	0,169	30	0,867	0,73833	4,36901	-8,18438	9,66105
	Equal variances not assumed			0,183	28,634	0,856	0,73833	4,04136	-7,53178	9,00844

The only parameters in which statistically significant differences were not highlighted are bicondylar femoral width (t-test=-2.118, p>0.05), ankle width (t-test=-2.813, p>0.05), arm length (t-test=-2.657, p>0.05), upper arm length (t-test=-2.564, p>0.05), leg length (t-test=-2.862, p>0.05), upper arm skinfold (t-test=-1.539, p>0.05), back skinfold (t-test=-1.895, p>0.05), abdominal skinfold (t-test=-1.152, p>0, 05), fat (t-test=-2.636, p>0.05) and water (t-test=0.754, p>0.05). In general, it can be concluded that there are noticeable differences in anthropometric characteristics between cadets and seniors.The results of the t-test (Table 3) between juniors and seniors in terms of anthropometric characteristics show that there are no significant statistical differences in most of the examined parameters because p>0.05. This fact is supported by the following measured parameters: bicondylar femoral width (t-test=-1.029, p>0.05), lower leg length (t-test=-1.146, p>0.05), ankle width (t -test=- 0.453, p>0.05), foot length (t-test=-2.770, p>0.05), upper leg circumference (t-test=-2.808, p>0.05), lower leg circumference (t- test=-2.820, p=0.05), arm length (t-test=-0.328, p>0.05), upper arm length (t-test=-0.067, p>0.05), forearm length (t -test=-0.491, p>0.05), leg length (t-test=0.463, p>0.05), upper arm skinfold (t-test=-1.713, p>0.05), back skinfold (t-test=-1.614, p>0.05), abdominal skinfold (t-test=-1.499, p>0.05), fat (t-test=1.585, p>0.05) and water (t-test=0.169, p>0.05).

DISCUSSION

Analyzing the results from Table 7, obtained by t-test (Independent Sample Test), which refers to the differences between cadets and juniors in terms of anthropometric measures or characteristics, it is concluded that there are very noticeable differences in most anthropometric characteristics. This is supported by the fact that the error p in most measurements is less than 0.05 (p<0.05), and from this, it can be concluded that there are statistically significant differences between cadets and juniors. Measurements in which statistically significant differences were observed refer to weight, height, sitting height, lower leg length, foot length, lower leg circumference, bicondylar upper arm width, hand width, upper arm circumference - relaxing position, upper arm circumference - during contraction, shoulder width, chest width, leg length, and pelvic width. The only measurements in which no major statistical differences were recorded were: upper arm length, forearm length, arm length, ankle joint width, and bicondylar femoral width. Krstulović (2006) analyzed the morphological characteristics of 40 cadets and 45 juniors practicing judo. The research found that there are significant morphological differences between cadets and juniors.On the other hand, when it comes to body composition (water, fat, skinfolds on the back, abdomen, and upper arms), there are no significant statistical differences between cadets and juniors, and the only measurement when it comes to body composition, in which significant statistical differences are recorded, is muscle mass.From the results of the t-test, Independent Sample Test, on the differences in the level of individual anthropometric measures between cadets and seniors (Table 9), we can notice that at the level of significance p<0.05, there are statistically significant differences in most of the analyzed variables. As in most previous research on this topic, the fact that there are very prominent differences between the mentioned two age groups is confirmed. Variables in which statistically significant differences were recorded were: weight, height, sitting height, lower leg length, foot length, upper leg circumference, lower leg circumference, forearm length, bicondylar upper arm width, hand width, upper arm circumference - relaxing position, upper arm circumference - during contraction, shoulder width, chest width, pelvic width. Measurements in which no statistically significant differences were recorded refer to the following variables: bicondylar femoral width, ankle width, upper arm length, and leg length. The second part of the performed measurements refers to the body composition between cadets and seniors. Regarding the mentioned measurements, the results show no statistically significant differences in most of the measured parameters (skinfolds of the back, abdomen, and upper arms, fat, and water), and the only variable in which certain differences were recorded is muscle mass.

Analyzing the results of the t-test in the differences in the level of anthropometric characteristics between juniors and seniors, whose values are in Table 11, we can safely conclude that at the level of significance p<0.05 and p=0.05, there are no statistically significant differences in most of the analyzed variables. Variables in which there are no statistically significant differences are bicondylar femoral width, lower leg length, ankle width, foot length, upper leg circumference, lower leg circumference, arm length, upper arm length, forearm length, leg length, and height. On the other hand, when it comes to the composition of the body between juniors and seniors, the results of the research show that there are no statistically significant differences between the mentioned age categories. No differences were recorded in the variables skinfolds of the back, abdomen, and upper arms, fat, and water, while a certain level of differences in measurements was recorded in the variable muscle mass. In terms of body composition, similar research results have been obtained in martial arts such as karate and judo.People who practice taekwondo are significantly thinner and have a lower percentage of subcutaneous fat compared to people who practice other martial arts (Mekić *et al.,* 2022). In a study of 30 elite Chinese taekwondo competitors, Gao (2001) proved that the dominant somatotype is of proportional stature, well-developed muscles and skeleton, and a small percentage of subcutaneous fat (Abdossaleh *et al.,* 2008). Marković et al. (2005) examined the differences between successful and less successful Croatian national taekwondo competitors and determined that successful athletes achieve significantly higher maximum running speed, have significantly higher anaerobic capacity, significantly lower heart rate, significantly higher explosive power, better lateral mobility, and a slightly lower percentage of subcutaneous fat tissue (2.3%) and are slightly taller (5.8 cm) than less successful athletes (Marković, Duraković-Mišigoj & Trninić, 2005). Kazemi et al. (2009) studied 124 taekwondo competitors, participants of the 2004 Olympic Games. They conclude that the medal winners are slightly taller and have a slightly lower BMI than the other participants.Because of the aerobic abilities that are present in taekwondo, it is very important to have a low percentage of subcutaneous fat, this was shown by the results and conclusion of the research they conducted (Gao *et al.,* 1998). Rapid weight loss affects cognitive performance and mood, which can affect performance in combat sports because it requires concentration, qualitative assessment, and a certain level of skill (Hall & Lane, 2001; Landers *et al.,* 2001). Research was conducted on a sample of 30 top Chinese taekwondo athletes (competitors). Gao (2001) proved that the dominant somatotype is proportional stature, well-developed muscles, skeletal musculature, and a very small percentage of subcutaneous fat (Abdossaleh *et al.,* 2008). The authors were

concerned with determining the normative values of body composition and anthropometric characteristics of senior Croatian taekwondo competitors of both genders, according to weight category. The sample of respondents consisted of 137 participants of the national senior championship in taekwondo. The examined sample was divided into two subsamples: seniors (n=73) and senior women (n=64). The measured variables are divided into two groups according to their role: morphological measures (body height, body mass) and variables that define body composition (body mass index, body fat (%), body fat (kg), muscle mass (kg), lean body mass (kg), total body water (kg) and basal metabolic rate (kJ)). The obtained results - mean value, variability (SD), and value ranges (MIN-MAX) - are Croatian reference values of anthropometric characteristics and body composition for seniors and female taekwondo competitors of different weight categories (+87g, -87 kg, -80 kg, -74 kg, -68 kg, -63 kg, -58 kg, -54 kg). The average of the measured values increases proportionally to the weight category. The largest range, i.e. the variability of the results is found in the variables of body fat (%, kg) and muscle mass (kg) (Čular, Bešlija & Kezić, 2020).

Conclusion

After looking at the results of the first category, the conclusion is that there are indeed statistically significant differences between cadets and juniors in most of the measurements where n was in most cases less than 0.05 (n<0.05). Only the following parameters did not show significant statistical differences: bicondylar femoral width, arm length, upper arm length, forearm length, upper arm, back and abdominal skinfold, fat, and water. Furthermore, similar results were obtained in the relationship between cadets and seniors. Statistically significant differences are also evident in the mentioned case, except for the following parameters: bicondylar femoral width, ankle width, arm length, upper arm length, leg length, skinfold of the upper arm, back and abdomen, fat, and water. The only category in which it is visible that there are no statistically significant differences is juniors-seniors. Differences between anthropometric characteristics were established, which in most segments show statistically significant differences. There are no statistically significant differences in the body composition of the mentioned age categories of the taekwondo national team. To achieve top results and success in taekwondo, it is necessary to achieve several factors. In addition to regular and persistent training and exercise, it is necessary to pay attention to the lifestyle that is led in addition to training. Nutrition is certainly one of the most important factors, both for successful training and exercise and for achieving top results. Of course, leading a healthy life and adapting the athlete to the living conditions required of a taekwondo player are connected to nutrition. What is certainly important for every taekwondo player is the structure and composition of the body. It is desirable, considering the type and characteristics of this sport, that such athletes have an ectomorphic physique: without a lot of muscle mass and deposits, a high level of endurance, and a fast metabolism. An indispensable aspect of a successful taekwondo player is the percentage of subcutaneous fat. The percentage of subcutaneous fat tissue should be significantly lower compared to other athletes. Anthropometric measurements by this type of sport, body composition and structure, flexibility, endurance, speed, explosive power, healthy and regular diet, low percentage of subcutaneous fat tissue, quality and correct exercise and training programs, are the components that describe a successful taekwondo player and top sports results.

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