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THE EFFECT OF SOMATOTYPE COMPONENT DIFFERENCES ON BIOMOTOR AND COGNITIVE ABILITIES*

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ABSTRACT

The aim of this study was to investigate the effect of somatotype differences on cognitive and biomotor abilities. This study was performed on 134 male (age average 21.85±2.34 years), 38 female (age average 21.28±2.22 years), and total 172 participants who do not have habit of regular exercise. The somatotype body types of participants were determined by Heath-Carter formula. As biomotor performance tests 30 m sprint, counter movement jump (CMJ), maximal anaerobic power (Ppeak), maximal anaerobic capacity (Pmean), Yo Yo Intermittent Recovery Test-1 (YIRT-1), hand-grip strength and flexibility (sit and reach) were measured. As measure of cognitive ability "The Transition to Higher Education Examination" (THEE) was used and evaluated the highest scores received by the participants. In this study participants with endomorph body type took the highest the THEE score (242.60±21.83), participants with mesomorph body type took lower scores than participants with endomorph (237.51±34.67) and finally participants who had ectomorphy body type showed lower scores than the ones with other two body types in terms of THEE scores (227.46±27.96). A statistically significant difference was found in jump test scores (p=0.04). According to these scores, participants with ectomorphic body type (p=0.34) and participants with mesomophic body type (p=0.14) the higher performance was seen in jump test scores. A statistically significant difference was found in YIRT1 test scores which is used to measure maximal oxygen consumption (p=0.00). According to results, participants with ectomorphic body type (p=0.01) and participants with mesomophic body type (p=0.00) the higher performance was seen in aerobic capacity scores. As result, participants with endomorphy body type who had the highest the THEE scores showed lower scores than the ones with other two body types in terms of hand-grip strength, flexibility, CMJ, 30 m sprint and YIRT-1 tests scores.

Keywords: *Somatotype, Cognitive, Biomotor, Performance.*

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INTRODUCTION

Somatotyping provides the quantitative description of the human physique. The most greatly used somatotype method was introduced by Heath and Carter; it is explained in three components (endomorphy, mesomorphy and ectomorphy) that empirically define different aspects of the body composition: degree of fatness, musculoskeletal development and the linearity of the body (Adhikara and Sinha, 2016; Rahmawati, 2012; Katarzyna et al., 2011). The somatotype evaluating measuring of body girth, percent body fat, and bone diameters. Somatotype, or morphological characteristics of the body, has become a major field of interest for many exercise and sports scientists as well as physiotherapists.

The contribution of morphological factors to athletic performance has been studied. Anthropological studies of highest ranking athletes characterised the typical somatotype associated with performance in specific athletic events (Chaouachi et al., 2005). One of the elements pointed out among important factors affecting performance is body structure; in other words, anthropometric features. When the literature is examined, there are studies showing that anthropometric features affect physical performance (Alwarez et al., 2010; Vila et al., 2011; Amri et al., 2012; Purenovic and Popovic, 2014; Mala et al., 2015). Anthropometric measurements of an individual are important existence for various sports, and this reason considered among the main criteria for success in many sports (Bompa et al., 1999). Cognitive ability base to the skill to describe and attain peripheral information for integration with existing cognizance in fact proper responses can be selected and administered (Mann et al., 2007). When the literature is examined, there is a very limited number of studies that especially investigate the association between physical activity and specific cognitive abilities (Eiland and Romeo, 2013). However, hardly any of them have studied effect of somatotype characters on cognitive abilities. Thus, it is still questioned whether somatotype chacarters are directly related to cognitive abilities.

If there is a effect of morphological characteristics on cognitive ability variables and biomotor performance scores, more information is needed about the somatotypes of participants developing their performance level. Thus, identifying the physiological requirement of participants might ensured a more objective basis on which coaches could evaluate prospective talent, formulate training programs and educators could determined to student selection examination score.

The purpose of this study was therefore to describe somatotype characteristics of participants and to determine the effect of morphological characteristics on their cognitive ability variables and biomotor performance scores.

MATERIAL AND METHODS

Subjects

A total of 172 volunteers, including 134 young men (age, 21.85±2.34; body mass, 69.17±8.48 kg) and 38 young women (age, 21.28±2.22; body mass, 57.34±10.79 kg) participated in the study. Prior to any participation, the experimental procedures and potential risks were explained fully to the subjects and all provided written informed consent. This study was approved by University of Inonu Ethics Committee for Research on Human Subjects. All of the subjects were previously informed about the testing procedures and any known risks, and provided their own written informed consent. All of the procedures were in accordance with the Helsinki Declaration of 2008 and the ethical standards of the International Journal of Sports Medicine (Harriss and Atkinson, 2009).

Data Collection

Anthropometric measurements and field test protocols were applied to volunteers participating in the study. Participants were told to rest 24 hours before the measurements, away from any heavy physical strain. All the measurements and test protocols applied in the study were applied in the Inonu University School of Physical Education and Sports (SPES) physiology laboratory and sports hall. Somatotype measurements were made on all participants in a resting state in the morning after 8 hours of fasting. The participants' motor tests were measured between 09.00 and 11.00. 5-min general warm-up protocol was applied to the volunteers participating in the study before all tests to minimize the risk of disability and to achieve optimal performance. As measure of cognitive ability "The Transition to Higher Education Examination" (THEE) was used and evaluated the highest scores received by the participants.

Anthropometric Measurements

First, height and weight were measured. We used an electronic body mass scale (HD-351 Tanita, Illinois, USA) and a portable stadiometer (SECA, Leicester, UK) to measure body mass in the nearest 0.1 kg and stature in the nearest 1 mm with participants being barefoot and in minimal clothing, respectively. These measurements were used to calculate Body mass index

(BMI) as the quotient of body mass (kg) to stature squared (m^2). Then body girths (flexed and tensed upper arm girth, waist girth and calf girth) were measured using Holtain flexible but non-stretchable tape (Holtain Ltd, Croswell, UK) to the nearest 0.1 cm. Upper arm girth was measured as the maximal girth of the upper arm with flexed and tensed elbow. Calf girth was measured as the greatest girth of the calf. Waist circumference was measured at the level midway between the lowest point of the rib margin and the highest point of the iliac crest. Finally, skinfold thicknesses (triceps, subscapular, supraspinale and medial calf) were measured using Harpenden caliper (Holtain Ltd, Croswell, UK) to the nearest 0.2 mm. Biepicondylar humeral and femoral breadth were measured using Holtain bicondylar caliper (Holtain Ltd, Croswell, UK) to the nearest 0.1 cm. All anthropometric measures were taken by the same investigator. The equations of Carter and Heath were used to calculate the anthropometric somatotypes. The Heath-Carter formula using our study is as follows (Carter, 2002):

1) Endomorphic component

= −0.7182 + 0.1451 × ΣSF − 0.00068 × ΣSF2 + 0.0000014 × ΣSF3

ΣSF = (sum of skinfold thickness of triceps brachii,

subscapular, and superior iliac) × [170.18/height (cm)]

2) Mesomorphic component

= 0.858 × breadth of biepicondylar humerus + 0.601 × breadth of biepicondylar femur + 0.188 × modified girth of upper arm + 0.161 × modified girth of calf − height × 0.131+4.5

Modified value is [value − (1/10 skinfold thickness)]

3) Ectomorphic component

The ectomorphic component is the difference according to the value of the height-weight ratio (HWR, HWR = height / 3√weight).

HWR ≥ 40.75 = 0.732 × HWR − 28.58

38.25 < HWR < 40.75 = 0.463 × HWR − 17.63

HWR ≤ 38.25 = 0.1

The formula marked on the somatotype chart is as follows:

X = Ectomorphic component − Endomorphic component

Y = 2 × Mesomorphic component − (Endomorphic component + Ectomorphic component).

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Field Tests

30 m Sprint Test

Each participant performed three trials in each test separated by five minutes of rest and times were recorded with an automated timer (Smart Speed; Fusion Sport, Australia). The subjects decided themselves when to start each test from a static position 30 cm behind the photocell, with the time being recorded from when the subjects intercepted the photocell beam. The best time taken to cover the 30 m distance in the sprint test was used in data analysis. The sprints were initiated from standard starting blocks set to individual preferences.

Counter Movement Jump (CMJ)

CMJ was determined using a force platform (Smart Jump; Fusion Sport, Australia). Jump height was determined as the centre of mass displacement, calculated from the recorded force and body mass. The CMJ began from an upright position; subjects made a downward movement to 90° knee flexion and simultaneously began the push-off phase. The best of 3 jumps was recorded for each test.

Wingate Anaerobic Test (WANT)

A 30-s WANT was performed on a cycle ergometer (Ergomedics 874, Monark, Sweden) against a resistance equaling 100 g kg-1 body mass. Instructions to begin pedaling as fast as possible against the inertial resistance of the ergometer were given and the appropriate load was applied instantaneously (within 3 s). Verbal encouragement was provided for the remainder of the 30-s test. During the warm-up period, the subjects were allowed to adjust the height and rotation of the handlebar to achieve the greatest comfort. As described elsewhere saddle height was adjusted so that, with the crank position at bottom dead centre and the foot secured to the pedal with toe clips, the knee joint was almost in full extension and the sole of the foot was parallel to the ground (Micklewright et al., 2006). This was sufficient as the optimal duration of a warm-up for moderate intensity exercise is 5–10 min (Bishop, 2003). A 3-min recovery followed the warm-up and preceded the beginning of the test. During the recovery period, each subject was allowed to continue cycling with zero load or to stop and stretch. At the beginning of the test, each subject was still seated. The participants were needed to remain seated throughout the 30 s test. After the completion of the test, the subjects were allowed to continue cycling against a light load until they recovered (Santos et al., 2010).

Hand -Grip Strenght

The subjects were tested in a laboratory environment while seated comfortably on a chair of adjustable height without armrests, with their backs against the chair. In measuring right and left hand grasping strength biomotoric features, Takei hand dynamometer that measures 0-100 kg strength was used. Each patient was given a demonstration and then asked to complete a maximal isometric contraction for 3 s. All participants were asked to not motion of the test position during testing (Amaral et al., 2012).

Sit and Reach Flexibility Test

The test was administered using a specially constructed box that had a slide ruler attached to the top. The height ofthe box was 33 em. For practical reasons, the box was placed on a raised platform against a Wall, leaving enough room for the participant to sit opposite the boxwith legs straight in front of him or her and bare feet against the box. Keeping the knees locked, the participant reached for the slide, smoothly pushed it as far away as possible, and then held the position for 2 s (Koen et al., 2003). The score was the shift of the slide in centimeters. After one practice trial, the best score of three trials was recorded.

Yo Yo Intermittent Recovery Test 1 (YIRT-1)

The Yo-Yo IR1 was used to measure ability to perform intense intermittent exercise with high aerobic energy production and a significant contribution from the anaerobic energy system (Bangsbo et al., 2008). The Yo-Yo IR1 was performed on an indoor 20 m running track. Participants repeated sequential 40 m runs at a progressively increasing speed that was controlled by auditory bleeps from a portable CD player. The participants had a 10 second active recovery between each 40 m run. There was a tester positioned at each end line to ensure that the participant completed the full distance. All Yo-Yo tests were carried out by the same testers in order to minimise inter-rater variability. The test was terminated when the participants failed to reach the finishing line for the second time before the auditory bleep sounded. The number of 40 m runs was recorded and this represented the test result (Krustrup et al., 2003).

Statistical Analyses

Statistical analyses were performed using "IBM SPSS 23" (SPSS, Chicago, IL, USA). Findings were reported as means ± standard deviations (SD). Looking at the "kurtosis and skewness" values (between +1.5 and -1.5) and because the number of participants was greater than 50, whether the research data were homogeneous or not was tested with the "Kolmogorov Smirnov" test (Jukic et al., 2012). It was determined in the study that the data showed normal distribution. The data were analyzed using the "One Way ANOVA", one of the parametric tests used for evaluating more than two independent variables. When there was a statistically significant difference between averages, the "Sheffee post-hoc" test was used to find out in which group's favor it was.

RESULTS

Comparison of some structural features of 172 participants attended in the study in terms of gender and somatotype componentes was given in Table 1. Comparison of their biomotoric features and THEE scores was given in Table 2. According to these data, it was determined that there was a meaningful difference between participants' motor performance and THEE scores according to somatotype character differences ($p<0.05$).

Table 1. Body composition and somatotype characteristics of participants.

Parameters	Female (n=38) X±sd	Male (n=134) X±sd
Age (year)	21.28±2.22	22.10±2.46
Height (cm)	163.66±5.09	176.00±6.3
BM (kg)	57.34±10.79	69.14±8.45
BFR (%)	18.89±5.47	12.77±5.28
BMI (kg/m^2)	21.17±3.39	22.33±2.58
Endomorphy	3.50±1.24	3.03±1.05
Mesomorphy	4.08±1.37	4.28±1.13
Ectomorphy	2.77±1.55	2.87±1.27

(BM: Body mass, BFR = body fat ratio, BMI = body mass index)

In the study, the age of female participants was found to be 21.28±2.22 (years), their height 163.66±5.09 (cm), their body weight 57.34±10.79 (kg), their BFR 18.89±5.47 (%) and their BMI 21.17±3.39 (kg/m2) and the age of the male participants was found to be 22.10±2.46 (years), their height 176.00±6.3 (cm), their body weight 69.14±8.45 (kg), their BFR 12.77±5.28 (%) and their BMI 22.33±2.58 (kg/m2). In terms of somatotype character scores, endomorphy was found as 3.50±1.24, mesomorphy as 4.08±1.37 and ectomorphy as 2.77±1.55 in female participants and somatotype values of male participants were found as 3.03±1.05 for endomorphy, 4.28±1.13 for mesomorphy and 2.87±1.27 for ectomorphy.

Table 2: Effects of Somatotype Character Differences on Components of Biomotor and Cognitive

N, $\bar{x}$ ve Sd Values					ANOVA Values					
Parameters	**Somatotype Character**	*N*	$\bar{x}$	Sd		Sum of squares	df	Mean square	*F*	*p*
THEE	Endomorphy	29	242.60	21.83	**B.Group**	4753,483	2	2376,742	2,443	.090
	Mesomorphy	98	237.51	34.67	**W.group**	164383,59	169	972,684		
	Ectomorph	45	227.46	27.96	**Total**	169137,07	171			
Hand-Grip Right Hand	Endomorphy	29	41.63	9.99	**B.Group**	495,451	2	247,726	2,274	.106
	Mesomorphy	98	46.31	10.70	**W.group**	18409,64	169	108,933		
	Ectomorph	45	44.80	10.10	**Total**	18905	171			
Hand-Grip Left Hand	Endomorphy	29	41.45	10.38	**B.Group**	292,710	2	146,355	1,339	.265
	Mesomorphy	98	44.85	10.26	**W.group**	18476,72	169	109,330		
	Ectomorph	45	43.08	10.90	**Total**	18769,43	171			
Flexibility	Endomorphy	29	28.53	7.17	**B.Group**	77,174	2	38,587	,623	.537
	Mesomorphy	98	30.38	8.12	**W.group**	10464,73	169	61,922		
	Ectomorph	45	29.90	7.70	**Total**	10541,91	171			
CMJ	Endomorphy	29	29.86	7.68	**B.Group**	404,531	2	202,265	3,268	**.041***
	Mesomorphy	98	33.99	8.20	**W.group**	10461,13	169	61,900		
	Ectomorph	45	33.87	7.18	**Total**	10865,66	171			
30 m	Endomorphy	29	4.41	.47	**B.Group**	1,124	2	,562	2,765	.066
	Mesomorphy	98	4.19	.45	**W.group**	34,353	169	,203		
	Ectomorph	45	4.21	.42	**Total**	35,477	171			
YIRT-1	Endomorphy	29	804.1	425.1	**B.Group**	11877719,6	2	5938859,79	12,175	**.000***
	Mesomorphy	98	1532.6	770.7	**W.group**	82433378,1	169	487771,46		
	Ectomorph	45	1364.8	669.9	**Total**	94311097,7	171			
MaxVo2	Endomorphy	29	43.15	3.57	**B.Group**	853,527	2	426,763	12,151	**.000***
	Mesomorphy	98	49.32	6.56	**W.group**	5935,72	169	35,123		
	Ectomorph	45	47.83	5.62	**Total**	6789,24	171			
Ppeak (W)	Endomorphy	29	618.6	204.8	**B.Group**	138776,40	2	69388,20	2,426	.091
	Mesomorphy	98	636.3	156.1	**W.group**	4833638,86	169	28601,41		
	Ectomorph	45	569.3	171.5	**Total**	4972415,276	171			
Pmean (W)	Endomorphy	29	420.4	135.2	**B.Group**	54775,51	2	27387,75	2,004	.138
	Mesomorphy	98	438.7	109.8	**W.group**	2309541,54	169	13665,92		
	Ectomorph	45	396.8	119.4	**Total**	2364317,06	171			
FI (%)	Endomorphy	29	55.78	7.53	**B.Group**	73,255	2	36,627	,569	.567
	Mesomorphy	98	55.38	8.22	**W.group**	10879,82	169	64,378		
	Ectomorph	45	54.02	7.87	**Total**	10953,07	171			

(THEE: The transition to higher education examination; CMJ = counter movement jump; YIRT-1: Yo Yo intermittent recovery test-1; MaxVo2: Maximal oxygen consumption; Ppeak = Peak power, Pmean = Mean power, FI = fatigue index; *: $p<0.05$).

According to the findings in Table 2, the effect of somatotype character differences were found on selected physical and THEE scores. In addition to this, it was determined that the endomorphy group obtained the highest score (242.60 ± 21.83) in the THEE of participants while ectomorphy group obtained the lowest score (227.46 ± 27.96) in the THEE. It was determined that the ectomorphy group obtained the highest score in the YI performance of participants but that this score favoring the ectomorphy participants was not statistically significant (p>0.05). In terms of all biomotor scores, it could be seen that the mesomorphy group had the highest scores while endomorphy group obtained the lowest performance scores. Besides this, it was determined that there were found statistically significant difference in terms of somatotype in the CMJ (p=.041), YIRT1 (p=.000) ve MaxVo2 (p=.000) physical performance scores. Differences obtained as a result of ANOVA in were analyzed with the Scheffe test in the study (Table 3).

Table 3: Scheffe test results to determine whether there are differences between groups according to somatotype differences

Parameters	Somatotype (i)	Somatotype (j)	$\bar{x}_i - \bar{x}_j$	$Sh_{\bar{x}}$	*p*
THEE	Endomorphy	Ectomorph	15,135	7,426	**.043**
Hand-Grip Right	Endomorphy	Mesomorphy	-4,674	2,206	**.036**
CMJ	Endomorphy	Mesomorphy	-4,130	1,663	**.014**
		Ectomorph	-4,014	1,873	**.034**
30 m	Endomorphy	Mesomorphy	,2216	,0953	**.021**
Ppeak	Mesomorphy	Ectomorph	-67,015	30,453	**.029**
Pmean	Mesomorphy	Ectomorph	41,896	21,050	**.048**
YIRT-1	Endomorphy	Mesomorphy	-728,515	147,638	**.000**
		Ectomorph	-556,751	166,310	**.001**
MaxVo2	Endomorphy	Mesomorphy	-6,174	1,252	**.000**
		Ectomorph	-4,677	1,411	**.001**

(THEE: The transition to higher education examination; CMJ: Counter movement jump; YIRT-1: Yo Yo intermittent recovery test-1; MaxVo2: Maximal oxygen consumption; Ppeak = Peak power, Pmean = Mean power; $p<0.05$).

As a result of the "Scheffe" analysis done to determine which somatotype character the significant differences found as a result of the study favored, a statistically significant difference between ectomorph and endomorph favoring endomorph was found in THEE scores (p=.043). A statistically significant difference favoring mesomorph was found between mesomorph and endomorph in the hand grip right (p=.036) and 30 m sprint (p=.021) scores. In the Ppeak and

Pmean scores of participants, a statistically significant difference between mesomorph and ectomorph favoring mesomorph was found (p=.029 and p=.048 respectively). In addition to this, a statistically significant difference favoring mesomorph (p=0.14) and ectomorph (p=0.34) in CMJ, a statistically significant difference favoring mesomorph (p=.000) and ectomorph (p=.001) in YIRT-1 performance scores. Finally, there was a statistically significant difference in favor of mesomorph (p=.000) and ectomorph (p=.001) in MaxVo2 scores.

DISCUSSION

The purpose of this study was to examine the effect of somatotype character differences on biomotor performance and cognitive abilities. The results of the study showed that somatotype body types have an important effect on versatile performance scores. In particular, it was seen that the mesomorphic character has a positive effect on sprint performance scores, that the endomorphic character has a negative effect on vertical jump scores and that the mesomorphic character has a positive effect on aerobic capacity. Also, it was found that those with a endomorpy group obtained the highest score and ectomorph group who obtained the lowest score in THEE points. In THEE scores of participants, a statistically significant difference between ectomorph and endomorph favoring endomorph was found (p=.043). As measure of cognitive ability, THEE was used and evaluated the highest scores received by the participants. The results can be interpreted more objectively with the use of the other cognitive ability tests in further studies.

The average somatotype scores of female participants who were included in the study habit were found as 3.50 (endomorphy), 4.08 (mesomorphy) and 2.77 (ectomorphy). The average somatotype scores of male participants were determined as 3.07 (endomorphy), 4.28 (mesomorphy) and 2.87 (ectomorphy). According to these results, male participants had a balanced mesomorphic structure. In a research on the somatotype body types of similar age groups in the literature, Gualdi and Graziani (1993) determined the somatotype scores of 717 male and 876 female young sports participants and found the scores as 2.7-4.7-2.7 for males and 3.6-3.7-2.8 for females. Can et al. (2004) determined the somatotype scores of 17 women athletes and 17 non-athletes women participants and found the scores as 3.07 (endomorphy) – 3.55 (mesomorphy) – 2.43 (endomorphy) for athletes women and found the scores as 3.57 (endomorphy) – 3.35 (mesomorphy) – 2.90 (endomorphy) for non-athletes women. It can be argued that this difference is caused by the difference in sport experience between the sample groups.

When compared with endomorphy in participants, a positive significance was found in favor of mesomorphy in the hand grip right (p=.036) and 30 m sprint (p=.021) scores. In addition to this, a statistically significant difference favoring mesomorph (p=0.14) and ectomorph (p=0.34) in CMJ. Based on these results, it is believed that the excess of fat mass in the endomorphic body type negative affects running and strength scores (Vucetic et al., 2008). In the study, a significance between ectomorphy and mesomorphy favoring mesomorphy was found in the Ppeak (p=.029) and Pmean (p=.048) scores of participants according to the results of the WAnT test. In addition to this, the highest performance scores were obtained by participants with an mesomorphy body type in terms of Ppeak and Pmean scores in participants. These results were found to be similar to the literature (Lewandowska et al.., 2013; Nikolaidis, 2014).

A significance favoring mesomorphy (p=.000) and ectomorphy (p=.001) was found in participants in terms of maximal aerobic capacity and somatotype body types. In VO2max scores, a significance between mesomorphy and endomorphy favoring mesomorphy (p=.000) was found in participants and a significance between ectomorphy and endomorphy favoring ectomorphy (p=.003) was found in participants. In one study in the literature, it is stated that there is a negative correlation between the body fat percentage and VO2max (Sporis et al., 2011) and endomorphy group has a disadvantage in terms of maximal oxygen consumption (Susana et al., 2007).

CONCLUSION

The results suggest that somatotype body type difference has an effective role on motor performance and cognitive scores. In the study, participants with mesomorphic and ectomorphic groups achieved the highest scores in almost all physical performance tests. In contrast, when compared with endomorphy and mesomorph, endomorphy group obtained the highest cognitive ability score. In this context, It can be said that this result is an important feedback regarding the SPES student profile and the school entrance exams. In addition, the results can be interpreted more objectively with the examination of the other cognitive ability tests. Finally, there is a need for further studies examining other cognitive ability tests in terms of somatotype components.

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