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The Relationship between Selected Motor Ability Determinants and Anthropometric Characteristics in Adolescent Athletes from Various Sport

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A B S T R A C T

The main purpose of this study was to examine the relationship between speed, lower extremities explosive power, simple, and complex responses in adolescent athletes from various disciplines. Thirty nine athletes of 16.5 years old, N=13 sprinters and jumpers, N=13 soccer players, and N=13 judokas participated in the experiment. Pearson correlations, a one–way ANOVA and an independent t-test for establishing differences between those three groups of athletes was applied. Additionally the Ward method of hierarchical cluster analysis also was applied. The strong correlation occurred between complex responses and speed; 20 m from standing and 20 m flying start (r=0.62 and r=0.65 respectively). In other cases, no strong association was found. The substantial differences between groups occurred in the 20 m run from flying start (t=5.92) and standing triple jump (t=4.16). The study indicates that adolescent athletes may need to be assessed differently to a certain extent, including sport specialization.

Key words: *physical ability test, motor skills, sprinting speed, explosive power*

Introduction

Different sports and events require different physical abilities; in addition there are specific requirements on body composition, and anthropometrical measurements[1–3]. One needs to accept that human motor ability potential is innate, it is dependent on genetics, ontogenesis and the adaptability of the athlete's special physiological abilities. Some research has investigated the relationship between anthropometrical characteristics, speed, explosive power, agility, and throwing speed performance in adolescent athletes in various sports[1,4,2]. Young at el.[5] claimed that strength quality has a significant impact on starting ability and maximum running speed. Running maximal speed and jumping abilities improve greatly during adolescence with the highest rate of increase at age of 14 and 15[6]. Pearson et al.[3] stated that the biggest increase in strength ability in adolescent athletes occurs at peaks between 14 and 16 years of age. The benefits from vertical jumps (often recognized as reactive strength) are well known: increases jump height[7], rate of force development[8], reduction in ground contact time[7] and contributes to an athlete's ability to change direction[9].

Girard and Millet[10] claimed that dramatic changes in physiological attributes in most athletes occur at about 12–15 years, however they pointed out there are large inter-subject differences considering the timing of maturation. The problem looks even more complicated when we consider the level of specific technical skills required for a certain sport or event[11]. Therefore, the influence of physical abilities on soccer, judo or track athletics may be more apparent during adolescence (15–18 years) due to dramatic increases in anthropometric variables (body weight, size, height) or based motor ability development (speed, strength, or endurance).

The purpose of this investigation was to examine the relationship between several physical attributes (sprinting speed, explosive power simple and complex response abilities) in terms of selected body composition in adolescent athletes from various disciplines: track, judo, and soccer. In addition to determine to what extent these physical abilities relate to specific sports. It was hypothesized that there will be a high correlation between complex response measurements, running speed, and explosive power mea-

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surements, but the value of the correlation may be related to the sport practiced, and above all, to the main motor ability, which determines the success of the particular sport, eg. track athletics – sprinting speed, judo – explosive power, soccer – agility.

Materials and Methods

Thirty nine healthy male athletes 16 to 17 years old (x 16.5 years) were tested as part of their school athletic training program at the completion of their sport season. Subjects were divided into three groups: track athletes (sprinters and pole vaulters – N=13), soccer players (N=13) and judokas (N=13). The criteria for this selection were: age and practicing the respective discipline. The subjects had been involved in regular training for minimum of 3 years, were considered to be specialized for that particular sport, and in great condition. The athletes and their parents signed an informed consent and were informed of the protocol and procedures for the experiment prior to the exercise. The study was approved by the Human Ethics Committee of the University School of Physical Education in Wroclaw.

The testing was carried out in track and field stadium and in biomechanical lab of Sport University, at the end of school year during the competition season. All subjects were familiar with the testing procedure and jumping exercises, which they were performing as part of their training routine. The experiment was conducted in the morning which corresponds to the regular athletes training routine. The athletes were instructed to be adequately hydrated, fed and rested prior to the testing day. Before the testing, subject was allowed to perform 20 min standardized warm-up, including light jogging, stretching routine, light jumping exercises and accelerations. During the test each subject performed three different jumps, two horizontal: standing long jump (SLJ) and standing triple jump (STJ) and one lateral ski jump. Physical tests were performed also for sprinting, where subject were asked to run 20 m from standing start and 20 m from flying start. Whatever the testing modality, the subjects were requested to exert maximal effort in each test. The subject executed the horizontal jumps as far as possible. Therefore during the trial each subject was verbally encouraged to perform maximally. The break between jumping trials was 1 minute and between sprints 3 minutes to avoid fatigue effects. The dependent variable was chosen to describe the link between physical attributes in competitive soccer, judo and track and field teenage athletes.

Body weight was measured by means of an electronic scale (SEKA, Axis, Gdansk, Poland) accurate to nearest 0.5 kg. Measurements were made at the start of the study, before warm-up, in training apparel without shoes. In order to eliminate any errors, measurements were repeated twice. Lower limb lengths (from the trochanter of the femoral bone down to the base) and sitting height (from the vertex to the base on which the participant was sitting) were measured by means of an anthropometer (Martin Metal Anthropometer) accurate to 0.5 cm. Additionally the BMI was calculated.

To determine maximum velocity two sprint runs were performed. After a standardized warm up routine the athletes performed two trials of maximum effort: 20 m from a standing start (stationary not rolling) and 20 m from a flying start. Two self-custom design light gates connected to timing system (SIMI) were placed at 0 m and 20 m marks. For the 20 m flying start, time starts as the sprinter passes the first timing gate and stops when he passes the second gate at finish line. The acceleration zone, was 10 meters, which allowed the athletes to reach the fly zone at maximum speed. The trial with the best time was chosen for analysis.

The power of the lower extremities was assessed by three types of jumps: standing long jump, standing triple-jump with a take-off from both feet and ski jumps (lateral). The ski jumps were executed (take-off and landing) from both legs, over a wooden strip (length – 1 m, height – 1cm, width – 2 cm). On the signal, (»hop«) athletes performed 12 jumps over the bar, as fast as possible (measurement accuracy of 0.01 s). The best performance of two attempts was used for data analysis. These tests are well recognized in fitness and sport performance research.

Simple and complex response rates were studied by using the PNTR – program for testing the effects of receptor-motoric coordination[12]. During the test the subject was sitting in a comfortable position in front of a keyboard, their head 50 to 70 cm from the monitor. The monitor was set to avoid the reflections of other sources of light. After a short examination, the subject made a trial test – five pulses and then the proper test – 11 pulses. The result is the average time after subtracting the highest and the lowest value.

a) Simple response – when a bright square appeared on the monitor, the subject had to push the »+« key as soon as possible with his thumb. A visual signal appeared 11 times at various time intervals (randomly selected).
b) Complex response – when a bright square appeared on the screen, the subject had to press the: Q,W,E,R,A,S,D,F keys. If the square appeared on the right hand margin, one should push one of the U,I,O.P,H,J,K,L keys. If the square appeared in the middle of the screen, the space bar would be pushed.

Statistics

The mean (±SD) values of the tests were determined. The relationship between variables were determined using Pearson product moment correlation. A one-way analysis of variance was used to examine the differences in sprinting speed, explosive jumping of lower extremities and, simple and complex response measurement tests between the three groups. Anthropometric characteristic differences were analyzed with independent Student t-test. Statistical significance was set up $p<0.05$. Statistical power was determined to be > 0.90 at the 0.05 alpha level. Additionally the Ward method of hierarchical cluster analysis based on the linkage distances was used to determine relatively homogeneous groups of athletes of different quality of motor abilities and anthropometrics characteristics.

Results

Table 1 presents the results of analysis across three groups of athletes (track, soccer, and judokas) with regards to all anthropometric characteristics and each of seven motor ability variables. The track athletes were the tallest group (183.69 cm). Judokas and soccer players were of similar height (172.38 and 173.00 respectively). The same pattern held for body weight. The average BMI factor in each group was similar and was within the range constituting the type slender.

Statistically important differences were observed in motor ability measurements between the groups in 20 m sprint from flying and standing start. The best results achieved were track and soccer athletes (2.88 sec and 2.83 sec, respectively). Standing long jump, triple jump, and lateral ski jump (agility) ($p \leq 0.05$, Tab 2) also differed between the groups. Average simple and complex response times in all groups were similar. The lowest average simple response time of to 0.256 sec. occurred in the group of track athletes.

As shown in Table 2, a significant relationship ($p \leq 0.05$) appeared between standing long jump and standing triple jump in track athletes and soccer players (r=0.96 and 0.80 respectively). Additionally, in track athletes a strong relationship occurred between standing long jump and the lateral ski jump r=–0.85 ($p \leq 0.05$). Similar patterns were found between 20m from a standing start and 20m from a flying start for all three groups (soccer players r=0.74, track athletes r=0.74 and judokas r=0.83). Furthermore, a strong relationship ($p \leq 0.05$) was between the standing long jump and the 20m sprint from the standing and flying start in the group of athletes r=–0.66 and judokas r=0.83. In the group of track athletes and judokas there was a strong relationship ($p \leq 0.05$) between BMI and body mass (r=0.64 and 0.79 respectively). As expected, the body height and sitting height, also showed strong correlation (r=0.89 for soccer players and r = 0.88 for judokas)

The one way ANOVA for establishing differences between groups of athletes showed that the most significant differences in averages between judokas and track athletes occurred in the results of the 20 m run from the

TABLE 1

ANTHROPOMETRICS CHARACTERISTICS AND MOTOR ABILITY MEASURMENTS IN THE GROUP OF SOCCER PLAYERS (N=13), TRACK ATHLETES (N=13), AND JUDOKAS (N=13), ($p \leq 0.05$)

VARIABLES	Soccer players	Athletes	Judokas
Age [year]	16.00±0.00	16.62±0.51	16.31±0.48
Body height [cm]	173.00±5.52	*183.69±8.43	172.38±8.62
Body mass [kg]	63.08±4.80	69.54±8.00	62.31±9.10
Length of lower extremity [cm]	89.04±3.33	*95.50±5.99	89.69±4.44
Sitting height [cm]	87.85±3.99	*95.65±4.21	89.54±4.93
BMI	21.06±0.98	20.56±1.32	20.87±1.73
Simple respons time [sec]	0.257±0.028	0.256±0.019	0.260±0.024
Complex respons time [sec]	0.409±0.053	*0.439±0.084	0.421±0.036
20 m run from standing start [sec]	2.83±0.08	2.88±0.23	3.20±0.19
20 m run from flying start [sec]	*2.54±0.07	2.54±0.23	3.01±0.16
Standing long jump [m]	2.24±0.08	*2.47±0.28	2.17±0.19
Standing triple jump [m]	6.98±0.47	*7.52±0.56	6.67±0.43
Lateral ski jumps [sec]	*2.87±0.20	3.41±0.41	3.23±0.33

*A significant difference p<0.05

Body parameters	Whole group	Advanced (G1) N=4	Beginners (G2) N=4
	$\overline{X}$	SD	
Age (years)	18.1±4.18	*21.5±3.0	14.6±0.48
Height (cm)	177.5±8.40	*182.2±5.74	172.7±8.46
Weight (kg)	67.25±5.09	70.75±4.79	63.75±2.22
Trunk length (cm)	65.19±6.50	*69.50±3.78	60.87±5.89
Leg length (cm)	88.31±9.09	*93.70±3.23	82.87±5.89
Leg/height Index	49.91±3.04	51.40±0.67	48.42±3.90
BMI	21.64±1.45	21.32±1.52	21.97±1.53
Rohrer	1.22±0.13	1.17±0.11	1.28±0.15

*A significant difference p<0.05

TABLE 2
RELATIONS BETWEEN (PEARSON CORELATION) THE MEASURMENTS OF SELECTED MOTOR ABILITY TESTS IN THE GROUP OF SOCCER PLAYERS, TRACK ATHLETES AND JUDOKAS

Parameters	Soccer players (N=13)					Track athletes (N=13)				Judokas (N=13)				
	1	4	6	8	9	3	4	6	9	4	6	8	9	10
Simple response time [1]														
Complex response time [2]														
Lateral ski jumps [3]														
Standing long jump [4]						–0.85								
Standing triple jump [5]		0.80				–0.84	0.96							
20 m run from standing start [6]							–0.66			–0.83				
20 m run from flying start [7]			0.74				–0.64	0.74		–0.68	0.83			
Body height [8]														
Body mass [9]				0.81								0.78		
Length of lower extremity [10]												0.90		0.83
Sitting height [11]				0.89	0.78							0.88		
BMI [12]	0.56					–0.69		–0.65	0.64				0.79	

flying start (p=0.0001), standing triple jump (p=0.0001) and standing long jump (p=0.0005). Soccer players achieved better results in the 20 m run from standing start (p=0.0001), and in the 20 m run from flying start (p=0.0001) and lateral ski (p=0.0065) compare to judokas. The lateral ski jump also achieved significance between soccer players and track athletes (p=0.0001) (Table 3).

In Figure 1 a three diagram of hierarchical grouping of athletes is presented. As a result of cluster analysis in track and field athletes, three individual clusters of features were formed at linkage distance of 1.5. The first cluster (I) contained features that characterized body build and power of the lower limbs, the second (II) contained only features describing body build, and the third (III) grouped features associated with the speed of the executed motor activities. Cluster analysis showed that power of the lower extremities is mainly determined by the size parameters of body build, and not by the speed features (the linkage distance close to 5). Three distinct clusters of features emerged in the soccer players as well (at linkage distance of 1.5, according to the author's decision). The first (I) cluster contained all the features associated with body build, the second (II) contained those associated with the time of execution of the motor activities (and hence speed), and the third (III) those describing power of the lower extremities.

TABLE 3
THE ONE WAY ANOVA FOR ESTABLISHING DIFFERENCES BETWEEN GROUPS OF SOCCER PLAYERS (N=13), TRACK ATHLETES (N=13), AND JUDOKAS (N=13)

Parameters	F	p	F	P	Football players vs. Judokas	Football players vs. Track athletes	Judokas vs. Track athletes
Simple response time [sec]	4605.20	0.0000	0.09	0.9144	0.7363	0.9607	0.6995
Complex response time [2]	1871.25	0.0000	0.81	0.4510	0.6105	0.2127	0.4553
Lateral ski jumps [sec]	3756.67	0.0000	9.53	0.0005	0.0065	0.0001	0.1745
Standing long jump [m]	5144.64	0.0000	8.07	0.0013	0.4153	0.0050	0.0005
Standing triple jump [m]	7620.41	0.0000	9.44	0.0005	0.1271	0.0097	0.0001
20 m run from standing start [sec]	11054.18	0.0000	16.00	0.0000	0.0000	0.4883	0.0001
20 m run from flying start [sec]	10009.59	0.0000	33.17	0.0000	0.0000	0.9723	0.0000
Body height [cm]	20697.19	0.0000	8.97	0.0007	0.8388	0.0011	0.0006
Body mass [kg]	2909.18	0.0000	3.62	0.0369	0.7958	0.0351	0.0193
Length of lower extremity [cm]	14664.49	0.0000	7.40	0.0020	0.7257	0.0013	0.0034
Sitting height [cm]	16706.71	0.0000	11.34	0.0002	0.3331	0.0001	0.0011
BMI	8905.51	0.0000	0.44	0.6495	0.7262	0.3606	0.5702

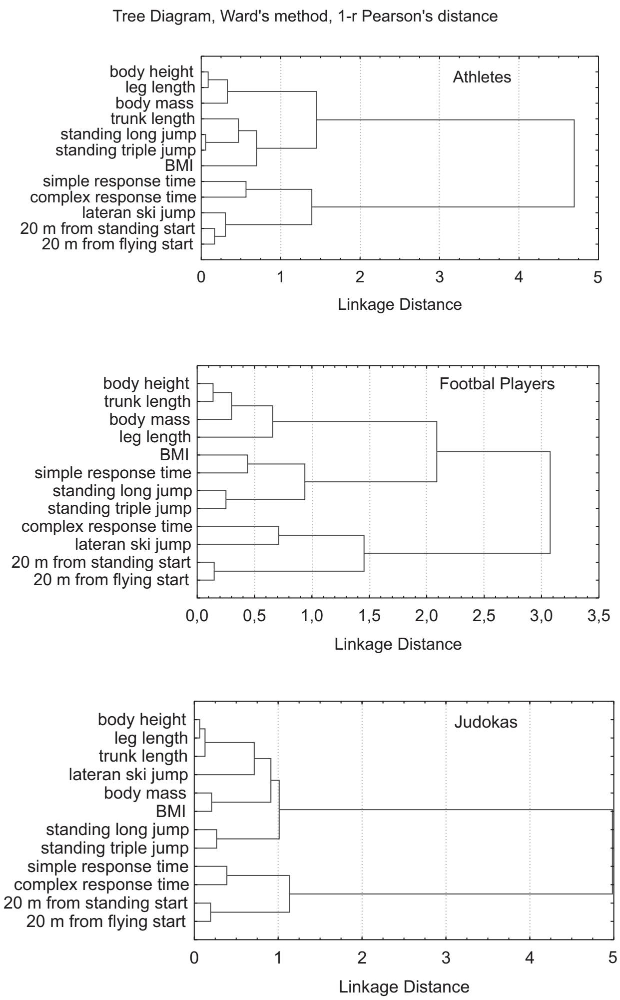

Fig. 1. Tree diagram of hierarchical grouping (cluster analysis) considering all anthopometrics characteristics and motor ability variables in track athletes, soccer players and judokas.

Discussion and Conclusion

The purpose of this investigation was to evaluate the relationship between sprinting speed and explosive power abilities in terms of selected body composition in adolescent athletes from various disciplines: track and field, judo, and soccer.

The compared groups differed in the somatic parameters (body height and body mass), despite being the same morphological age. The largest statistically significant differences in average values determining the somatic constitution concerned the sitting height (t=4.85) and body height (t=3.82). The average values of these parameters were higher in track athletes. Statistically important differences in the averages of all somatic parameters under examination also occurred between the group of track athletes and the group of judokas. Higher average values of these parameters are shown by the track athletes. The results proved that somatic features must be taken into consideration when we evaluate motor ability[1]. However Malina et al.[11] in his research on an adolescent soccer players stated that the contribution of body size, maturity status, age, and years of performance experience to success in soccer-specific skills tests is relatively small (8–21%).

In most cases the 20 m run from standing start and flying start are often applied as a maximum speed measurement or training too[13,14]. Bangsbo[15] found that soccer players sprint for an average length of 17 m, and 96% of sprints are less than 30 m, with an average duration of less than 6 s and an occurrence of every 90 s. In his study Mirkov[16] found that almost half of short sprints are less than 10 m, and often commence from a rolling start better known as flying start. The large majority of sprints performed in soccer take six seconds or less to complete, over distances of only 10–30 meters, and many of the sprints involve at least one or two changes of direction.

The lateral ski test represents more agility skill than jumping ability, therefore this variable showed significant difference in averages t=4.29. As expected better results in this test were by soccer players. Agility is described as the ability to change direction, stop and start quickly[17,18]. However, fast straight running and agility tests assess specific qualities which do no transfer one to another[5,17]. Mirkov et al.[16] claimed that the most appropriate indicator of overall soccer performance may be agility, which constitutes around 11% of player movement [12, 19], and on average, a player will make 50 turns during a match[9]. It is known that the turns are inseparably connected with cutting movement therefore we consciously used the lateral ski jump as a measurement of level of agility[20] (2). In this test, soccer players had better than expected results. They completed 12 jumps in 2.87 s, track athletes in 3.41 s. The relationships with the strongest statistical significance (in these two groups) occurred between the standing long jump and standing triple jump and lateral ski jump (respectively $r=-0.85$ and $r=-0.84$) in the track athlete group. Little and Williams[17] in their study confirmed that there is a significant correlation between maximum speed and agility ($r=0.34$ $p<0.05$). Although, according to Balsom[13], soccer players who have good sprint ability may not be skilled in agility. Similar results were found in the study done by Herm[21]. He found that there was a correlation between 30 m sprint value and agility ($r=0.65$), that data supports our findings. There is a notion that maximum speed and agility are distinctly specific attributes, however we can suppose given a higher speed ability, their will be a better performance in agility skills, as demonstrated by the track athletes ($r=0.55$ and $r=0.57$). In contrast, the soccer players group reached only $r=0.10$ for 20 m run from a standing and $r=0.12$ for 20 from flying start.

Our hypothesis was partially confirmed by the track athlete group. The only statistically significant correlation occurred between complex responses and sprint speed; 20 m from standing and 20 m flying start ($r=0.62$ and $r=0.65$ respectively). In other cases, no association was found between the complex and explosive power, response, and lateral ski tests that represent agility skills in all three groups. The same rule confirmed the relationships between complex responses and characteristics of body build in all three groups of subjects.

The Ward methods of hierarchical cluster analysis have been applied. Based on linkage distance as a level of significances, the cluster method determines relatively homogeneous groups of athletes (track, soccer, and judokas) of different quality of anthropometric characteristics and motor ability variables. The presence in the third cluster (III) of the feature expressed as the simple reaction time can likely be explained by the ballistic character of the movements taking place during measurements of power of the lower limbs, which lasted no longer than approximately 0.2 s. According to Bernstein's theory, no correction of the movement can be made during performance. That these features fall within one cluster suggests that the employed motor trials were executed at the level of simple reaction. It seems that training in individual sports such as judo and track and field brings similar results. In contrast, the specific preparation required in soccer as a team sport produces different effects. The best results were reached by soccer players, then the judokas. This partly confirms this assumption Gabbett and Benson[22], who investigated the importance of reactive agility in rugby players. They claimed that elite players had faster movement times on the reactive agility tests, and much better response accuracy. In addition they stated that the contribution of perceptual skills to agility is of great importance to the final success in rugby and therefore in team sport.

In conclusion, for the measurement of speed capacity, response time and lower extremity power the same type of test can be used although it is questionable whether the normative data derived for soccer players are relevant for judokas or track athletes, and vice versa. Our hypothesis was partially confirmed by a group of track athletes. The only statistically significant correlation occurred between complex responses and sprint speed; 20 m from standing and 20 m flying start (r=0.62 and r=0.65 respectively). In other cases, no association was found between the complex and explosive power response and lateral ski that represent agility skills. The applied cluster method allowed the identification of structural differences of anthropometric characteristics and motor abilities between various sport groups. This approach seems to be a credible tool. It seems that training in individual sports such as judo and track and field brings similar results. In contrast, the specific preparation required in soccer as a team sport produces different effects. On the basis of this, the adolescent athletes from various sports may need to be trained and assessed differently to a certain extent for some physical performance of dynamic power (sprinting speed and explosive power) and capability development.

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ODNOS IZMEĐU ODABRANIH ODREDNICA MOTORIČKIH SPOSOBNOSTI I ANTROPOMETRIJSKIH OBILJEŽJA KOD ADOLESCENATA SPORTAŠA IZ RAZLIČITIH SPORTSKIH DISCIPLINA

S A Ž E T A K

Glavna svrha ovog istraživanja bilo je ispitati odnos između brzine, eksplozivne snage donjih ekstremiteta, jednostavnu i složenu reakciju u adolescenata sportaša iz različitih disciplina. Trideset devet sportaša od 16,5 godina, N=13 sprinteri i skakači, N=13 nogometaši i N=13 judisti sudjelovalo je u istraživanju. Korišteno je Pearsonova korelacija, primijenjena jednosmjerna ANOVA i nezavisni t-test za utvrđivanje razlika između tih triju skupina sportaša. Dodatno, Ward metoda hijerarhijske klaster analize je također primijenjena. Visoka korelacija je utvrđena između složenih reakcija i brzine; 20 m od stajanja i 20 m leteći start (r=0,62 ir=0,65). U ostalim slučajevima visoka korelacija nije pronađen. Značajne razlike između skupina utvrđena je u 20 m trku s letećim startom (t=5,92) i troskoku (t=4,16). Studija pokazuje da adolescenti sportaši možda u određenoj mjeri moraju biti različito procjenjeni, uključujući i sportsku specijalizaciju.