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Levels and structural differences of morphological characteristics and motor abilities among boys, classified according to the level of overall stability index (OSI)

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Summary
The aim of this paper is to classify the levels and structures of motor and morphological specifics, which affect the overall stability index coefficient (OSI) using Biodex Balance System. A sample of 31 boys aged 12, 05 ± 1, 51 were classified into three qualitative groups by the OSI mean and standard deviation (SD) results. Multivariate analysis of variance (MANOVA) revealed the existence of differences and statistical significance in morphological and motor abilities between groups. Based on the results of MANOVA there is a highest level of significance when classifying into the groups. Univariate F test found the greatest difference between the groups in variable of body mass (AMAS, p – 0,003). Leven's test for heterogeneity of variance determined differences between groups in: body height (AVIS, p - 0,01); lengthwise standing on the balance bench with left foot (MRUUL, p – 0,037); lengthwise standing on the balance bench with right foot (MRUUD, p – 0,003); lengthwise standing on the balance bench with both feet (MRUB, p – 0). LSD post hoc test found differences between two groups in three ball slalom with feet (MKP3N, p – 0,045) and agility assessing test (MTTEST, p – 0,034). The results of the research can be used for selecting and choosing talented boys for complex sports, in which dominates agility, coordination and balance, while using the stability index coefficient, height and weight.

Key words: **stability index, morphological characteristics, balance, coordination, agility**

Introduction

Motor skills foundations are based on the mechanisms of neural excitation. Manifestation of higher level of nerve – motor control while at kid's age, may suggest the existence of top prepositions for achieving high sports accomplishment. For a toddler to walk, it is necessary to stand first, and by analogy, immobilization of the elderly occurs for the same reason as the beginning of walking - balance. Balance is the basis for performing dynamic movements of the whole body, such as throwing, jumping and running. Movements in structure of dynamic chains are based on the stabilization of the joints, which are located closer to the body. Balance is largely dependent on the capabilities of the nervous system to react to the slightest stimuli as well as the vestibular apparatus, which detects the slightest changes in the disruption of stability – sensory integration (Ayres et al., 1980; Latash et al., 2010). To maintain balance, in addition to detection, intramuscular coordination of stabilizer muscles is also needed. Coordination and balance, as motor abilities, are closely related. Coordination and agility are classified as a mechanism for structuring movements, while balance participates in work of the mechanism for synergistic regulation and tone regulation (Gredelj, 1975). These three aforementioned motor abilities are the leading abilities in previously mentioned mechanisms for movement regulation. It can be said that an individual has a good coordination if he moves easily and if time and order of his actions are well controlled. Coordination represents motor intelligence (Fleishman, 1955.). According to (Malacko & Rađo, 2004), coordination abilities are structured in several subspaces of which balance represents main. Sensitive period for coordination development among boys, by majority of authors, is from ages 7 to 14, while sensitive period for balance development among boys is from ages 10 to 11 (Bompa, 1999). As motor abilities, coordination and balance in sports selection take a very important role. Coordination and balance are highly innate motor abilities and expressing qualities of these abilities may suggest a great genetic potential for sports. Successful performing of complex agile movements, which can be found in sports, may be associated with frequent changes of positions of center of body's gravity (OCCT) which disrupts body balance. Agile movement ability largely depends of the equilibrium position of the body, apropos balance as a motor ability (Francis, 1997). This paper will contribute to a better understanding of the relationship between agility and coordination of children, as a selective value for complex sports. The research goal is the comparative analysis of the levels and structures of balance, coordination and agile qualities of boys with different levels of stability index.

Results of this research may offer a set of field balance, coordination and agility tests that describe overall stability index, which may suggest latent characteristics of coordination abilities system.

Methods

Sample

A sample of 31 boys aged 12,05 ± 1,51 were classified into three qualitative groups on the score of the overall stability index (OSI) results. All subjects were healthy without knee or ankle injuries, or any neurological conditions, which could influence results while measuring OSI. All respondents are engaged in football training from 1 to 3 years.

Postural stability assessment protocol

Stability index coefficient was measured by Biodex Balance System (BBS Model 945 – 300, Biodex Medical Systems; Shirely, New York) at the level 4 (range from 1 to 8 – most difficult, least difficult) protocol stability, and based on level tilting, the overall stability index coefficient was expressed in numerical character (OSI) (Arnold, 2005.). Protocol for general postural stability - dynamic bilateral stance assessment, means a dual test of 20 seconds (Biodex Medical System, 2006; Nevitt et al., 1991). For each subject identical protocol of 3 trials of 20 seconds and 30 seconds rest period at level 4 difficulties were implemented for determining overall balance index (OSI) (Arnold & Schmitz, 1998). For each repeated attempt, the exact foot position was re-entered. Lower score value means better result. Group classification (GC) was made on the results of mean values and standard deviation (SD) of the overall stability index (OSI) for whole sample of subjects tested. First group consist boys with results within –2 SD of mean values – group above average results (AA) n = 5, or 16,1% of respondents. The second group summarizes results within ±1 SD of mean values – average results (A) n = 20, or 64,5% of respondents. Third group included results within +2 SD of mean values – group below average results (BA) n = 6, or 19,3%. In this sample of subjects were not found any extreme result - ±3 SD.

Morphological characteristics

Morphological – anthropometric characteristics were represented by two variables: standing body height (AVIS), measured with anthrop meter by Martin and body mass (AMAS), measured with calibrated scale Tanita BC420SMA (Tanita Corp; Tokyo, Japan) with a precision of ±0,1 kg.

Motor abilities

Motor – balance abilities were estimate with stopwatch, three times measured, where time starts when subject establishes balance and ends by falling off the balance bench. Maximum score achieved may be 60 seconds. Measured variables (n = 6) were:

a. MRPUL – transverse standing on the balance bench with left foot;
b. MRPUD – transverse standing on the balance bench with right foot;
c. MRUUL – lengthwise standing on the balance bench with left foot;
d. MRUUD – lengthwise standing on the balance bench with right foot;
e. MRUB – lengthwise standing on the balance bench with both feet;
f. MRPB – transverse standing on the balance bench with both feet.

Motor coordination – agility abilities were measured by stopwatch, with three repetitions for each, expressed by test variables (n=3):

a. MKP3R – three ball slalom with hands between the cones;
b. MKP3N – three ball slalom with feet between the cones;
c. MTTEST – T test for assessing agility by Bloomfield et al. (1994.).

Statistical analysis

All data are featured as a Means and SD. Data analysis was conducted with help of software package SPSS 22.0 (IBM corp.) and Excel (Microsoft corp.). For all variables, measures of central tendencies and data distribution were calculated and Kolmogorov – Smirnov test for normality of distribution. Multivariate analysis of variance (MANOVA) was used to determine the existence of differences in results, between groups of boys, classified according to the stability index (OSI). Multivariate tests validated statistical significance of classification into the groups and result differences. Fisher's LSD post – hoc test was used to determine statistically significant differences between groups within each of the variables, at statistical level of $p < 0,05$. Obtained results were standardized and displayed in Z values chart.

Results

Based on the results of the measures of central tendencies and data distribution, as well as the K-S test, it was found that all data were within limits of normal distribution. MANOVA of groups formed according to the overall stability index (OSI) within variables of the morphological characteristics and motor abilities obtained mean values for each group (Table 1).

Table 1 Average value of morphological characteristics and motor skills by groups classified by the score value of the overall stability index (OSI)

GC		*Mean*	*SD*		*Mean*	*SD*		*Mean*	*SD*
	AA	1,28	,11		158,20	9,90		50,64	18,95
	A	2,35	,6		164,10	11,94		50,97	12,15
	BA	4,63	,23		171,66	4,18		73,90	12,11
OSI	*Sample*	2,62	1,18	**AVIS**	164,61	11,10	**AMAS**	55,35	15,85
	AA	9,44	4,47		12,38	12,62		23,75	24,57
	A	7,32	4,18		11,45	7,93		23,28	19,50
	BA	5,23	2,58		5,24	3,43		7,37	6,94
MRPUL	*Sample*	7,26	4,06	**MRPUD**	10,4	8,36	**MRUUL**	20,5	21,99
	AA	24,65	23,02		17,62	12,86		14,89	12,38
	A	16,72	15,12		10,87	6,01		14,29	5,81
	BA	5,03	2,63		6,08	2,42		3,51	1,24
MRUUD	*Sample*	15,74	15,92	**MRUB**	14,3	11,55	**MRPB**	12,59	11,06
	AA	29,03	5,80		39,83	11,46		9,34	,67
	A	29,56	5,76		48,06	8,66		9,85	,65
	BA	30,74	3,85		51,32	10,84		10,05	,79
MKP3R	*Sample*	29,41	5,33	**MKP3N**	43,28	11,60	**MTTEST**	9,56	,73

Table 2 represents results of the multivariate tests for classifying into groups based on the overall stability index, within the space of morphological characteristic and motor abilities variables. All tests show the highest level of statistical significance ($p<0{,}01$) for classification into groups by overall stability index.

Table 2 Multivariate tests for determining the statistical significance of differences between groups

Test	*Value*	*F*	*Error df*	*Sig.*
Pillai's Trace	1,312	2,857	36,000	,000
Wilks' Lambda	,064	4,164	34,000	,000
Hotelling's Trace	8,683	5,789	32,000	,000
Roy's Largest	7,949	11,924	18,000	,000

Table 3 represents the results of univariate F – test which determined the statistical significances of differences between groups within the morphological characteristics and motor abilities variables. Based on the test results, it can be concluded that within the morphological characteristics space, statistically significant differences exist in variable body mass AMAS p – 0,003 for at least between two groups.

Within the area of motor abilities manifest variables, there were no differences found between the groups at statistically significant level. Other variables showed no statistically significant differences when classifying into groups, but results were close to limit values.

Table 3 Univarite F test for differences between classified groups

	F	*Sig.*
AVIS	2,24	,126
AMAS	7,20	**,003**
MRPUL	1,53	,234
MRPUD	1,49	,243
MRUUL	1,36	,273
MRUUD	2,38	,111
MRUB	2,89	,072
MRPB	2,82	,077
MKP3R	,19	,822
MKP3N	2,92	,070
MTTEST	3,01	,066

Leven's test for heterogeneity of variance (Table 4) was further used to find statistically significant differences among groups, in the area of manifest variables. Variables AVIS, MRUUL, MRUUD and MRUB show that the presumption of variance equality of their changeable was disturbed, and also present a higher level of statistically significant heterogeneity of variance of p – 0,05. Based on this, it can be concluded that the groups classified by the level of OSI, differ statistically significant precisely in these variables.

Table 4 Levene's Test for heterogeneity of group variance within the space of morphological and motor manifest variables

	F	*Sig.*
AVIS	5,46	0,01
AMAS	0,58	0,564
MRPUL	1,04	0,366
MRPUD	1,99	0,156
MRUUL	3,71	0,037
MRUUD	7,02	0,003
MRUB	10,1	0
MRPB	3,27	0,053
MKP3R	0,11	0,894
MKP3N	0,2	0,816
MTTEST	0,24	0,791

Post – hoc LSD test determined statistically significant difference between groups, and separately within each of the variable. Table 5 presents statistically significant differences of groups based on stability index (OSI) within area of morphological and motor variables. In addition to the previously determined differences, LSD test showed statistically significant differences between the two groups in variables MKP3N and MTTEST, which were not determined on higher levels of multivariate analysis by F – test and Leven's test of variance heterogeneity.

Table 5 Post hoc LSD test for identifying size of differences

			Mean D.	*Sig.*	*95% CI*	
AVIS	AA	BA	-13,47	**,046**	-26,7	-,23
	AA	BA	-23,26	,008	-39,8	-6,7
AMAS	A	BA	-22,94	,001	-35,6	-10,2
MRUUD	AA	BA	19,62	,042	,72	38,5
MRUB	AA	BA	11,54	,031	1,2	21,9
MRPB	AA	BA	11,38	,027	1,4	21,3
MKP3N	AA	BA	-11,48	,045	,29	22,7
MTTEST	AA	BA	-,71	,034	-1,4	-,06

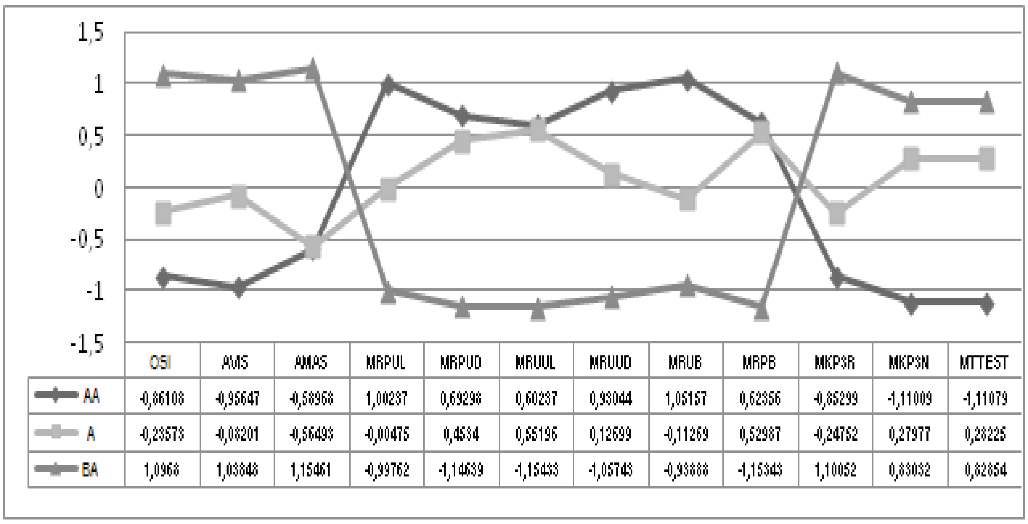
Mean values results of all manifest variables were recorded to a matrix, and calculated standard Z values for each group. Based on the Z matrix values, a Z graph was formed (Figure 1.), which presents differences between groups classified on the basis of stability index, in the areas of morphological and motor manifest variables. According to the Z graph of achieved results for groups, there are easily noticeable qualitative differences between groups formed by the stability index. Based on the chart, it can be concluded that the respondents with a higher level of overall stability index (OSI) have better results in agility and coordination tasks. It is important to note that lower values for coordination and agility tests represent better achievement in abilities (inversion results). In the space of balance abilities, a higher value represents better results.

On the basis of mean values, it was determined that in the area of morphological variables, body height (AVIS) variable showed that the above average (AA) group was 13,47cm shorter than the below average group (BA), which was statistically significant.

Compared to the average group (A), subjects were shorter on average 6,1cm, without any statistical significance. In the space of the morphological variables, body mass variable (AMAS) within above average group (AA) showed less body mass for average of 23,26kg than the below average group (BA), with statistical significance. Group of average respondents (A) had a lower body mass for average of 22,94 kg than the below average group (BA).

In the space of motor balance abilities, for lengthwise standing on the balance bench with left foot – MRUUL, the above average group scored for average of 16,33sec better than the below average group (BA). The above average group (AA), also scored a better result than the below average group within variable MRUUD – lengthwise standing on the balance bench with right foot. The above average group (AA) scored for average of 7,63sec less than the average

Figure 1. Graph of Z group values within morphological and motor manifest variables



group (A), on average of 19,62sec less than the below average group (BA). There are noticeable differences within all three groups for variable MRUB - lengthwise standing on the balance bench with both feet. Statistically significant difference between the above average (AA) and below average (BA) groups, with a difference of average 11,54 sec. Statistically significant differences were detected within variable MRPB – between groups above average (AA) and below average (BA) for average score of 11,38sec. Within coordination abilities, a significant difference between the above average (AA) and below average (BA) groups was determined for variable MKP3N - three-ball slalom with hands, or 11,48 sec in favor of the above average group (AA). Significant difference was found in MTTEST – T test for assessing agility, where the above average group (AA) achieved better score on average of 0,71 sec than the below average (BA) group.

Discussion

In a sample of 59 men, 17,4 to 63,8 kg/m^2, Hue (Hue et al., 2007.) determined, using regression analysis that a larger body mass has a negative effect on overall stability index. Similar results found Goulding (Goulding et al., 2003.), on a sample of 93 men aged 10 – 21 years. Most authors and studies results revile that excess of body mass – high BMI negatively affects the mechanisms responsible for maintaining a high level of postural stability (McGraw et al., 2000.). Results of this study also show differences in total body mass between groups, where above average results (AA) have a much lower total body mass than the below average (BA) group of respondents, based on the overall stability index, so that higher body weight directly contributes to worse postural balance, resulting a worse expression of motor skills.

Body height highly correlates with lateral stability of the knee joint and postural balance (Kejonen et al., 2003.). The results were obtained using tensiometric platform, on a sample of 100 respondents (50 male, 50 female), through regression analysis of anthropological measures of lower extremities, height and weight of subjects. Results of this study show that respondents of above average group (AA) have a lower body heights and have a better quantitative score of overall stability index (OSI) than the below average group (BA) who are taller.

In a sample of 21 amateur soccer players, aged 26 $\pm$ 3,3 years, with weight of 74,6 $\pm$ 8,5kg and height of 176,8 $\pm$ 6,1cm, Gstöttner (Gstöttner et al., 2009) investigated the differences between the levels of stability between dominant and non-dominant legs. Stability level was determined using Byodex balance system (BB) and Terax System. Differences were determined using student T test. Lack of significant differences between the scores of legs stability was found, with a slight tendency to greater stability in the non – dominant leg. Statistical differences were not found in the medial – lateral stability, p - ,23. Results of this research have actually found biggest differences between above average and below average groups, within tests of unilateral character for medial – lateral stability. Guided by previous research and the results gain in this, it can be concluded that there are individually small differences of unilateral stability, but they are significantly expressed between subjects with different levels of overall stability index (OSI).

Complexity of the management mechanism of the central nervous system issues for coordinating movements was research subject for many scientists (Sahan, 2009.). The largest research contribution for exploring the impact of CNS to establishment of the movement, gave Bernstein who formed the so – called „Bernstein problem“ (Latash, 2004.). Hatzitaki (Hatzitaki et al., 2002.) determined relations between balance and coordination and visual information processing, on a sample of respondents aged 11 – 13 years. Test consisted of balancing on one foot on the platform, which measures deviations and changes when in balanced position, while subjects were performing different tasks. Research results show high correlation between static balancing on one leg with receiving and processing information, which is essential for establishing basic stability control. Influence and relation of coordination with postural stability, studied by Wong (Wong et al., 2001.) using a sample engaged in Thai Chi, aged 2 – 35 years (n = 35) and control group (n = 14). Using tests for dynamic and static balance, he established the existence of differences in levels of postural balance between those engaged in Thai Chi and control groups, especially when performing complex balance tests. There was no high influence of age duration in sport to a postural balance. Author concludes that complex coordination training, as found in Thai Chi, helps maintaining the level of balance abilities, and that coordination training has acute effects on increasing postural stability. Given that coordination is closely related to body stability and agility, which depend on processing visual information, results of this research confirmed former findings. In fact, the largest group results differentiation, above average (AA) and below average (BA), by the quality of the overall stability index (OSI), have been found within test for legs coordination – MKP3N and legs agility (MTTEST), in the area of coordination and agility.

It is obvious that a higher level (lower overall stability index coefficient) of steady quality, positively affects situational manifestation of balance, coordination and agility. Boys classified into average and above average groups, based on OSI, state better results in solving complex motor coordination tests in continuity and better proprioceptive abilities also. These groups of boys also have a lower body weight and height, which is associated with researches of other authors who have proved with scientific methods that those with lower body mass and height have better coordination – balance abilities. Result were also confirmed by multivariate test for significance of classifying into groups (Table 2), showing the greatest statistical differences between groups.

Conclusion

The results obtained by measuring the stability index using Byodex Balance System (BBI), morphological characteristics and motor abilities: balance, coordination and agility, have valid and usable value, considering respect of protocol for measuring and using valid measuring methods. Boys aged 10 – 14 years, divided into groups depending on their level of overall stability index, significantly differ in morphological characteristics and balance and coordination abilities. Boys classified as above average (AA) are smaller in height with lower body mass, and score better results in field test for unilateral medial – lateral balance, legs coordination and legs agility. Considering the high level of differentiation potential of boys with high overall stability index, set of variables for assessing morphological characteristic and motor abilities applied in this research, can be a partial contribution for forming models of selecting boys for sports (almost all sports) dominated by neuro muscular apparatus abilities and movement regulation mechanisms. It should be noted that all tests are field feasible. Stability index is a great indicator for selecting boys into complex sports.

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