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THE CONNECTION BETWEEN THE ANTHROPOMETRIC CHARACTERISTICS OF THE BODY AND THE ISOMETRIC ENDURANCE OF THE LUMBAR AND ABDOMINAL MUSCULATURE OF CHILDREN

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Abstract. *This study was carried out with the aim of studying the relations that hold between the anthropometric characteristics of the body and the isometric endurance of the lumbar and abdominal musculature, and was based on a sample numbering 406 subjects aged 7 to 10. One subsample of the subjects consisted of 199 boys whose average height was 136.67cm (±8.65) and average weight was 33.83kg (±8.45). The other subsample consisted of 207 girls whose average body height was 137.75cm (±9.20) and average body weight was 37.05kg (±7.60). The following parameters were used to evaluate the anthropometric characteristics: body height, leg length, arm length, upper arm length, height while seated, shoulder width, pelvic width, knee diameter, body weight, average thorax volume, abdominal volume, hip volume, upper leg volume and calf volume. In order to evaluate the isometric endurance of the lumbar and abdominal musculature, the following tests were used: the Biering-Sorensen test of the endurance of the lumbar extensors, the test of endurance of the lateral flexors of the torso and the test of endurance of the flexors of the torso. The obtained data was processed by means of a canonical correlation analysis. The results and the discussion led us to the conclusion that there are statistically significant relations between anthropometric characteristics and the isometric endurance of the lumbar and abdominal musculature of boys and girls aged 7 to 10.*

Key words: *anthropometrics, lumbar extension, abdominal and lateral flexion, children, correlation*

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INTRODUCTION

During the ongoing process of the growth and development of children, their spinal columns represents one of the points of the locomotor system which is most sensitive to the effects of outside factors. During the growth process, a decrease in the strength of the abdominal and lumbar musculature can be noted. This discrepancy is one of the causes of postural deformities and child lumbar syndrome (Viry, Creveuil, & Marcelli, 1999).

The relevant literature on the subject does not contain enough research into the relations that hold between anthropometric characteristics and the isometric endurance of the musculature of the lower back and abdomen. Data on the anthropometric characteristics and endurance of the muscles of the lower back and abdomen can be found in most of the studies that dealt with the influence of certain psychological factors (Balague, Skovron, Nordin et al., 1995; Salminen, Okansen, & Maki, 1993); external factors (Viry, Creveuil, & Marcelli, 1999; Watson et al., 2002; Balague, Dutoit, & Waldburger, 1999); the status of the spinal column (Bajić, 1986) or pain in the lumbar region (Brattberg & Wickman, 1992; Grimmer & Villiams, 2000; Gunzburg, Balague, Nordin et al., 1999; Kukolj & Radisavljević, 1995; Troussier, Davoine, Gaudemaris et al., 1994).

Sorrensen (1984) proved that a decrease in the endurance of the body is a definite indicator of future problems in the lumbar region of the spinal column. The results of current research have indicated that the balance between the muscle endurance of the flexors, extensors, and lateral flexors of the torso can best be illustrated by people who have problems with this region of the spinal column, as the groups of muscles of the lumbar region of the spinal column play a part in maintaining spinal stability during various locomotor movements (Power, Frank, Hertzman et al., 2001; Salminen, 1993; Balague, 1995; Cholewicki, 1996; Sjolie & Ljunggren, 2001).

The postural status of children and their lumbar-abdominal region is most vulnerable when it comes to the negative effects of the modern way of life (Brooks, 2001). Due to a lack of sufficient movement, the musculature that is responsible for proper posture weakens in time and becomes susceptible to various influences from both the internal and external environment (Živković, 2000). Postural defects and deformities occur as the result of a decrease in the isometric endurance of the muscles responsible for posture (McGilll, 2004). This problem is not characteristic only of the young and of adolescents, but of young children as well (Norris, 2000). The causes of such postural deformities are partially based on hypokinesis, the lack of motivation among children for movement, playing outdoors and participating in sports activities (Norris, 2000).

The postural status of the population of schoolchildren is susceptible to the influence of external factors. The most intense development of morphological characteristics takes place during this period of a child's life. Morphological development does not take place at the same time as the development of the strength and endurance of the muscles of the entire body, especially the muscles of the lumbar and abdominal regions. In order to balance the effects of the internal and external factors on the proper growth and development of children, it would be useful to study the relationship between anthropometric characteristics and the isometric muscle potential of the lumbar and abdominal musculature of boys and girls aged 7 to 10.

We can assume that the anthropometric characteristics are in correlation with the isokinetic endurance of the lumbar extensors.

The aim of this research is to determine the significance and characteristics of the relations between the anthropometric characteristics of the body and the isometric endurance of the lumbar and abdominal musculature of boys and girls.

The results of this research should answer the question of the degree of the correlation and the question of which parameters of both spaces contribute most to the correlation.

THE METHOD

The sample of subjects

The overall population from which the sample of subjects was extracted consisted of the male and female students of the "Đorđe Natošević" elementary school in the town of Novi Sad. The sample consisted of 199 boys and 207 girls, all aged 7 to 10. All of the subjects showed pronounced somatic deficiencies and regularly attended physical education classes.

Sample of measuring instruments

The following parameters were used to evaluate the anthropometric characteristics: body height, leg length, arm length, upper arm length, height while seated, shoulder width, pelvic width, knee diameter, body weight, average thorax volume, abdominal volume, hip volume, upper leg volume and calf volume. The measuring of the listed characteristics was carried out in accordance with the guidelines of the International Biological Programme (Lohman, Roche, & Martorell, 1988).

The following motor tests were used to evaluate isometric endurance of the lumbar and abdominal musculature: the Biering-Sorensen test of endurance of the lumbar extensors, the test of endurance of the lateral flexors of the torso and the test of endurance of the flexors of the torso, whose validity was confirmed by McGill, Childs, & Liebenson (1999). The following variables were identified based on the obtained data: lumbar extension, abdominal flexion, left lateral flexion, and right lateral flexion.

The statistical procedure

In order to determine the relation between the two areas of study, we used the canonical correlation analysis. The data was processed using the "Statistics 6" program.

THE RESULTS AND THE DISCUSSION

The means and standard deviation of the anthropometric characteristics variables and the static endurance of the lumbar and abdominal section of the spinal cord for the boys and girls aged 7 to 10 are shown in Table 1. Certain numeric differences can be seen in the obtained parameters of some of the studied variables pertaining to the girls and boys. The statistical significance was not determined. The greatest numerical differences in the space of anthropometric characteristics were found for thorax volume and waist volume in favor of the boys, while in the space of isometric muscle endurance, they were found for the lumbar extension in favor of the girls and for the right lateral flexion in favor of the boys.

Table 1. The means and standard deviations of the studied variables

Variables	Boys		Girls	
	Means	Standard deviation	Means	Standard deviation
Body height	136.67	8.65	135.72	9.20
Height while seated	72.28	4.05	72.08	4.33
Leg length	78.48	6.24	77.68	6.62
Arm length	57.62	5.02	56.92	5.46
Upper arm length	25.99	2.41	26.15	2.57
Shoulder width	29.53	1.93	28.98	1.97
Pelvic width	20.72	1.60	20.46	1.77
Knee diameter	9.01	0.81	8.65	.81
Thorax volume	67.50	6.88	65.64	6.62
Upper arm volume	20.20	2.72	19.84	2.48
Lower arm volume	19.64	1.93	19.01	1.86
Hip volume	71.85	07.67	71.92	7.51
Waist volume	61.73	7.97	58.27	6.68
Upper leg volume	41.72	5.72	41.87	5.26
Calf volume	27.95	2.90	27.69	3.04
Body weight	33.83	8.45	32.05	7.60
Lumbar extension	129.29	76.85	157.68	80.98
Abdominal flexion	125.41	96.53	120.83	103.23
Left lateral flexion	63.91	35.06	64.41	37.60
Right lateral flexion	69.80	40.25	67.42	39.93

Between the system of anthropometric characteristics of the body and the system of static endurance of the lumbar and abdominal musculature in the case of the subsample of boys, a statistically significant canonical factor was isolated, one which explains 27% of the shared variability of both systems (Table 2). This factor exhibits a high statistical significance (p=.000059).

Table 2. The canonical root, canonical correlation and significance – the subsample of boys

Can. R	Can. R2	Chi-sqr.	Df	P
.52	.27	117.13	64	.000059

Legend: Can.R – Extent of the canonical correlation; Can. R^2 - Canonical root of determination; Chi-sqr. – Barlett's Lambda test; Df – Degree of freedom; p – Level of significance Lambda

Table 3. The structure of the canonical factor of static endurance of the lumbar and abdominal musculature of the boys

Variables	Root 1
Lumbar extension	.845184 *
Abdominal flexion	.253230 *
Left lateral flexion	.814323 *
Right lateral flexion	.777418 *

The structure of the canonical factor of static endurance of the lumbar and abdominal musculature consists primarily of three variables which have high statistically significant projections based on the following hierarchy: lumbar extension, left lateral flexion, and right lateral flexion. The smallest projection, but also statistically significant, can be found for the abdominal flexion variable. Considering the fact that this factor is primarily made up of variables for the evaluation of the static endurance of the lumbar extensors and lateral flexors of the torso, while the back extension of the lumbar musculature variable stands out with the extent of its projection, this factor has been interpreted as the factor of lumbar extension and lateral flexion (Table 3).

Table 4. The structure of the canonical factor of anthropometric characteristics of the subsample of boys

Variables	Root 1
Body height	**.318747 ***
Height while seated	**.284622 ***
Leg length	**.271607 ***
Arm length	**.266222 ***
Shoulder width	**.248296 ***
Upper arm length	.126139
Pelvic width	.068931
Thorax volume	-.001676
Body mass	-.076501
Calf volume	-.126769
Forearm volume	-.166152
Hip volume	-.181614
Knee diameter	**-.229633 ***
Waist volume	**-.291293 ***
Upper leg volume	**-.291576 ***
Upper arm volume	**-.343976 ***

The structure of the canonical factor of anthropometric characteristics of the subsample of boys consists of nine statistically significant variables. The remaining seven variables have statistically significant projections on this factor. Table 4 shows that the structure is primarily made up of variables marked by an asterisk for the evaluation of longitudinal dimensionality, body volume and transversal dimensionality, so this factor can be interpreted as the factor of the anthropometric characteristics of the body.

Nevertheless, the structure of the relation of canonical factor indicates that the boys who had smaller body volume measures, and numerically greater longitudinal dimensions, achieved better results on the tests for the isometric endurance of the lumbar and abdominal musculature and vice versa. The values of the transversal variables, due to their bipolarity (knee width -.229; shoulder width .248), and even though they have the smallest projections on this factor, but are nevertheless still significant, can be interpreted in the following manner: the boys who had greater shoulder width and a smaller knee diameter achieved better results for the static endurance of the lumbar and abdominal musculature and vice versa.

On the basis of the previously explained results, we can conclude that during the period between the ages of 7 and 10, in the case of the boys, the connection between the

variables of the static endurance of the back extension and lateral flexors as one space and the anthropometric characteristics of longitudinal and voluminous dimensionality as the second space, is the greatest.

It has also been noted that the abdominal flexors are not primarily connected to the anthropometric dimensions. On the one hand, the smaller the body volume values, the better the static endurance of the lumbar and abdominal musculature for the members of this group, and on the other, greater longitudinal values of the skeleton lead to greater endurance of the aforementioned musculature and thus the chances of the occurrence of lumbar syndrome are minimal. Conversely, with an increase in body volume and a decrease in the length of certain parts of the body, the static endurance of the lumbar extensors and lateral flexors weakens, and endangers the stability and functionality of the lumbar segment as well as of any individual spinal unit, thus creating the necessary conditions for the occurrence of other spinal deformities in the lumbar region.

Table 5. The canonical roots, canonical correlation and significance – the subsample of girls

Can. R	Can. R2	Chi-sqr.	Df	P
.57	.32	140.95	64	.000000
.41	.17	63.86	45	.033612

Legend: Can.R – Extent of the canonical correlation; Can. R^2 - Canonical root of determination; Chi-sqr. – Barlett's Lambda test; Df – Degree of freedom; p – Level of significance Lambda

By studying Table 5 we can note that between the system of anthropometric characteristics and the system of isometric endurance of the lumbar and abdominal musculature in the case of the subsample of girls, two statistically significant roots were isolated. The first canonical root explains 32% of the common variability and has a high level of significance (p=.000000). The second canonical root explains 17% of the common variability and has a low level of statistical significance (.03).

Table 6. The structure of the canonical factors of the static endurance of the lumbar and abdominal musculature of the subsample of girls

Variables	Root 1	Root 2
Lumbar extension	.82 *	-.53
Abdominal flexion	-.18	-.19
Left lateral flexion	-.79 *	.24
Right lateral flexion	-.77 *	.43

The structure of the first factor of static endurance of the lumbar and abdominal musculature of the girls is made up of the following variables: lumbar extension, left lateral flexion and right lateral flexion. The numeric differences between the aforementioned variables are small, and so this factor can be defined as the factor of lateral flexion and lumbar extension. Abdominal flexion does not have a statistically significant projection on this factor.

The structure of the second canonical root, which is bipolar, consists of: lumbar extension, left lateral flexion and right lateral flexion. The numeric values of these variables are not homogenous enough, and so the defining of the latent factor has been left out.

Table 7. The structure of the canonical factor of the anthropometric characteristics of the subsample of girls

Variables	Root1	Root 2
Body height	**-.66**	**-.59**
Height while seated	**-.59**	**-.37**
Leg length	**-.66**	**-.66**
Arm length	**-.65**	**-.41**
Shoulder width	**-.23**	**-.74**
Leg length	**-.63**	**-.66**
Pelvic width	**-.23**	**-.51**
Thorax volume	-.13	**-.56**
Body mass	**-.66**	**-.64**
Calf volume	-.02	**-.54**
Upper arm length	-.59	**-.48**
Hip volume	-.03	**-.68**
Knee diameter	**.21**	**-.65**
Waist volume	.15	**-.59**
Upper leg volume	.07	**-.60**
Upper arm volume	.19	**-.53**

The structure of the first pair of canonical factor of anthropometric characteristics is made up of nine variables of longitudinal and transversal dimensionality of the body, while the volume variables do not have any statistically significant projections on this factor. Thus, this factor can be interpreted as the factor of longitudinal and transversal dimensionality of the body.

The structure of the second pair of the canonical factor of anthropometric characteristics consists of all 16 variables, or in other words, all of the anthropometric characteristics. This factor can be defined as the general factor of the anthropometric status of the body.

The relations of the first canonical pair indicate that the girls who had numerically smaller longitudinal and transversal dimensions of the body variable values got lower results on the isometric endurance of the lumbar and abdominal musculature tests and vice versa.

The relations of the second canonical pair indicate that the girls who got numerically lower anthropometric status variable values got numerically smaller results on the isometric endurance of lumbar extension test, but numerically higher results on the isometric endurance of the lateral flexor tests and vice versa.

This conclusion points out the complex nature of the relations between the space of the isometric endurance of the lumbar and abdominal musculature and the anthropometric dimensions, and requires a further, more detailed analysis which would include research carried out on children of both sexes and of various ages.

CONCLUSION

The results and the discussion of this study have confirmed the claim that there are statistically significant relations between the studied anthropometric characteristics and the isometric endurance of the lumbar and abdominal musculature of boys and girls aged 7 to 10.

In the case of the boys, we have determined that the lower the body volume values, and the higher the longitudinal dimensionality values, the lower the isometric endurance of the lumbar and abdominal regions and vice versa.

In the case of the girls, we have determined that there are statistically significant relations between the longitudinal and transversal dimensions, body volume and mass and the isometric endurance of the lumbar and abdominal musculature, in addition to the fact that a numerical increase in one system leads to a numeric increase in another system. The relations between body volume and mass on the one hand and isometric muscle potential on the other are inversely proportional.

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POVEZANOST ANTROPOMETRIJSKIH KARAKTERISTIKA TELA I IZOMETRIJSKE IZDRŽLJIVOSTI LUMBALNE I ABDOMINALNE MUSKULATURE DECE

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Istraživanje je sprovedeno sa ciljem da se istraže relacije između antropometrijskih karakteristika tela i izometrijske izdržljivosti lumbalne i abdominalne muskulature na uzorku 406 ispitanika uzrasta od 7 do 10 godina. Subuzorak ispitanika je činilo 199 dečaka telesne visine 136,67 cm (±8,65) i telesne težine 33,83 kg (±8,45). Subuzorak ispitanica je činilo 207 devojčica telesne visine 137,75 cm (±9,20) i telesne težine 37,05 kg (±7,60). Za procenu antropometrijskih karakteristika primenjeni su sledeći parametri: telesna visina, dužina noge, dužina ruke, dužina nadlaktice, sedeća visina, širina ramena, širina karlice, dijametar kolena, težina tela, srednji obim grudnog koša, obim trbuha, obim kuka, obim nadkolenice i obim potkolenice. Za procenu izometrijske izdržljivosti lumbalne i abdominalne muskulature primenjeni su: Biering-Sorrensen-ov test izdržljivosti lumbalnih ekstenzora, test izdržljivosti laterofleksora trupa i test izdržljivosti fleksora trupa. Dobijeni podaci su obrađeni kanoničkom korelacionom analizom. Rezultati i diskusija omogućavaju da se zaključi da postoje statistički značajne relacije između antropometrijskih karakteristika i izometrijske izdržljivosti lumbalne i abdominalne muskulature dečaka i devojčica uzrasta od 7 do 10 godina.

Ključne reči: *antropometrija, lumbalna ekstenzija, abdominalna i lateralna fleksija, deca, korelacija*