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PREDICTION OF THE ISOMETRIC ENDURANCE OF THE LUMBAR AND ABDOMINAL MUSCULATURE OF YOUNG BOYS

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Abstract. *The aim of this study was to determine the possibility of predicting isometric endurance of the lumbar and abdominal musculature based on a sample of 199 boys, aged 7 to 10, who had an average height of 136.67cm (SD±8.65) and average weight of 33.83 kg (SD±8.45). The predictor set of variables consisted of anthropometric characteristics, and the criterion set of variables consisted of isometric endurance of the lumbar and abdominal musculature. The following variables were used to evaluate the anthropometric characteristics: body height, leg length, arm length, length of the upper arm, 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 following tests were used to evaluate the isometric endurance of the lumbar and abdominal musculature: the Biering-Sorensen test of endurance for the lumbar extensors, the endurance test for the lateral flexors of the torso, and the endurance tests for the flexors of the torso. The obtained data was processed by means of a regression analysis. The results and the discussion led us to the conclusion that there is a statistically significant correlation between the anthropometric characteristics and the endurance of the lumbar extensors and lateral flexors, and that the multiple correlation between the anthropometric characteristics and the endurance of the abdominal musculature is not statistically significant.*

Key words: *anthropometrics, lumbar extension, abdominal and lateral flexion, prediction, young boys*

INTRODUCTION

The relevant literature on the subject of the so-called lumbar syndrome among young children and the young includes a great many studies (Salminen, 1993; Panjabi, 1996; Cholewicki, 1996; McGill, 1996; Balague, Skovron, & Nordin, 1995; Skoffer, 2007;

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Gibbson, Videman, & Battie,1997; Negrini & Carabalona, 2002; Keller, Johansen, Hellesnes, & Brox, 1999; Adams, Mannion, & Dolan, 1999; Arbogast, Gholve, Friedman, Maltese, Tomasello, Matthew, & Dormans, 2007; Bo, Andersen, Wedderkopp, & Leboeuf-Yde, 2006).

One of the studies (Viry, Creveuil, & Marcelli, 1999) was carried out in order for the authors to identify the role of ergonomics and other factors in the prevention of lumbar pain among schoolchildren, and included the use of a questionnaire created especially for that purpose. On the basis of the results that were obtained from the questionnaire, the authors were able to identify the relevant demographic characteristics, lumbar pain history, school and after-school activities, the weight of the children's schoolbags, data regarding the characteristics of the relevant furniture, the children's usual complaints and the psychological factors of the group in question. A total of 679 children filled out the questionnaire, 343 of which were boys, and 336 of which were girls. Their average age was 12.8, and their average body mass index was 19. In this study, over 30% of the children had experienced pain in their lumbar region during the month-long study, and 20% of them experienced pain during one of the weeks of the study. Around 20% of the subjects reported experiencing pain for at least 1 day during this same month. Almost 12% of the subjects reported experiencing medium-intensity pain and 8% reported experiencing high intensity pain.

Most adults experience the first signs of lumbar pain during their early teens or early twenties. The results of the latest research indicate a high frequency of lumbar pain among schoolchildren. In the study carried out by Grimmer & Williams (2000), a connection was established between lumbar pain and the weight of children's schoolbags.

Balague, Skovron, Nordin et al. (1995) determined a connection between psychological factors and unspecific pain in the lumbar region. A statistically significant relation exists between the variables for state of mind and lumbar pain (Salminen, Okansen, & Maki, 1993).

Taimela, Kujala, Salminen et al. (1997) assumed that the height of a chair and the height and position of the back influenced the onset of lumbar pain, and determined that a strong connection existed between them. The aim of their study was to determine the role of mechanical factors and psychological factors (including emotional and behavioral problems, as well as other experiences of somatic pain) on the occurrence of lumbar pain during childhood. The results showed that mechanical factors are the primary cause of lumbar pain. These conclusions were supported by the conclusions of other authors, such as Egger, Costello, Erkanli et al. (1999). An overview of the results of a similar study, carried out on a population of 1446 subjects aged 11 to 14, also presented similar results. Information on the factors relevant for lumbar pain was obtained by means of a questionnaire which the children filled out themselves, as well as data from a five-day journal that was kept in order to note the weight of their schoolbags every day. Mechanical factors, such as physical activity, and the weight of the schoolbags were not connected to lumbar pain in this study. Nevertheless, emotional problems, behavioral problems, strong headaches, stomach problems, sore throats, as well as everyday exhaustion are significantly connected to lumbar pain (Troussier, Davoine, Gaudemaris et al., 1994).

Balague, Dutoit, & Waldburger (1999) have indicated an increase in the number of people between the ages of 12 and 14 afflicted by lumbar syndrome. Subjects aged 15 are especially susceptible to this affliction, while the risk is greater for members of the female sex by around 14% in relation to the male population when the number of subjects of different sexes is the same. Improper posture while sitting was the primary cause that they cited for any postural status deficiencies.

Similar data has been presented by Huang, Palmer, & Forbes (2000), who have indicated that children living in the country are less susceptible to lumbar syndrome than children living in the city. The cause of this affliction, according to the authors, can be found in weak abdominal musculature, which occurs more often among city children. The authors concluded that the causes of lumbar syndrome are the following: the muscular disbalance between the lumbar and abdominal musculature, and thus also hypokinesis, lethargy, the manner in which one spends his free time, stress, dissatisfaction, and so on.

Leboeuf-Yde, Kyvik, & Bruun (1999) carried out a study that involved 29, 424 subjects aged 12 to 41. The aim of the study was to determine the exact age that marks the onset of back pain. The results showed that lumbar syndrome occurs among 56% of children aged 12, among 50% of the children aged 18, and among 67% of the population of adults aged 40. On the basis of these results, the authors concluded that follow-up research should focus on the period of early childhood and the period of adolescence, so as to obtain precise information about the critical age for the onset of this affliction.

Watson et al. (2002) used a sample consisting of 1446 subjects, aged 11 to 14, and tried to determine which sex was more susceptible to pain in the lumbar region. Their results showed that girls are more susceptible to this affliction, and that the main cause was the increase in the weight of schoolbags, which reached more than 20% of their body weight.

Mikkelsson et al. (1998) determined the influence of postural status on lumbar pain. They concluded that first stadium scoliosis has no bearing on this problem, nor does kyphosis, and that lordosis affects it only to a small extent. Nevertheless, the authors themselves indicated that research of this kind has to be defined precisely in the sense that categories must be formed on the basis of the degree of the deformity, and that muscle status of the region being tested must be established at the same time (primarily endurance and strength). Nevertheless, the study carried out by Gunzburg, Balague, Nordin et al. (1999) has shown that postural deformities influence the onset of lumbar syndrome, especially scoliotic and kyphotic posture.

The modern way of life of children affects their postural status in a very negative way, especially their lumbar-abdominal region. Due to insufficient movement, the musculature responsible for proper posture weakens in time and becomes susceptible to various internal and external influences. Primarily, the surface muscles deteriorate, and this process is followed by the deterioration of the muscles of the middle region and finally, the muscles at the deepest levels. After that, the overall load is passed on to the ligament and bone structure. Load leads to changes in the structure of the bone mass and a decrease in locomotor functions. Postural defects and deformities occur as a result of a decrease in the static endurance of the postural muscles (McGill, 2004). A decrease in the static endurance of the abdominal and lumbar musculature influences the occurrence of a muscular disbalance in the region, which over time leads to lumbar syndrome (McGill, 2004). Unfortunately, this affliction is no longer characteristic only of adults and adolescents, and now a great number of children complain of pain in the lumbar region (Norris, 2000). Lumbar syndrome is becoming an everyday occurrence as part of the activities of the modern-day child. The causes of these postural deformities vary in nature (Norris, 2000).

Norwegian scientists (Sjolie & Ljunggren, 2001), in a study that involved 101 subjects, determined a connection between the agility of the lumbar region, analyzed by means of Schober's test, and the test of static endurance of the lumbar musculature, measured by the Biering-Sorensen test. The results show that a total of 88 subjects, with an average age of 14.7, had low levels of endurance of their lumbar extensors, which is closely connected to the occurrence of the lumbar syndrome. In addition, the authors claim that the mobility of the lumbar region is not connected to weakness of the aforementioned musculature.

Balague, Damidot, Nordin, Parnianpour, & Waldburger (1993), while working with a sample of 117 subjects, aged 10 to 16, found that 30% of the subjects suffered from lumbar syndrome. In addition, they determined that anthropometric characteristics are significantly related to the isokinetic endurance of the lumbar extensors.

In addition to the aforementioned research, a certain amount of research focused on the influence of the inadequacies of school seats and desks as one of the causes of muscular disbalance of the static endurance in the lumbar and abdominal region. In addition, an insufficient number of physical education classes and a lack of participation in corrective gymnastic exercises which are aimed at preventing deformities have certainly influenced the decrease in postural status and the disbalance of the lumbar and abdominal musculature of children.

While studying how the characteristics of school seats affect the kyphotic and lordotic posture among fifth grade elementary school children, Bogdanović (2004) studied the extent to which the inadequacy of school desks for reading and writing, on the basis of the subjective analysis of the boys, causes the kyphotic and lordotic posture of fifth graders in the city of Kragujevac in Serbia. The study included 299 boys from several elementary schools from both the inner city area and the suburbs. On the basis of the obtained indicators, they author concluded that kyphotic and lordotic body posture was caused by the weakness of the lumbar and abdominal musculature. In the studied population, the weakness of the lumbar and abdominal musculature dominated the groups of boys whose school seats were not adequate for reading or writing.

On the basis of the results of the aforementioned research, it has clearly been indicated that he modern way of life of our children causes changes to the physical characteristics of the lumbar and abdominal region. Insufficient movement and a lack of exercise of the appropriate musculature stand out as the most important factors. The effects of these and other factors can cause pathological changes which are known and studied as the lumbar syndrome of children and the young.

The aim of this research is to determine whether there are any statistically significant relations between anthropometric characteristics and the isometric endurance of the lumbar and abdominal musculature of boys aged 7 to 10.

THE METHOD

The Sample of Subjects

The population from which the sample of subjects was extracted consisted of the elementary school students from the "Đorđe Natošević"elementary school in Novi Sad. The sample consisted of 199 boys aged 7 to 10, who had an average height of 136.67 cm (SD ± 8.65) and an average weight of 33.83 kg (SD ±8.45). During the measuring, none of the subjects had pronounced somatic deficiencies and regularly attended their physical education classes.

The Sample of Measuring Instruments

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

The following motor tests were used to evaluate the 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 the endurance of the flexors of the torso, whose validity was confirmed by McGill, Childs, & Liebenson (1999). By means of the data obtained at these measurings, we determined the following variables: lumbar extension, abdominal flexion, left lateral flexion and right lateral flexion.

The Statistical Analysis

The influence of anthropometric characteristics on the variables of isometric endurance of the lumbar and abdominal musculature was calculated by means of a regression analysis. The data was analyzed using the "Statistics 6"program.

THE RESULTS AND THE DISCUSSION

Table 1. The regression analysis of the lumbar extension

Variables	Beta	t	RP	Siq.
Thorax volume	.424	2.285	.052	.023
Body height	.420	1.138	.206	.257
Shoulder width	.286	2.471	.184	.014
Arm length	.165	1.023	.180	.308
Calf volume	.132	.806	-.011	.421
Pelvic width	.080	.678	.098	.499
Height while seated	.060	.327	.170	.744
Upper leg volume	-.038	-.227	-.043	.820
Forearm volume	-.047	-.235	-.074	.815
Body weight	-.061	-.168	.020	.866
Hip volume	-.105	-.481	-.032	.631
Waist volume	-.130	-.724	-.058	.470
Knee diameter	-.178	-1.610	-.076	.109
Length of the upper arm	-.222	-1.820	.082	.070
Leg length	-.276	-1.004	.185	.317
Volume of the upper arm	-.486	-1.952	-.127	.052
R=.478 R2 = .229 F=3.370 p=.00				

Legend R – the multiple correlation coefficient, R2 – the determinant of the coefficient matrix, F – extent of the F-relationship, p – the level of the significance of the regression connection, Beta – the standardized regression coefficient, t – t-test, RP – partial correlation, sig – significance.

By analyzing the values obtained in Table 1, we can conclude the following.

The positive numeric value of the multiple correlation coefficient (R=.478) indicates that the hypothesis about the statistically significant influence of the predictor anthropometric variables on the criterion variable of lumbar extension can be confirmed.

The determinant of the coefficient matrix (R2=.229) indicates that the entire system of predictor variables influences the criterion variable with 23%. The remaining unexplained 77% of variability is under the influence of other unidentified factors.

The high value of the F-test (3.370) confirms that we are dealing with a statistically significant system of predictor variables in relation to the criterion variable. Despite the lower value of the determinant coefficient (R2=.229), the level of statistical significance (p=.00) indicates that the system of predictor variables has a statistically significant effect on the criterion variable. Individually speaking, the greatest contribution to the relation between the anthropometric variables and lumbar extension was made by the following variables: shoulder width, thorax volume, and upper arm volume. These variables are marked by the highest levels of the t-test. We can conclude that transversal characteristics and torso volume have the greatest influence on the static endurance of lumbar extensors among boys aged 7 to 10.

Table 2. The regression analysis of the abdominal flexion

Variables	Beta	t	RP	Sig.
Leg length	.378	1.269	.094	.206
Shoulder width	.206	1.637	.120	.103
Thorax volume	.125	.623	.046	.534
Upper arm volume	.120	.444	.033	.657
Upper leg volume	.101	.559	.041	.577
Knee diameter	.065	.540	.040	.590
Height while seated	.049	.245	.018	.807
Waist volume	.045	.230	.017	.818
Pelvic width	.010	.076	.006	.940
Body height	-.012	-.030	-.002	.976
Arm length	-.012	-.067	-.005	.946
Calf volume	-.082	-.459	-.034	.647
Hip volume	-.146	-.615	-.046	.539
Forearm volume	-.197	-.908	-.067	.365
Upper arm length	-.205	-1.548	-.114	.123
Body weight	-.337	-.855	-.063	.394
R=.304 R2=.093 F=1.162 p=.303				

Legend R - the multiple correlation coefficient, R2 - determinant of the coefficient matrix, F-extent of the F-relationship, p - the level of the significance of the regression connection, Beta - the standardized regression coefficient, t - t-test, RP - partial correlation, sig - significance

On the basis of the results shown in Table 2, we can conclude that the anthropometric variables have a statistically significant influence on the isometric endurance of the abdominal flexors. This conclusion is supported by the results for statistical significance (p=.303), the F-test (1.162), the multiple determinant of the coefficient matrix (R2=.093) and the multiple correlation (R=.304). By analogy, the t-test has shown that the predictor has no influence on the criterion.

Table 3. The regression analysis of the left lateral flexion

Variables	Beta	t	RP	Siq.
Thorax volume	.476	2.541	.185	.012
Forearm volume	.342	1.688	.124	.093
Body height	.300	.803	.059	.423
Shoulder width	.185	1.580	.116	.116
Forearm volume	.125	.753	.056	.453
Height while seated	.043	.232	.017	.817
Knee diameter	.027	.243	.018	.808
Upper arm length	.018	.147	.011	.883
Body weight	-.003	-.008	-.001	.993
Pelvic width	-.029	-.245	-.018	.807
Leg length	-.049	-.176	-.013	.861
Arm length	-.099	-.610	-.045	.543
Hip volume	-.237	-1.076	-.080	.283
Upper arm volume	-.319	-1.268	-.094	.206
Waist volume	-.372	-2.051	-.150	.042
Upper leg volume	-.437	-2.585	-.188	.011
R=.461 R2=.212 F=3.067 p=.00				

Legend R - the multiple correlation coefficient, R2 - determinant of the coefficient matrix, F - extent of the F-relationship, p - the level of the significance of the regression connection, Beta - the standardized regression coefficient, t - t-test, RP - partial correlation, sig - significance

The value of the multiple correlation (R=.461) clearly indicates that we are dealing with the significant influence of the predictor anthropometric variables on the criterion variable of the left lateral flexor of the torso (Table 3). The multiple determinant of the coefficient matrix (R2=.212) indicates that the entire system of predictor variables has a 21% influence on the static endurance of the lateral flexor of the torso. The remaining 79% of the variability are under the influence of other unidentified factors. The high value of the F-test (3.067) and its significance (p=.00) indicates the statistically significant influence of the predictor variables on the criterion variable.

The following predictor variables have the greatest influence on the criterion: thorax volume, waist volume and upper leg volume. These three variables have the greatest t-test and beta coefficient values. Nevertheless, in addition to these variables, we can say that forearm volume and shoulder width do have a certain effect on the criterion variable. On the basis of these facts, we can conclude that the static endurance of the left lateral flexor among boys aged 7 to 10 is primarily under the influence of the voluminous dimensions of the torso and upper legs, and to a slightly lesser extent, forearm volume and shoulder width.

Table 4. The regression analysis of the right lateral flexor

Variables	Beta	t	RP	Sig.
Thorax volume	.330	1.759	.129	.080
Forearm volume	.254	1.249	.092	.213
Body weight	.226	.613	.045	.541
Shoulder width	.222	1.888	.139	.061
Height shile seated	.158	.853	.063	.395
Leg length	.135	.484	.036	.629
Hip volume	.110	.498	.037	.619
Knee width	.034	.305	.023	.761
Body height	.023	.061	.005	.951
Arm length	.000	.001	.000	.999
Pelvic width	-.026	-.214	-.016	.831
Forearm volume	-.141	-.844	-.062	.400
Upper arm length	-.293	-2.369	-.173	.019
Waist volume	-.306	-1.678	-.123	.095
Upper arm volume	-.425	-1.684	-.124	.094
Upper leg volume	-.459	-2.708	-.197	.007
R=.455 R2 = .207 F=2.977 p=.00				

Legend R - the multiple correlation coefficient, R2 - determinant of the coefficient matrix, F - extent of the F-relationship, p - the level of the significance of the regression connection, Beta - the standardized regression coefficient, t - t-test, RP - partial correlation, sig - significance

The results shown in Table 4 indicate that the multiple correlation (R=.455) is statistically significant, which indicates that we are dealing with the statistical significant influence of the predictor anthropometric variables on the right lateral flexor.

The multiple determinant of the coefficient matrix (R2=.207) indicates that the entire system of the predictor variables influences the criterion variable with 21%. The remaining unexplained 79% variability is under the influence of other factors, which demand further study. The F-test (2.977) and its statistical significance (p=.00) confirm the statistically significant influence of the predictor variables on the criterion variable. In Table 4, two variables stand out with their predictive value: upper arm length and upper leg volume. These two variables have displayed the greatest t-test and beta coefficient values. Nevertheless, the values of shoulder width, thorax volume, and waist volume differ only slightly from the borderline values of the F-test. On the basis of the obtained results we can conclude that the static endurance of the right lateral flexor of the torso among boys aged 7 to 10 is primarily connected to upper arm length and upper leg volume, and to a lesser extent to shoulder width, thorax volume and waist volume.

CONCLUSION

On the basis of the results and the discussion we can conclude that anthropometric characteristics have a statistically significant influence on isometric endurance of the lumbar extensors and lateral flexors of the torso, and that they do not influence the abdominal flexors.

Lumbar extension is primarily influenced by shoulder width, thorax volume and upper arm volume, while the lateral flexors are influenced by thorax volume, waist volume, upper leg volume, forearm volume, shoulder width, and upper arm length. The results and the discussion indicate that the isometric endurance of the lumbar extensors and lateral flexors of the body depend on the influence of volume and the transversal characteristics of the body. Anthropometric characteristics do not have a statistically significant effect on the abdominal flexors. The development of anthropometric characteristics at this point is not yet stable, and so we can assume that this is one of the explanations for the results of this study.

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PREDIKCIJA IZOMETRIJSKE IZDRŽLJIVOSTI LUMBALNE I ABDOMINALNE MUSKULATURE DEČAKA

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Istraživanje je sprovedeno sa ciljem da se istraži mogućnost predikcije izometrijske izdržljivosti lumbalne i abdominalne muskulature na uzorku 199 dečaka, uzrasta 7 do 10 godina, telesne visine 136,67 cm (SD±8,65) i telesne težine 33,83 kg (SD±8,45. Prediktorski skup varijabli činile su antropometrijske karakteristike, a kriterijume izometrijska izdržljivost lumbalne i abdominalne muskulature. Za procenu antropometrijskih karakteristika primenjene su sledeće varijable: 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 regresionom analizom. Rezultati i diskusija omogućavaju da se zaključi da između antropometrijskih karakteristika i izdržljivosti lumbalnih ekstenzora i laterofleksora postoje statistički značajne multiple korelacije. Multipla korelacija između antropometrijskih karakteristika i izdržljivosti abdominalne muskulature nije statistički značajna.

Ključne reči: *antropometrija, lumbalna ekstenzija, abdominalna i lateralna fleksija, predikcija, dečaci*