Miroljub Ivanović[1] and Uglješa Ivanović[2]

Types of body posture of pupils of pre adolescent age

[1]*Faculty of professional studies for kindergartner teacher,s education, Sremska Mitrovica, Serbia*
[2]*University of sport menagement, Belgrade, Serbia*

Original scientific paper

Abstract
The aim of the research was to identify structure of body posture, as well as stastical significance of differences between clusters, upon the indicators of body posture, as well as to analyze types of body posture. Examinee sample included (N=132) pupils of primary schools in Valjevo, aged between 10-13. Five variables of body posture in frontal plane and four variables in sagittal plane, measured by Tribastoneu's instrument -scoliometer Stastically significant bipolar linear discriminative function was isolated by algorithm of canonical discriminant analysis. Three variables in the frontal plane (asymmetric knee position, asymmetric leg joint position, and head position according to a vertical) and four variables in the sagittal plane (head position, shoulder position, pelvis position, knee position according to gravitation line) were of the greatest importance for the differentiation between the types of examinees. Sample results mostly coincide with the results obtained from the samples of previous research of the population that was subjected to analysis.

Key words: **scoliometer, frontal plane, sagittal plane, discriminnt function, body type**

Sažetak
Cilj ovoga istraživanju bio je da se na osnovu indikatora telesnog držanja identifikuje struktura telesnog držanja, statistička značajnost razlika između klastera i analiziraju tipovi telesnog držanja. Odgovarajući uzorak ispitanika činili su (N=132) učenici osnovnih škola iz Valjeva, uzrasnog nivoa 10–13 godina. Pet varijabli telesnog držanja u frontalnoj i četiri varijable u sagitalnoj ravni, merene Tribstonovim instrumentom skoliozometrom (Tribastoneu, 1994). Algoritmom kanoničko–diskriminativne analize, izolovana je jedna statistički značajna bipolarna linearna diskriminativna funkcija. Najveći uticaj na diferencijaciju između tipova ispitanika imale su tri varijable u frontalnom položaju (nesimetričan položaj kolena, nesimetričan položaj zglobova nogu i položaj glave u odnosu na vertikalu) i četiri varijable u sagitalnom položaju (položaj glave, ramena, karlice i položaj kolena u odnosu na gravitacionu liniju). Rezultati iz uzorka uglavnom su saglasni sa nalazima dobijenim na uzorcima iz prethodnih istraživanja drugih populacija koje su bile predmet istraživanja.

Ključne reči: **skoliozometar, frontalna ravan, sagitalna ravan, diskriminativna funkcija, telesni tip**

Introduction

Research of discriminant structure and quantitative differences of variables of body posture between the clusters of examinees represents fundamental scientific problem of kinesitherapy. Body proportions, i.e. body shape as the most prominent part of latent morphological dimensions, represents the most manifest component of anthropological status which contributes to the development and improvement of other human abilities and qualities.
Garrison and Read (1980) defined body posture as body segments at the line, without inclination angle, as well as thier balance which is realized with minimal strength, but the most successfully. Somatotype characteristics and correct body posture are extremely important in everyday life and succseful mobility of both children and adults. It is necessary to exercise regularly every day in order to have correct body posture. On the other hand, irregular body posture of children – weakened functional state of postural muscles (flat foot, “O” legs, “X” legs, lordosis, flat back, kyphosis, rounded back, scoliosis and kypholordosis) represent important problem of children today, especially in the early life age.
Different methods, such as: manual testing of musle strength, movement scope measuring, thermography, photopography, X-rays, plumb assesment method, scoliometer, photography etc. were used in order to define morphological state and make precise diagnosis of body status. Precondition of evaluation and measuring of body structure is to identify its latent discriminant structure.
Kosinac and Katic (1999) assessed body posture (head, shoulder and scapula postures, Lorenzo's angle, kyphosis and lordosis) of examinnes aged from 10 to 14 applying visual method. Obtained data results pointed out significant irregularities in the position of analyzed body parts.
Pausic (2005) investigated body posture of primary school children applying scoliometer. The instrument was highly valid concerning internal metric characteristics ($\alpha >$ of 0.89). Obtained results pointed out that 51, 58% of first graders had asymmetric body posture. A year later the number of students with incorrect body posture grew to 62,1%. It was also stated that 28,4 % of children had impaired thoracic cage; a year later the number grew to 51,6%. Flat foot was registered in 47,3% of first graders and 60,7% of second graders.
Pausic (2007) also defined different types of body posture in her latest study according to the indicators of body posture measured by scoliometer. The research included boys aged from 10 to 13 and it defined following types: a) correct body posture, mild scoliotic body posture, mild body posture with both-side inclination in frontal plane; b) correct body posture, mild impaired body posture and marked impaired body posture in sagittal plane.
Bavchevic, Bozinovich-Madjor, and Vlahovic (2008) analyzed incorrect body posture in longitudinal research which lasted 8 years and included examinees of both sexes aged 14. Obtained results pointed out growing number of examinees with incorrect body posture, especially with spinal column deformity. The analysis of differences between genders in 1998/99 showed higher percent of incorrect body posture of female pupils (scoliosis and flat foot), whereas kyphosis was more common in male pupils. In 2006/07. incorrect body posture and scoliosis were more common in female students, whereas kyphosis and flat foot were more common in male pupils.
The results of the researh did not match in latent discriminant structure and definition of numeric differencies of body profile of the groups, beacuse of different samples and different age of examinees. Thus, the aim of our empirical research is to apply suitable multivariate statistical methods based upon measuring of significant variables of body posture at symetric body parts of

younger pupils. It is also necessary for the relevant phenomenon to be identified, classified, defined, hypothetically suggested from discriminant aspect. Thus, we can offer distinctive model of types of body posture.

The aim of research paper is to define types of body posture from discriminant aspect, upon manifest variables of body posture in frontal and sagittal planes, as well as to define statistical significance of numeric differencies between two clusters of primary school pupils in Valjevo, aged from 10 to 13.

Methods

Examinee sample

132 pupils aged from 10 to 13 (IV,V,VI grade of The First Primary school and „Vladika Nikolaj Velimirovic" primary school were submitted to body posture measuring. None of examinees had deformities or malfunction of the limbs. The results were obtained during May and June of 2009.

Research instrument and variables

The choice of indicators of body posture was done according to scoliometer (Tribastoneu, 1994). According to the standards of Auhter, Pufer and Hueting, (1997), Palmer and Epler (2001), measuring protocol included five significant points in frontal plane and four significant points in sagittal plane.

Indicators of body posture of examinees in **frontal plane** presented by codes in the tables are:

(1) head position according to a vertical line – deviation of the line that connects upper edge of left and right ears from horizontal line (HPIFP)

(2) asymmetric shoulder position– deviation of the line that connects left *acromion* to the right from horizontal line (ASPIFP)

(3) asymmetric pelvis position – deviation of the line that connects *spinu iliacu anterior superior* to the right from horizontal line (APPIFP)

(4) asymmetric knee joint position – deviation of the line that connects left *epicondylus medialis* to the right from horizontal line (AKPIFP)

(5) asymmetric leg wjoint position – deviation of the line that connects *malleolus medialis* to the right from horizontal line (ALPIFP).

Indicators of body posture of examinees in **sagittal position** are:

(1) head position according to gravitation line – deviation of upper edge of left ear from vertical line (HPISP)

(2) shoulder position according to gravitation line – deviation of *acromiona* of left side of the body from vertical line (SPISP)

(3) pelvis position according to gravitation line – deviation of *spine iliace anterior superior* from vertical line (PPISP)

(4) knee position according to gravitation line – deviation of *epicondylusa lateralis* of left side of the body from vertical line (KPISP).

Procedure of evaluation of symmetric body parts with scoliometer

Assessment of symmetric body parts was done by scoliometer (170 x 75 cm) which records any type of asymmetry or deviation from correct body posture, as well as kyphosis, scoliosis and lordosis. The instrument has aluminum frame, stand and transparent board made of plexiglass (with diameter of 75 cm). Square net is drawn on the board. Larger squares are coloured (5 x 5 cm), whereas smaller squares are positioned at the central part (1 x 1 cm), in order not to disturb examinees observation. Abscissa, as well as the coordinate on which the examinee leaned his/her back, were marked with dark colour, so that *processus spinosis* covered vertical red line in the centre of the board. Significant points of examinees' extended skeleton parts (*angulus superior et inferioir scapulae, acromion, spina iliaca anterior superior*) were marked with chalk. Assessment of body posture was done according to these points. After that examinee was placed in frontal or sagittal plane. P.E. professor was standing on the other side of plexiglass board and marked deviation between indicators of body posture. The results were presented in centimetres.

Measuring was done in P. E. gym in smaller groups (from 10 to 20) examinees, with room tempreture of 20 °C. Examinees were barefoot, they wore exercise eqiupment (shorts and t-shirts). Measuring procedure was repeated three times for each indicator, so that the instrumentobtained characteristics of multiitem (composite) type.

Multivariate data processing

Normatization was used for data processing. Basic descriptive indicators were calculated for each statistic multivariance canonical discriminant analysis. Software programme for statistics, SPPS for Windows ver 14.0 was used for statistical data processing.

Results and Discussion

Defining of types of bosy posture in frontal plane

Statistically significant high linear discriminant function (Rc=0.85), was set by algorithm of canonical disciminant analysis (Table 1). It is classified with three groups of examinees according to variables, with error probabilty of 2 %. The second discriminant function is not statistically significant, so that it is not interpreted.

Table 1. *Statistics and testing of significance of discriminant functions of clusters of body postures in frontal position*

	λ	Rc	$\chi 2$	DF	P
DF1	3.82	0.85	673.29	10	0.02
DF2	1.64	0.16	147.33	4	0.35

Legend: λ – characteristic value, RC – canonical correlation coefficient, $\chi 2$– Hi–square value, df – deviation level, p – significance level (error probability)

There are statistically significant differences in the whole system of analyzed vectors of variables, with minimal possibility of wrong classification within the group. Canonical correlation coefficient value in the first isolated discriminant function is very high. This fact points out the intensity between linear combination of the set of variables and linear variables of another set. Canonical correlation significance is set by the results of nonparametric Hi-square test ($\chi 2$=673,29).

Vectors of the structure of staistically significant two- pole discriminant functions (linear correlations of manifest variables with discriminant function) of classified types of body posture in frontal position are shown in Table 2. According to variance analysis aspect, discriminant functions or canonical factors, maximize distance between the groups according to the variance inside the groups.

Table 2. Standard coefficients of discriminant functions of variables of body posture in frontal plane

	DF1	DF2
HPIFP	**0.58**	0.16
ASPIFP	0.07	0.09
APPIFP	-0.06	0.09
AKPIFP	**-0.63**	-0.07
ALPIFP	**-0.72**	0.08

According to positive and negative discriminant coefficients of the first linear discriminant function we can evaluate partial influence of variables on formation of its dimension. In data matrix they were presented in bold letters of discriminant coefficients, which show that each variable partially correlates with disriminant function, which brings to statistically significant differences. Greatest statistical contribution to analysis of discrimination between the types of body posture at first discriminant factor had (according to their negative sign) discriminant ponders of two variables of negative direction: *asymmetric knee position* (0.63) and *asymmetric leg joint position* (0.72). On the other hand, positive pole of discriminant factor defined dicriminant ponder of *head position according to vertical line* variable (0.58). Thus, above mentioned variables are the best predictors of quantitative differences between clusters according to variance inside the groups.

Taking into account the fact that two variables had very low values in the first isolated discriminant function, we can state that they have no practical significance for setting crucial differences between clusters of body state of examinees.

Identified content of the structure of the first canonical discriminant function can hypothetically be interpreted as latent dimension of **asymmetric knee and leg joint position**.

More detailed analysis of separation can be noticed from the values of centroids of groups (C), i.e. points the coordinates of arithmetic mean of examinees of which are at all variables of discriminant space (Table 3). Obtained middle values and signs of group centroids point out statistically significant distance between defined types of body posture of examinees in frontal plane.

***Table 3.** Group centroid values at discriminative factors*

	CENTROIDS	CENTROIDS
Type 1	-2.02	-0.21
Type 2	0.99	0.26
Type 3	3.22	-0.73

Greatest distinctions of variables in the structure of the first significant function can be noticed between Type 3 (high centroid) and Type 1 (low centroid) clusters. Thus, results of arithmetic values of discriminant results of discriminant function of the groups of examinees show that positive pole of the first discriminant function is characterized with Type 3 (C3=3.22). These examinees have high scores in the variables of *body posture in frontal plane.* On the other hand, Type 1 is in the negative pole of discriminant function (C1=-2.02). These examinees have low scores at the same variables. Type 2 (C2=.99) also has high centroid but of lower intensity and it is situated at the same pole of dimension as Type 3.

According to the sign of group centroids we can state that disriminant (of variable of body posture in frontal plane) distinguishes following types of examinees:

a) Type 3 – it shows tendency to higher results with the distance of 3.22 standard deviations from expected value

b) Type 2 – it shows tendency to higher results with the distance of .99 standard deviations from expected value

c) Type 1 – it shows tendency to lower results with the distance of −2.02 standard deviations from expected value

Defining of body posture types in sagittal plane

In order to divide examinees to groups, so that groups consisit of similar members, but mutually differ as much as possible, we have presented results of statistical processing of basic descriptive statistics in Table 4.

***Table 4.** Statistics and testing of significance of discriminant functions of clusters of body posture in sagittal plane*

	λ	RC	$\chi 2$	DF	P
DF1	6.07	0.87	658.32	8	0.01

Table 4 shows statistically significant high linear discriminant function (Rc=.87),, with the lowest error porobability of 1 %, which points out differences of variables between three classified types of body posture of examinees in saagittal plane. Taking the intensity of the values of canonical correlation coefficient, as well as the values of nonparametric Hi-square test ($\chi 2$=658,32), the first isolated discriminant function with high distribution of probabilities of frequencies, according to theoretical expectations of frequencies of variables, statistically significant explains differences between vectors of variables of body posture in frontal plane.

Vectors of structure of discriminant function of original variables of body posture in sagittal plane are shown in Table 5.

***Table 5.** Standard coefficients of discriminant functions of variables of body posture in sagittal position*

	DF1
HPISP	-0.62
SPISP	-0.58
PPISP	0.45
KPISP	-0.39

Positive and negative values of standard discriminant coefficients of statistically significant bipolar canonical discriminant function in structural matrix point out approximately partial contribution of all analyzed variables as well as differences between types of body postures of examinees in sagittal view.

Detailed investigation of statistically significant discrimination of three defined types of body posture of examinees in sagittal plane is shown in Table 6, according to the values of the centroids of the groups (C, i.e. mutual arithmetic value at separate discriminant factors.

***Table 6.** Values of the centroids of groups at discriminant factor*

	Centroids
Type 1	2.18
Type 2	-2.93
Type 3	4.20

First discriminant function diferrentiates moslty Type 3 (high centroid) and Type 2 (low centroid) clusters. Thus, positive sign of arithmetic means in centroid matrix points out that Type 3 (C3=4,20) represents main characteristic of the structure of the first discriminant function, i. e. it consists of examinees who have high results at the tests of body posture in sagittal plane. At negative side of discriminant function, distinction is made by Type 2 (C2=−2,93) i.e. examinees who have the lowest results at the same tests. Type 1 (C1=−2,18) also has high centroids of lower intensity and it is situated at the same side of dimension as Type 3.
Taking the signs of group centroids into account, we can undoubtedly state that variables of body posture in sagtittal plane differentiate following types of examinees:
a) Type 1 – it shows tendency to higher results with the distance of 2,18 standard deviations from expected value
b) Type 3 – it shows tendency to higher results with the distance of 4,20 standard deviations from expected value
c) Type 2 – it shows tendency to higher results with the distance of −2,93 standard deviations from expected value. Therefore, discriminants of the centroids of groups at the second linear discriminant function could not be used for assessment of mutual discrimination of body posture types in sagittal plane.
Comparison of obtained results with results of earlier studies is not possible, since we have not found studies on body posture of school poopulation of preadolescent period in frontal and sagittal plane in available references.

Conclusion

The results of research paper point out that applied instrument scoliometer (Tribastoneu, 1994), with its referential points in the body according to gravitation line in sagittal and frontal views, can be used for assessment of symmetric body parts of the population of lower graders of primary school.
Discriminant ponders of two variables of negative sign gave maximal contribution to the distinction between the types of body posture in **frontal position**: *asymmetric knee position* and *asymmetric leg joint position*, whereas the structure of positive side of second discriminant factor was defined with *head position according to vertical line* variable. Centroid values in linear discriminant function suggest that its positive side is characterized with Type 3 (*both-side scoliotic posture*), i.e. examinees who have highest results of body posture tests in frontal plane. Type 1 (mild scoliotic posture) is situated in the negative side, i.e it comprises of examinees who have lowest results of the same tests.
Positive signs of centroids point out that Type 3 (*marked incorrect body posture*) is dominant discriminant of the first discriminant factor in sagittal position. Examinees who have high results of body posture tests in sagittal plane belong to this type. On the other hand, Type 2 is situated in the negative side of discriminant function, i.e. examinees who achieve lowest results in the same tests belong to this type.
From discriminant point of view, presented results do not pretend to lead to general conclusions, but they can be used as the basis for further research in the field of body posture assesment. Taking into account the fact that this phenomen was not thoroughly investigated by now, it is supposed that discriminant results of the paper will have heuristic influence upon other authors and motivate them to do some research on longitudinal design of body posture types and statistically significant quantitative diiference between the clusters of examinees.

References

Auxter, D., Pyfer, J., & Huettig, C. (1997). Principal and methods of adapted physical education and recreation. *WCB McGraw-Hill*, New York.

Bavchevic, T., Bozinovich-Madjor, S., & Vlahovic, L. (2008). The analysis about incidence differences between some parameters of school boys, who are 14-years-old. Boris, *Memoir of the 17. summer kinesiology's school, Croatia* (page 470-475).

Garrison, L., & Read, A.K. (1980). Fitness for every body. Palo Alto, Calif. Mayfield Publishing.

Kosinac, Z., & Katic, R. (1999). The longitudinal study about morphological and motor development of boy's and girl's, who are from 5-7-years old, characteristics. *Kinesiology for the 21. century. Dubrovnik*, 144-146.

Palmer, L.M., & Epler, E.M. (2001). *Fudamentals of Musculoskeletal Assessment Techniques*. Lippincott Williams & Wilkins.

Paushic, J. (2005). *Evaluation of the body posture changes of children, who are from7 to 9-years –old.* Master thesis, Zagreb: Faculty of Kinesiology.

Pauchic, J. (2007). *Construction and evaluation of the boy's, who are 10-13-years-old, measure procedures for body posture evaluation*. PhD thesis, Zagreb: Faculty of Kinesiology.

Tribastone, R. (1994). *Compendio Ginnastica Correttiva*. Società Stampa Sportiva, Roma.

Submitted: April 27, 2010.
Accepted: May 23, 2010.

Correspondence to:
Miroljub Ivanovic, Ph.D.
Faculty of professional studies for kindergarten teacher's education,
Zmaj Jovina 29
22.000 Sremska Mitrovica, Serbia
E-mail:miroljub.ivanovic@gmail.com