# DIFFERENCES BETWEEN STUDENTS AND ATHLETES IN SPACE OF MECHANISM FOR ENERGETIC REGULATION

**Ratko Pavlovic[1] and Toplica Stojanović[2]**

*[1] Faculty of Physical Education and Sport, University of East Sarajevo, Bosnia & Herzegovina*
*[2] Faculty of Physical Education and Sport, University of Banja Luka, Bosnia & Herzegovina*

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**Abstract**

*Motor skills are an important segment of the anthropological space of man and are often the subject of scientific research. Due to their complex structure often in studies of this segment we have a different approach in defining the model that will serve as the basis for the selection and definition of manifest variables. Usually there is a phenomenological approach, but not rare are studies that are based on a functional model of motor skills. This work analyzes the space of motor skills of the population of students and athletes, youth ages with the aim of determining the difference in the space of the mechanism of energy regulation. The study included 90 students involved in various sports teams and 90 athletes from four athletic clubs. Twelve manifest variables from the area of energy regulation mechanism are measured. In analyzing the data, using t-test and canonical discriminant analysis the obtained results significantly explain the differences among the examinees.*

***Keywords***: *students, athletes, differences, t-test, canonical - discriminant analysis*

## Introduction

Athletics includes racing, throwing, jumping and walking disciplines characterized by motor movements and can be successfully applied in the educational process or through other forms of exercise, by which a significant impact on raising the general mental and physical abilities of a person. It is the starting point and foundation for all other sports and is one of the oldest forms of sports events, from ancient Greece to the modern Olympic Games. In any aspect of sports, including athletics it is necessary to know certain characteristics that correspond to different ages, and are influenced by endogenous or exogenous factors. There are very interesting studies which look at specific segments in the space of anthropological characteristic age periods (junior, intermediate and senior school age). Some are oriented to the younger and middle schoolers studying the motor status of children and young athletes (Anastasovski 1981; Despot et al. 1983; Cousin et al. 2001; Breslauer, 2006; Pavlović et al., 2008). Very often as a research problem are defined the differences in morphological and motor dimensions of different populations of the same age. Sometimes it comes to determining the differences in sports performance (Delija et al., 1995; Bojić et al., 2007; Prahović et al., 2007; Krsmanović et al., 2008; Kalentić et al., 2008; Fratrić et al., 2009; Štirin, 2010; Molnar et al., 2010) in motor behavior, and some research based on the study of morphological dimensions between athletes and students (Trent, 1996; Breslauer et al., 2006; Pelemiš et al., in 2009; Vučković et al., 2011; Kos et al., 2010; Kahrović et al., 2011). The interest in such research is based on the knowledge of the existence of possible differences, if certain groups are engaged in a form of physical activity in relation to groups who are not, or within the same sport discipline when it comes to implementation of the training process and the effects of this process on possible modifications of the subject. It is very important the proper dosage and performance of the physical activity at a time when the young organism is in the process of growth and development, whe comes to acceleration, primarily of locomotor system and other systems in the body (muscle, cardiovascular, respiratory) on the basis of which possibilities is determined certain training process in order to avoid possible unwanted consequences hazardous to health (Tončev & Mihajlović, 1999; Pavlović, 2010). As an important part of anthropological space occupy motor skills that carry information on motor activity and play an important role in achieving the results of the individual sport or team members. In the analysis of motor skills, very often in defining of manifest variables the functional model is taken not a phenomenological model. In the functional model, the ability of certain areas of energy regulation movement have high (repetitive and static strength) to a high genetic component (explosive strength) and work to improve the results of these capabilities is very small (explosive power) or slightly higher when it comes to repetitive and the static force (Stojanović, Kostić & Ahmetović, 2006).

The studies that have been done, especially of recent date deal with man as a bio-psycho-social being and his possibility of transformation from one form to another over a directed physical exercise, with various modifications of training work or differences between certain populations. The research problem is to investigate whether there are significant differences between students and athletes in the space of variables moving energy regulation. The main objective is to determine any existing differences between students and athletes in the area of defined motor skills.

## Methods

*The sample of examinees*
The sample population consisted of junior athletes of athletic clubs: Prijedor, Borac (Banja Luka), Doboj, Prnjavor and the population of secondary school in Prijedor Machine, aged 15-16 years. A total of 90 runners and jumping athletes is included from these clubs that more than one year train athletic and 90 students which also more than one year train some of the sports (sports games, martial arts).

*Sample of variables*
For the purposes of this study a sample of 12 variables is determined to assess the mechanism of energy regulation of movement: 1. First mechanism of regulation of excitation intensity (explosive power) - jump in distance from a standing point (MSDM), triple jump from a standing point (MTRS) Sargent (MASR), throwing a medicine ball (MBMD); 2. Two mechanism of duration of the excitation regulation (repetitive and static strength)– Push-ups (MSKL), raising body (MDTK), chin-ups (MZGV), squats with a load (MDČO); Hold in pushing up rear (MVIS) hold in loads in flexion of the hands (MFLE) hold in half squat (MPOČ) body hold ventrally (MITV). All measurements were performed in the first semester of school year 2011/12 year. In order to obtain relevant results based on which we will get answers, basic statistical parameters were applied, and in terms of determining the differences the analysis by applying T-test is applied for independent samples of large univariant level and canonical discriminant analysis on the multivariate level.

## Results and discussion

In Tables 1 and 2 are the basic statistical parameters of the motor abilities of the investigated sample of students and athletes. For each variable the relevant central and dispersion parameters and measures of variability were calculated. Most of the variables are within the normal distribution. If we consider the value of the results (Table 1) all variables of explosive strength, that is those variables that have a high genetic coefficient, we have the slightest deviation in terms of distribution of results. Of course, one should have in mind the fact that if we know the way of performing a specific motor task, the possibility of its successful performance is higher. From this can be seen that we can very little influence on the explosive strength by training, somewhat more on static and repetitive force that are subject to greater influence on the basis of the which can lead to movement of the initial state of these capabilities. In regard to this, their represent – variables are in that relation one to each other and demonstrate their numerical values, in difference to those that can be influenced on to a greater extent. It should be noted that a number of examinees are actively engaged in certain sports, as opposed to those who do little exercise, so those are also limiting factors to the eventual different distribution of variables, normally in a positive sense, depending on the type of motor task. The values of Std. Dev are within the allowed values based on which we can assess the significant sensitivity of the tests.

Table 1. Basic statistical parameters of the motor skills of students

| | Mean | Min | Max | Range | Std.D. | Skew | Kurt |
|---|---|---|---|---|---|---|---|
| MSDM | 171,73 | 110,00 | 230,00 | 120,00 | 26,89 | -,01 | -,64 |
| MTRS | 542,80 | 330,00 | 725,00 | 395,00 | 82,59 | -,32 | -,37 |
| MSAR | 37,23 | 24,00 | 54,00 | 30,00 | 6,51 | ,59 | -,23 |
| MBMD | 310,02 | 85,00 | 454,00 | 369,00 | 80,63 | -,55 | -,16 |
| MSKL | 11,00 | 1,00 | 30,00 | 29,00 | 6,14 | ,63 | ,47 |
| MDTK | 23,00 | 9,00 | 32,00 | 23,00 | 4,59 | -,35 | -,03 |
| MZGV | 4,00 | 1,00 | 13,00 | 12,00 | 2,88 | 1,10 | 1,00 |
| MDČO | 16,00 | 4,00 | 26,00 | 22,00 | 5,91 | -,56 | -,93 |
| MVIS | 38,30 | 9,54 | 102,60 | 93,06 | 20,63 | ,79 | ,53 |
| MFLE | 41,97 | 2,30 | 122,40 | 120,10 | 22,38 | ,80 | ,97 |
| MPOČ | 50,18 | 4,60 | 141,70 | 137,10 | 23,22 | 1,02 | 2,70 |
| MITV | 49,82 | 15,10 | 143,70 | 128,60 | 24,55 | 1,56 | 3,29 |

TablE 2. Basic statistical parameters of the motor skills of athletes

| | Mean | Min | Max | Range | Std.D. | Skew | Kurt |
|---|---|---|---|---|---|---|---|
| MSDM | 192,27 | 119,00 | 270,00 | 151,00 | 31,20 | ,20 | -,31 |
| MTRS | 637,54 | 389,00 | 1004,00 | 615,00 | 141,49 | ,48 | -,39 |
| MSAR | 38,82 | 27,00 | 64,00 | 37,00 | 7,59 | 1,03 | ,97 |
| MBMD | 431,03 | 184,00 | 790,00 | 606,00 | 132,76 | ,45 | -,39 |
| MSKL | 13,00 | 3,00 | 34,00 | 31,00 | 7,15 | ,69 | ,05 |
| MDTK | 25,00 | 13,00 | 36,00 | 23,00 | 4,65 | -,49 | -,40 |
| MZGV | 6,00 | 1,00 | 15,00 | 14,00 | 3,07 | ,69 | ,09 |
| MDČO | 18,00 | 8,00 | 28,00 | 20,00 | 4,47 | -,58 | -,02 |
| MVIS | 52,42 | 8,70 | 109,30 | 100,60 | 27,17 | ,34 | -,91 |
| MFLE | 44,90 | 12,30 | 122,90 | 110,60 | 21,85 | ,78 | ,72 |
| MPOČ | 52,47 | 10,10 | 129,30 | 119,20 | 24,07 | ,71 | ,81 |
| MITV | 52,59 | 15,60 | 150,80 | 135,20 | 25,54 | 1,19 | 1,95 |

By analyzing the values of motoric abilities of athletes (Table 2) values of Std. Dev are within the allowable values based on which we can assess the significant sensitivity of the tests. In some variables of repetitive and static strength, there is a strong mezokurtic and more leptokurtic distribution of the results as an indicator of the homogeneity of the sample expressed in these variables. Significant differences between the good and weaker performance in motor tests of athletes can be attributed to the fact that in this region play crucial role factors, primarily dealing with some kind of physical activity, sports activity in the home club, on the basis of which can be increased the successfulness of the performance of the score tests, then the pre-motor experience, the maturation of central nervous system, numerous exogenous and endogenous factors. In any case, here is more clearly expressed the distribution of results in a positive direction as a result of targeted physical activity, specifically athletes training process. As a general conclusion the following can be said, that the motor area in phase of the turbulent psychosomatic changes, have been under change of certain modifications and transformations in a positive direction in the sample of athletes, and a slightly smaller sample of students.

Although it is about the same age, on the same motor tests changes are evident. That is somewhere more expressed and somewhere less, but it is significant. It follows that, based on indicators of these central and dispersion statistical parameters, we can predict the changes and differences on a larger level, multivariant, their strength and reliability. This is certainly the purpose of this research, and those and other information will be presented in the rest of this work. At the univariant level it is applied the T-test for large independent samples, and on the multivariant level, canonical discriminant analysis. The quantitative aspect of change is determined by testing the difference between the results that were measured in students and the results that have been measured in athletes. The analysis of the significance of results were done on univariant and multivariant level. In analyzing the differences it was started from the level of univariant statistical analysis because it can provide relevant information that may be lost when using multivariant analysis. To show the differences of means and standard deviations in motor skills of students and athletes, basic statistical measures are shown, required by the analysis of the T-test (Tables 3, 4, 5).

Table 3. Differences of variables of explosive strength of students and athletes

| | Mean | | Std. Dev. | t-value | df | p |
|---|---|---|---|---|---|---|
| MSDM | U | 174,01 | 24,90 | -4,987 | 178 | ,000 |
| | A | 193,60 | 3,04 | | | |
| MTRS | U | 542,80 | 82,59 | -5,783 | 178 | ,000 |
| | A | 640,06 | 139,98 | | | |
| MSAR | U | 37,23 | 6,51 | -1,590 | 178 | ,114 |
| | A | 38,82 | 7,59 | | | |
| MBMD | U | 314,51 | 74,94 | -7,791 | 178 | ,000 |
| | A | 436,02 | 129,35 | | | |

Table 4. The Differences of variables of repetitive strength of students and athletes

| | Mean | | Std. Dev | t-value | df | p |
|---|---|---|---|---|---|---|
| MSKL | U | 11,00 | 6,14 | -2,238 | 178 | ,026 |
| | A | 13,00 | 7,15 | | | |
| MDTK | U | 23,00 | 4,59 | -3,583 | 178 | ,000 |
| | A | 25,00 | 4,65 | | | |
| MZGV | U | 4,00 | 2,88 | -3,902 | 178 | ,000 |
| | A | 6,00 | 3,07 | | | |
| MDČO | U | 16,00 | 5,91 | -3,211 | 178 | ,002 |
| | A | 18,00 | 4,47 | | | |

Table 5. The Differences of variables of static strength of students and athletes

| | Mean | | Std. Dev | t-value | Df | p |
|---|---|---|---|---|---|---|
| MVIS | U | 38,30 | 20,63 | -4,138 | 178 | ,000 |
| | A | 52,42 | 27,17 | | | |
| MFLE | U | 42,74 | 21,94 | -,935 | 178 | ,351 |
| | A | 44,90 | 21,85 | | | |
| MPOČ | U | 50,18 | 23,22 | -,686 | 178 | ,494 |
| | A | 52,47 | 24,07 | | | |
| MITV | U | 49,82 | 24,55 | -,781 | 178 | ,436 |
| | A | 52,59 | 25,54 | | | |

These are the arithmetic mean (Mean), standard deviation (Std. Dev), the numerical value of the t-test (t-value), degrees of freedom (df) and probability of error when rejecting the hypothesis that the difference was not significant (p). By review and analysis of means differences in variables of explosive strength (Table 3) we observe statistically significant differences between students and athletes in almost all measured tests. These differences are in favor of the athlete's sample, and they are the ones who accomplished better results in all measurements (they jumped further and higher and threw a longer distance), except Sargent test (MSAR .114) where there is a difference in favor of the athlete but itis not statistically significant. Jumps in height are also dominant in sports basketball, volleyball, handball, football when you need before your opponent to catch a ball, kick or throw the ball (Kalentić et al.2008; Fratrić and Starovlah, 2009) and their result is important in achieving success. The biggest difference was expressed in tests that assessed the caudal extremity explosive power and jump from position in distance (.000 MSDM) and triple jump (000 MTRS) and the explosive force of arms and shoulders belt -medicine-ball throws (.000 MBMD). If we know that the explosive force is extremely important in racing and jumping disciplines, then these results are not surprising. It is particularly expressed in the moment of reflection in distance, high altitude jumps, in a moment of reflection for racing disciplines, in the last moment of resisting, when the last reflective impuls is expressed (Pavlovic, 2010). In all that, meaningful participation and assistance is made throughout active strokes and hand movements so that they with caudal limbs have synchronized work with the racing and jumping disciplines. Also it is known the genetic involvement of explosive power (over 85%), and its conditionality by good condition of CNS, which means that it can be less impacted, then one can conclude that it is a well-executed selection of athletes for racing and jumping disciplines. It is very important to note that this form of power is of a general character, so to this benefit go the performance of testing of arms and shoulders belt, what can be seen from the measured values of the parameters of explosive power. By review and analysis of the difference of means in repetitive strength variables (Table 4.) were observed statistically significant differences between student and athletes in all measured tests. The differences are in favor of the athletes population, and they all accomplished a better result in these repetitive strength measurements with a high level of significance. Those are tests which examined the strength of the arms and shoulders: push - ups (MSKL .026), chin- ups (MZGV .000), raising body (MDTK .000) and squat with a load (MDČO .002). Isolated differences of means are not large but are very significant, considering that the repetitive force is about 60% of genetically caused and the other part is offset by training, training process that adapts to the needs of the subject (Nićin, 2000).

Although repetitive movements for power development are represented in other sports and sports games it is interesting that also here athletes had a better result, which can be characterized by a well managed training process which at any point does not make a priority in the development of one relate to the other motor ability. In contrast to the explosive force that is general in nature, repetitive force is not, and it is suitable for power development in activities where we have a large number of repeating movements of the same or different amplitudes (Pavlovic, 2005). Similar results can be found by most authors (Kukolj et al. 2001; Pivac, Markovic, 2005; Krsmanovic et al. in 2008, Molnar et al. 2010) who solved the same or similar problems. By detailed insight and analysis of quantitative differences on some means in variables of static strength (Table 5) we observe statistically significant differences between students and athletes in just one variable from this set. In fact, this is a test Hold in pushing up rear (MVIS .000), while the other three measures did not record statistical difference, although difference of means was evident. Static power is a power with the genetic cause about 60% as well as repetitive force, controlled by mechanism of energy regulation developments. Also, it can only develop power in that part of the movement that we want, and it depends on the type of activity (Furjan, 1985; Dragaš, 2005). Looking at the athletic activities of cyclic type of running and jumping we can see that we do not have a large number of situations in which we perform isometric muscle contraction, but it is a dynamic isotonus myometric contraction and of plyometric nature, where the goal is to make faster and stronger muscle shortening or stretching, and just such a situation we have at running and jumping (Brankovic, 1997; Tončev, 2001, 2005; Pavlovic, 2010). In our case, although the values are in favor of athletes they are not as expressed, because it is known that the static force has little involvement in racing and jumping disciplines as opposed to throwing. Based on these facts, these results are not surprised, where the likelihood of these results would be different. If now we generalize these univariant differences in motor skills between students , athletes, it can be concluded that from the total number of manifest variables (12) in eight were achieved statistical significance at the level of p = .000, p = .001, p = .010. Expressed as a percentage, it amounts to about 67% which is very important and a high percentage ratio. In all variables were those athletes who have achieved a better results specially in those variables that are prevalent and important in athletic racing, and jumping disciplines. Only the variable in the MSAR space of excitation intensity and variable MFLE, MDČO, MITV from the space duration of excitation have not achieved statistically significant difference. It is even more important for practice, taking into account the fact that among the many students who are actively involved in various sports clubs and directly in the training process, but they still showed inferior results compared to the athletes of the same age. At the multivariant level using canonical discriminant analysis were analyzed the differences between the students and athletes motor abilities (Table 6).

Table 6. Discriminant function of motor abilities of students and athletes

| | Eigen-value | Canonicl R | Wilks' Lambda | Chi-Sqr. | p-level |
|---|---|---|---|---|---|
| 0 | 3,47 | ,90 | .72 | 374,07 | 0,00 |

Eigen-square coefficient of discrimination; CanoniclR-isolated discriminant function; Wilks'Lambda-intensity isolated discriminant function; Chi-Sqr-Bartletiv chi square test p-level-error probability of rejection of a function is not significant.

In the space of 12 motor variables, one significant discriminant function was isolated (Table 6). There was recorded extremely high discrimination of variables of defined populations in the amount of Canonicl R = .90. This high association between the variables shows in which correlation is the data set of motor skills, based on which discriminant analysis of motor space was performed . The results of discriminant variables of strength, that is the determination coefficient functions of motor skills are very high (Wilk's Lambda = .72), indicating that the differences between the students and athletes _ in area of energy regulation are very significant at the level p= .000. Also Eigen value. roots is significant (3.47) and height (= Chi-Sqr. .374,07). Based onthe above parameters of discriminant functions it can be determined that there was a significant global quantitative changes in the area of energy regulation variables between students and athletes.

Table 7. Factor structure of the discriminant function

| | Root 1 | St.Coef. |
|---|---|---|
| MSDM | -,32 | -,08 |
| MTRS | -,38 | -,26 |
| MSAR | -,16 | -,17 |
| MBMD | -,30 | -,42 |
| MSKL | -,29 | ,02 |
| MDTK | -,37 | -,20 |
| MZGV | -,35 | -,05 |
| MDČO | -,22 | -,15 |
| MVIS | -,26 | -,09 |
| MFLE | -,24 | ,19 |
| MPOČ | -,23 | -,16 |
| MDTI | -,23 | ,30 |

In Table 7 presented is the factor structure of discriminant function, participation of motor skills in its formation. From total of twelve motor abilities the greatest contribution to the discriminant function achieved variable by which is defined the explosive power (MTRS, MSDM, MBMD), repetitive power (MSKLE, MDTK, MZGV, MDČO) with high numerical projections. The main carrier is variable lift of body on the bench (MDTK - .37), chin-ups

(MZGV -.35), triple jump from a position (MTRS -.38), long jump (MSDM - .32), throwing a medicine ball (MBMD - .30 ). Also, the static strength variables had a significant contribution to the discriminant function. This is confirmed by the values of the standard coefficient. What is interesting here is a negative sign for all variables of energy regulation. According to the negative sign follows that these variables in athletes directly influence to discrimination related to the students because they are in negative correlation with the centroid position of the athletes population.

Checking the arithmetic mean distance of groups, large enough differences can be seen (Table 8), which were confirmed on the basis Mahalanobis distance (Table 9). On the basis of isolated variables that determined the discriminant function of the motor space, this function could be defined as a function of power. From the sign of centroid values which has positive character in the sample of students, it is possible to explain their direct relationship with the variables that discriminate them from the sample of athletes, and those are all variables that have a positive value.

Table 8. Centroids of discriminant measures

| | Root 1 |
|---|---|
| G_1:1 | 1,65 |
| G_2:2 | -1,65 |

Table 9. Mahalanobis distance

| | G_1:1 | G_2:2 |
|---|---|---|
| G_1:1 | 0,00 | 13,89 |
| G_2:2 | 11,90 | 0,00 |

Table 10. Classification matrix

| | Percent Correct | G_1:1 p=,50 | G_2:2 P=,50 |
|---|---|---|---|
| G_1:1 | 96,00 | 96 | 4 |
| G_2:2 | 100,00 | 0 | 100 |
| Total | 98,00 | 96 | 104 |

Table 11. Significance of discriminant function F-values

| G_1:1 | G_2:2 | |
|---|---|---|
| G_1:1 | -- | 18,13 |
| G_2:2 | 11,10 | -- |

Separation of groups, of students and athletes in discriminant function is presented as percentiles (Table 10), indicating that the separation of groups was conducted with high accuracy of 98%. To test the significance of the function and justification of our results, we tested it through F-values (Table 11) which showed a positive answer.

Based on these indicators can be concluded that the isolated discriminant functions statistically significant, with the relevant parameters of function and that is though in most of motor skills different, heterogeneous. In general are confirmed the results of univariant analysis of motor skills and on the multivariant level. The differences are in favor of the athletes in all variables of the mechanism of energy regulation (excitation intensity and duration of excitation), that is to the explosive, repetitive and static strength, to those specific structures that impact and have importance in athletic racing and jumping disciplines.

## Conclusion

The research was carried out on a sample of 180 entities chronological age 15-16 years± 6 months, with the aim of determining the difference between students and junior athletes in the area of energy regulation mechanism. By analyzing the results of differences of means of tested measures of motor space in student athletes we can clearly see that there is a significant difference in almost all measures, but only in 8 cases the difference is statistically significant at a high level (p = 0.00, 0.01), which is 67% difference of the total number of measured variables. Those differences are noted in almost all variables of intensity and duration of excitation favor of the athletes (higher values). In all the variables the athletes were those who have achieved a better result especially in those variables that are prevalent and important in athletic racing and in jumping disciplines. Only the variable of MSAR from the space of excitation intensity and variable MFLE, MDČO, MITV from the space of duration of excitation have not achieved statistically significant differences on the given level. It follows that the athletes were those who generally have better ability and mobility of the CNS because the explosive force depends on the speed of afferent and efferent motor neurons that transmit the certain stimulus, the impulse to the muscles mobilized. Variables of static forces have made the differences (in favor of the athletes) between the entities, but they were not statistically significant. Since the static force does not have a prominent place in the racing and in jumping disciplines, then this result is not surprising, and opposite we have students who practice sports games and martial arts, where the static force is probably more important in a given activity. Also, the results of canonical discriminant function in the mobility area showed that there is a statistically significant difference and that the function is defined by measures of power identical as on the univariant level in favor of the athletes.

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## RAZLIKE IZMEĐU STUDENATA I SPORTAŠA U PROSTORU MEHANIZMA ENERGETSKE REGULACIJE

***Sažetak***

*Motoričke sposobnosti su nezaobilazan segment antropološkog prostora čovjeka i često su predmet znanstvenih istraživanja. Obzirom na njihovu složenu strukturu vrlo često u istraživanjima ovog segmenta imamo različit pristup u definiranju modela koji će poslužiti kao temelj za odabir i definiranje manifestnih varijabli. Najčešće se radi o fenomenološkom pristupu ali nisu rijetka istraživanja koja su utemeljena na funkcionalnom modelu motoričkih sposobnosti. U radu je analiziran prostor motoričkih sposobnosti populacije učenika i atletičara, juniorskog uzrasta sa ciljem utvrđivanja razlika u prostoru mehanizma energetske regulacije. Istraživanjem je obuhvaćeno 90 učenika koji su uključeni u različite sportske klubove i 90 atletičara iz četiri atletska kluba. Izmjereno je 12 manifestnih motoričkih varijabli iz prostora mehanizma energetske regulacije. U analizi podataka, primjenom t-testa i kanoničke diskriminativne analize dobiveni su rezultati koji statistički značajno objašnjavaju razlike među ispitanicima.*

***Ključne riječi****: učenici, atletičari, razlike, t-test, kanonička-diskriminativna analiza*

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*Correspondence to:*
*Assoc.Prof.Ratko Pavlović, Ph.D.*
*University East Sarajevo*
*Faculty of Physical Education and Sport*
*Stambulčić bb, 71420 Pale, RS – Bosnia & Herzegovina*
*Phone: +389 2311 3654*
*E-mail: pavlovicratko@yahoo.com*